Final Progress Report for Research Projects Funded by Health Research Grants

Instructions: Please complete all of the items as instructed. Do not delete instructions. Do not leave any items blank; responses must be provided for all items. If your response to an item is "None", please specify "None" as your response. "Not applicable" is not an acceptable response for any of the items. There is no limit to the length of your response to any question. Responses should be single-spaced, no smaller than 12-point type. The report **must be completed using MS Word**. Submitted reports must be Word documents; they should not be converted to pdf format. Questions? Contact Health Research Program staff at 717-783-2548.

1. **Grantee Institution:** Albert Einstein Healthcare Network

2. **Reporting Period (start and end date of grant award period):** 1/1/13 – 6/30/14

3. **Grant Contact Person (First Name, M.I., Last Name, Degrees):** Mary Klein, PhD

4. **Grant Contact Person's Telephone Number:** 215-456-7864

5. **Grant SAP Number:** 4100062198

6. **Project Number and Title of Research Project:** #2 - Home-Based Mirror Therapy for Lower-Limb Rehabilitation Post-Stroke: A Pilot Study

7. **Start and End Date of Research Project:** 1/1/13 – 6/30/14

8. **Name of Principal Investigator for the Research Project:** Erin Vasudevan, PhD

9. **Research Project Expenses**.

   9(A) Please provide the total amount of health research grant funds spent on this project for the entire duration of the grant, including indirect costs and any interest earned that was spent:

   $ 30,891.02

   9(B) Provide the last names (include first initial if multiple individuals with the same last name are listed) of **all** persons who worked on this research project and were supported with health research funds. Include position titles (Principal Investigator, Graduate Assistant, Post-doctoral Fellow, etc.), percent of effort on project and total health research funds expended for the position. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name, First Name	Position Title	% of Effort on Project	Cost
Vasudevan, Erin	Principal Investigator	5%	4,560.68
Hamzey, Rami	Research Assistant	30%	11,224.06
Packel, Andrew	Research Physical Therapist	1%	2,371.87

9(C) Provide the names of **all** persons who worked on this research project, but who *were not* supported with health research funds. Include position titles (Research Assistant, Administrative Assistant, etc.) and percent of effort on project. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name, First Name	Position Title	% of Effort on Project
Shah, Anoop	Research Assistant	10%

9(D) Provide a list of **all** scientific equipment purchased as part of this research grant, a short description of the value (benefit) derived by the institution from this equipment, and the cost of the equipment.

Type of Scientific Equipment	Value Derived	Cost
No new equipment purchased		

10. Co-funding of Research Project during Health Research Grant Award Period. Did this research project receive funding from any other source during the project period when it was supported by the health research grant?

Yes_____ No___X_____

If yes, please indicate the source and amount of other funds:

11. Leveraging of Additional Funds

11(A) As a result of the health research funds provided for this research project, were you able to apply for and/or obtain funding from other sources to continue or expand the research?

Yes_____ No____X_____

If yes, please list the applications submitted (column A), the funding agency (National Institutes of Health—NIH, or other source in column B), the month and year when the application was submitted (column C), and the amount of funds requested (column D). If you have received a notice that the grant will be funded, please indicate the amount of funds to be awarded (column E). If the grant was not funded, insert "not funded" in column E.

Do not include funding from your own institution or from CURE (tobacco settlement funds). Do not include grants submitted prior to the start date of the grant as shown in Question 2. If you list grants submitted within 1-6 months of the start date of this grant, add a statement below the table indicating how the data/results from this project were used to secure that grant.

A. Title of research project on grant application	B. Funding agency (check those that apply)	C. Month and Year Submitted	D. Amount of funds requested:	E. Amount of funds to be awarded:
	☐NIH ☐ Other federal (specify:_____ _____) ☐ Nonfederal source (specify: _____)		$	$
	☐NIH ☐ Other federal (specify:_____ _____) ☐ Nonfederal source (specify: _____)		$	$
	☐NIH ☐ Other federal (specify:_____ _____) ☐ Nonfederal source (specify: _____)		$	$

11(B) Are you planning to apply for additional funding in the future to continue or expand the research?

Yes___X_____ No_____

If yes, please describe your plans:

We plan to use this data to support a NIH R01 application examining the effectiveness of home-based lower limb mirror therapy for people with stroke.

12. Future of Research Project. What are the future plans for this research project?

We plan to present these preliminary data at the International Stroke Conference (ISC 2015) in Nashville, TN. We also plan to use these data to support an R01 application to fund a larger randomized control trial.

13. New Investigator Training and Development. Did students participate in project supported internships or graduate or post-graduate training for at least one semester or one summer?

Yes_____X____ No_____

If yes, how many students? Please specify in the tables below:

	Undergraduate	Masters	Pre-doc	Post-doc
Male			1	
Female				
Unknown				
Total			**1**	

	Undergraduate	Masters	Pre-doc	Post-doc
Hispanic				
Non-Hispanic			1	
Unknown				
Total			**1**	

	Undergraduate	Masters	Pre-doc	Post-doc
White				
Black				
Asian			1	
Other				
Unknown				
Total			**1**	

14. Recruitment of Out-of–State Researchers. Did you bring researchers into Pennsylvania to carry out this research project?

Yes_____ No____X_____

If yes, please list the name and degree of each researcher and his/her previous affiliation:

15. Impact on Research Capacity and Quality. Did the health research project enhance the quality and/or capacity of research at your institution?

Yes_____ No___X_____

If yes, describe how improvements in infrastructure, the addition of new investigators, and other resources have led to more and better research.

16. Collaboration, business and community involvement.

16(A) Did the health research funds lead to collaboration with research partners outside of your institution (e.g., entire university, entire hospital system)?

Yes_____ No___X_____

If yes, please describe the collaborations:

16(B) Did the research project result in commercial development of any research products?

Yes_____ No____X_____

If yes, please describe commercial development activities that resulted from the research project:

16(C) Did the research lead to new involvement with the community?

Yes_____ No____X_____

If yes, please describe involvement with community groups that resulted from the research project:

17. Progress in Achieving Research Goals, Objectives and Aims.

List the project goals, objectives and specific aims (as contained in the grant agreement). Summarize the progress made in achieving these goals, objectives and aims <u>for the period that the project was funded (i.e., from project start date through end date).</u> Indicate whether or not each goal/objective/aim was achieved; if something was not achieved, note the reasons why. Describe the methods used. If changes were made to the research goals/objectives/aims, methods, design or timeline since the original grant application was submitted, please describe the changes. <u>Provide detailed results of the project.</u> Include evidence of the data that was generated and analyzed, and provide tables, graphs, and

figures of the data. List published abstracts, poster presentations and scientific meeting presentations at the end of the summary of progress; peer-reviewed publications should be listed under item 20.

This response should be a DETAILED report of the methods and findings. It is not sufficient to state that the work was completed. Insufficient information may result in an unfavorable performance review, which may jeopardize future funding. If research findings are pending publication you must still include enough detail for the expert peer reviewers to evaluate the progress during the course of the project.

Health research grants funded under the Tobacco Settlement Act will be evaluated via a performance review by an expert panel of researchers and clinicians who will assess project work using this Final Progress Report, all project Annual Reports and the project's strategic plan. After the final performance review of each project is complete, approximately 12-16 months after the end of the grant, this Final Progress Report, as well as the Final Performance Review Report containing the comments of the expert review panel, and the grantee's written response to the Final Performance Review Report, will be posted on the CURE Web site.

There is no limit to the length of your response. Responses must be single-spaced below, no smaller than 12-point type. If you cut and paste text from a publication, be sure symbols print properly, e.g., the Greek symbol for alpha (α) and beta (ß) should not print as boxes (□) and include the appropriate citation(s). DO NOT DELETE THESE INSTRUCTIONS.

Mirror therapy (MT) is a relatively new therapeutic intervention for hemiparesis. MT involves performing movements with the unimpaired limb while watching its mirror reflection superimposed over the (unseen) impaired limb, thus creating a visual illusion of enhanced movement capability of the impaired limb. A growing body of clinical research indicates that upper limb MT benefits stroke patients to a degree comparable to or better than other therapies [1]. Only one study has demonstrated efficacy of lower limb MT in a subacute stroke population [2], and potential benefits in a chronic population are unknown.

The primary aim of this study was to determine whether a home-based form of MT is an effective treatment of lower limb hemiparesis in chronic stroke survivors. The secondary aim was to evaluate the relationship between the amount of MT delivered (i.e., amount of practice) and improvement in key outcome measures, in order to identify the optimal dosage for this treatment. Before we could test these aims, it was necessary to design and build the devices to deliver the MT at home and to monitor changes in outcome measures. This work was conducted during the first six months of funding (01/01/13-06/30/13) and is described below.

Our first step was to design a mirror stand to allow participants to practice MT in their home (Figure 1). The final design consisted of a wooden frame holding a shatter-resistant plastic mirror (24"x30"). This was fixed to a stand with a wide base of support, which causes the MT device to be very stable. The top of the mirror frame supported a platform for a portable DVD player – a DVD was used during home practice sessions to guide the participant through MT (explained in following paragraph). There was also an arm connected to the mirror frame that holds a video camera used to record each home-based session. A member of the research team reviewed this video to ensure at-home compliance with the therapy schedule. The MT device was been designed with dimensions that will allow it to fit into

the backseat of a small car, enabling easy transport. We built two such devices, which allowed us to enroll two participants in the training phase of the study concurrently.

As part of the home-based MT device, we also made a DVD that provided therapy instructions. The full 30 minute video consisted of 2 repetitions of a set of 15 movements including flexion and extension of the knee, ankle dorsiflexion and plantarflexion, and foot circumduction. Each trained movement was first shown to the participant 3 times, after which the screen went blank to allow the participant to focus on viewing his/her movements rather than the video monitor. A metronome sound was presented on the video at ~30 bmp and participants were instructed to move in time to the metronome. The metronome ran for 1 minute and 45 seconds followed by a 15 second rest break, after which the next movement was presented. Instructions on the video reminded participants to look in the mirror and make the same movement with both limbs "as well as possible".

In addition to building the MT device, we designed and built a device that quantitatively assesses the ability to voluntarily control movement around the ankle joint. This was one of the outcome measures that was predicted to change with MT. This device is shown in Figure 2A&B. The leg was supported in a position of 30° of knee flexion and 90° of hip flexion, and movement of the shank was restricted using Velcro straps attached to a fixed board. Movement about the ankle was constrained to movement in the sagittal plane (ankle dorsiflexion and plantar flexion) using an ankle brace with a low-friction hinge. There was a potentiometer placed on this joint to record rotation. The potentiometer communicated with a computer via an arduino microcontroller. The resistance reading from the potentiometer was displayed as a large dot on a computer monitor placed in front of the participant. This method gave a visual representation of the ankle angle. Participants were able to control the height of the dot on the screen by dorsiflexing or plantar flexing their ankle. They were instructed to match the position of the dot to a sine wave that was continuously oscillating on the screen at 0.4Hz during a 60s trial (Figure 2C). The amplitude of the sign wave was set to 70% of the participant's range of motion. All data are sampled at 1000Hz. We refer to this task as the "ankle tracking task".

Once the equipment was constructed and tested in the first funding period, we were able to focus our efforts on human subjects testing in the second funding period (07/01/13-06/30/14). Our original aim was to recruit 8 participants. We recruited 11 participants, although only 7 of these individuals were included in the analysis. Two participants were withdrawn after consenting because they did not meet the inclusion criteria. An additional two withdrew shortly after baseline testing, but before training began, for personal reasons.

The 7 participants that were included underwent the testing paradigm shown in Figure 3. Unfortunately, 2/7 withdrew after completing mid-treatment session 3; both participants withdrew due to personal reasons (lack of time). The remaining 5/7 participants completed all training sessions and reported that the training was quite feasible. In fact, many responded positively to the training and reported that they were pleased to be trying these exercises at home. Nevertheless, our drop-out rate in the small pilot study was 2/7 or 29%. It is important that we have identified this high drop-out rate before pursuing a larger-scale study. Now that we know this, we will revisit our recruitment and communication strategies to help identify individuals who are likely to stick with training (i.e. those that have enough time) and to help motivate individuals who are undergoing training.

The primary aim of this study was to determine whether a home-based form of MT is an effective treatment of lower limb hemiparesis in chronic stroke survivors. Efficacy was evaluated with a series of tests measuring movement production ability and functional mobility, including tests of volitional ankle control, lower limb Fugl-Meyer Assessment (FMA), preferred walking speed and maximal

walking speed. Volitional ankle control was measured using an ankle tracking task, which was described in detail above. To quantify performance in this task, an accuracy index (AI) was calculated as *AI=(P-E)/P*, where E is the root-mean-square (rms) error between the target sine wave and the participant's response (i.e. potentiometer signal), and P is the rms value between the sine wave and the midline separating the upper and lower phases of the sine wave. The maximum possible score is 100%, indicating perfect accuracy. Figure 4 shows example data from the ankle tracking task – the red dotted line shows the position of the target and the blue line shows the potentiometer output corresponding to the participant's ankle angle. Pre-treatment data (Figure 4, top) shows large deviations from the target signal (AI = 11%). Following 3 weeks of MT (bottom), this participant showed improved accuracy (AI = 54%), demonstrating better control of the hemiparetic ankle movement.

We first examined whether there were significant changes in any of these tests from the beginning to the end of training in the 7 participants. The post-training measurement was taken after 4 weeks of training for 5 participants; for the 2 participants who only completed up to the 3rd mid-treatment assessment, post-training was taken after 3 weeks of training. We found that only the accuracy index on the more affected side improved significantly over the course of training ($p<0.05$) (Figure 5). Accuracy index on the less affected side and scores on the lower limb Fugl-Meyer Assessment also trended towards significance ($p = 0.07$), which is notable considering our small sample size and low power. There were no significant changes in preferred walking speed ($p=0.67$), or fastest walking speed ($p=0.30$).

The secondary aim of this study was to evaluate the relationship between the amount of MT delivered (i.e., amount of practice) and improvement in key outcome measures, in order to identify the optimal dosage for this treatment. These changes are shown by box and whisker plots in Figure 6. Outcome measures during the second baseline period (BL2) were used as reference values. Changes from BL2 are shown for accuracy index (more affected & less affected legs), Fugl-Meyer Assessment scores, preferred walking speed, and fastest walking speed across MT training. Note that only five subjects were included in Post and Post 1Mo, since two withdrew after Mid3.

It is acknowledged that the data shown in Figure 6 are preliminary, but there are a couple of trends emerging that are worth noting. First, all subjects appear to be improving accuracy index on the more affected leg (Figure 6B) – this trend begins around Mid2 and persists up to 1 month post-training (Post 1Mo). This suggests that MT improved volitional control around the ankle joint on the more affected side. Many people with hemiparesis due to stroke have weak dorsiflexors and evertors, and rely on ankle-foot orthoses (AFO) to walk. It is possible that training the ankle muscles through a paradigm like MT could significantly improve functional gait in these people (see also [3]).

Second, all subjects improved their preferred walking speed at Post 1Mo, but these improvements were not evident earlier in training (Figure 6D). The minimally clinically important difference (MCID) in walking speed is 0.16 m/s in persons with stroke [4], and two out of the five participants who completed all sessions achieved this (all subjects mean = 0.14 m/s). This change from baseline did not occur until after MT has ended – it is not clear whether this was a delayed effect of MT and improved ankle control, or if the training encouraged individuals to be more active once the training ended. Regardless, such delayed effects of training have been reported in other gait training studies [5]. In fact, Reisman and colleagues [5] did not show walking speed improvements exceeding the MCID until 8 weeks post-training, whereas we only tested up to 4 weeks post-training. It is also important to note that we were able to achieve close-to MCID improvements in gait speed using a home-based treatment; to the best of our knowledge, this has not been previously reported.

Overall, we have identified some positive effects of MT, particularly on volitional control of the more affected ankle. MT may also contribute to improved walking speed over time. The pilot study funded by this award is a first step towards establishing a home-based therapy for gait rehabilitation for stroke survivors who have limited access to other forms of rehabilitation.

Reference List

1 Thieme, H., Mehrholz, J., Pohl, M., Behrens, J., and Dohle, C.: 'Mirror therapy for improving motor function after stroke', The Cochrane database of systematic reviews, 2012, 3, pp. CD008449

2 Sutbeyaz, S., Yavuzer, G., Sezer, N., and Koseoglu, B.F.: 'Mirror therapy enhances lower-extremity motor recovery and motor functioning after stroke: a randomized controlled trial', Arch Phys Med Rehabil, 2007, 88, (5), pp. 555-559

3 Madhavan, S., Weber, K.A., 2nd, and Stinear, J.W.: 'Non-invasive brain stimulation enhances fine motor control of the hemiparetic ankle: implications for rehabilitation', Exp Brain Res, 2011, 209, (1), pp. 9-17

4 Tilson, J.K., Sullivan, K.J., Cen, S.Y., Rose, D.K., Koradia, C.H., Azen, S.P., and Duncan, P.W.: 'Meaningful gait speed improvement during the first 60 days poststroke: minimal clinically important difference', Phys Ther, 2010, 90, (2), pp. 196-208

5 Reisman, D.S., McLean, H., Keller, J., Danks, K.A., and Bastian, A.J.: 'Repeated split-belt treadmill training improves poststroke step length asymmetry', Neurorehabil Neural Repair, 2013, 27, (5), pp. 460-468

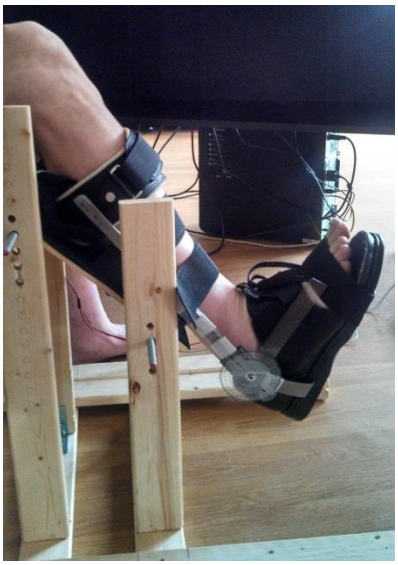
Figure 1:

Design of MT device. A wooden frame was built to hold a shatter-resistant plastic mirror, and this is attached to a wide base, ensuring stability of the device. The participant sits in a chair and places the non-paretic leg on the reflective side of the mirror and the paretic leg on the other side. This creates the illusion where the observed reflection of non-paretic leg in the mirror is mistaken for the paretic leg. A portable DVD player attached to top of the mirror frame displays therapy instructions. A camera attached to the back of the mirror frame (not shown) records each session to ensure therapy compliance.

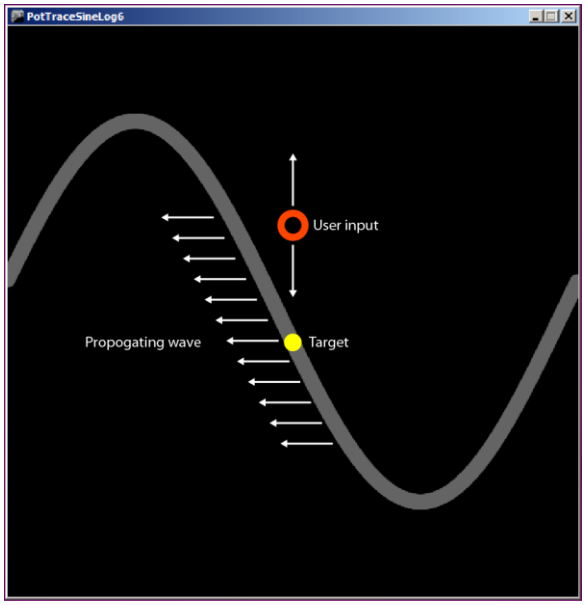
Figure 2:

A.

B.



C.

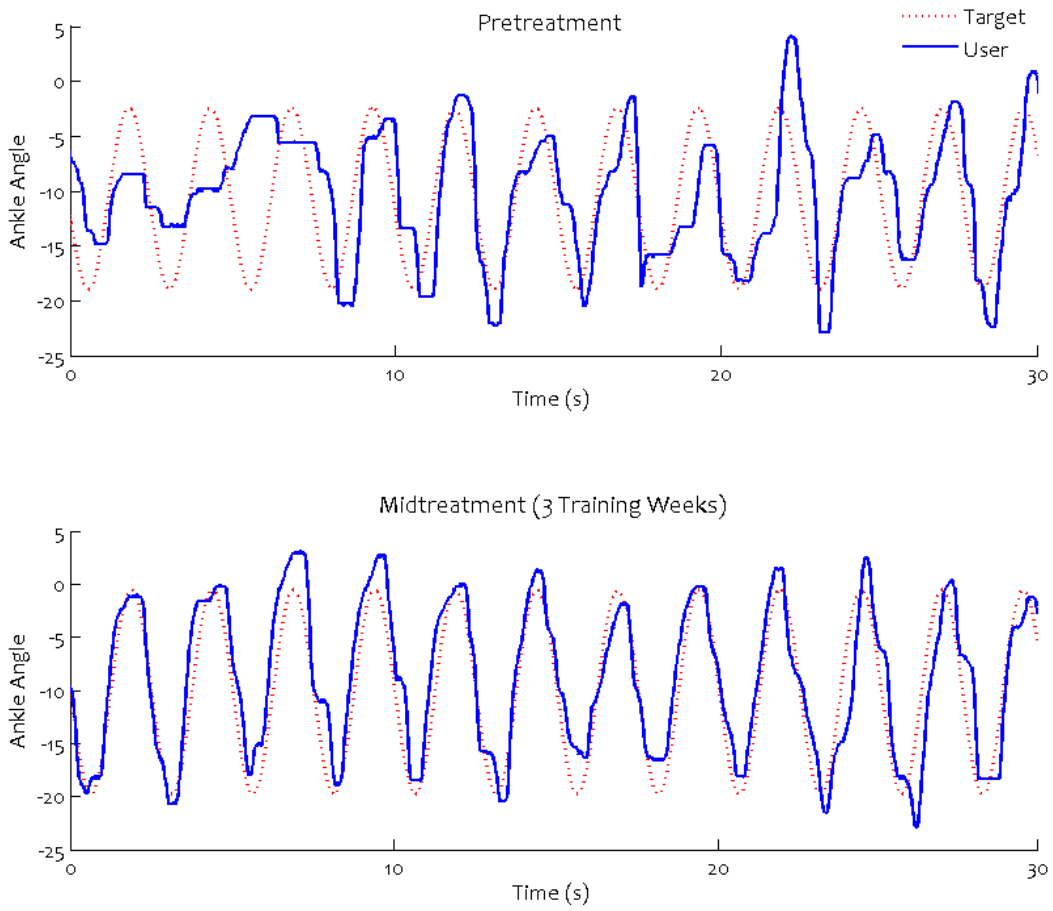


Design of ankle tracking task. (A) Experimental set-up: participant is seated comfortably in a chair with hemiparetic ankle in a brace that allows movement only in the sagittal plane (dorsi and plantar flexion). The shank is held in position by Velcro straps that fix the leg to a wooden board. A potentiometer is attached to the low-friction hinge of the ankle brace to record joint angle (close-up shown in B). (C) A computer monitor placed in front of the subject shows displays a propagating sine wave (0.4 Hz) with a yellow target dot corresponding to the desired ankle angle. A red circle displays the potentiometer output, corresponding to the participant's ankle angle.

Figure 3:

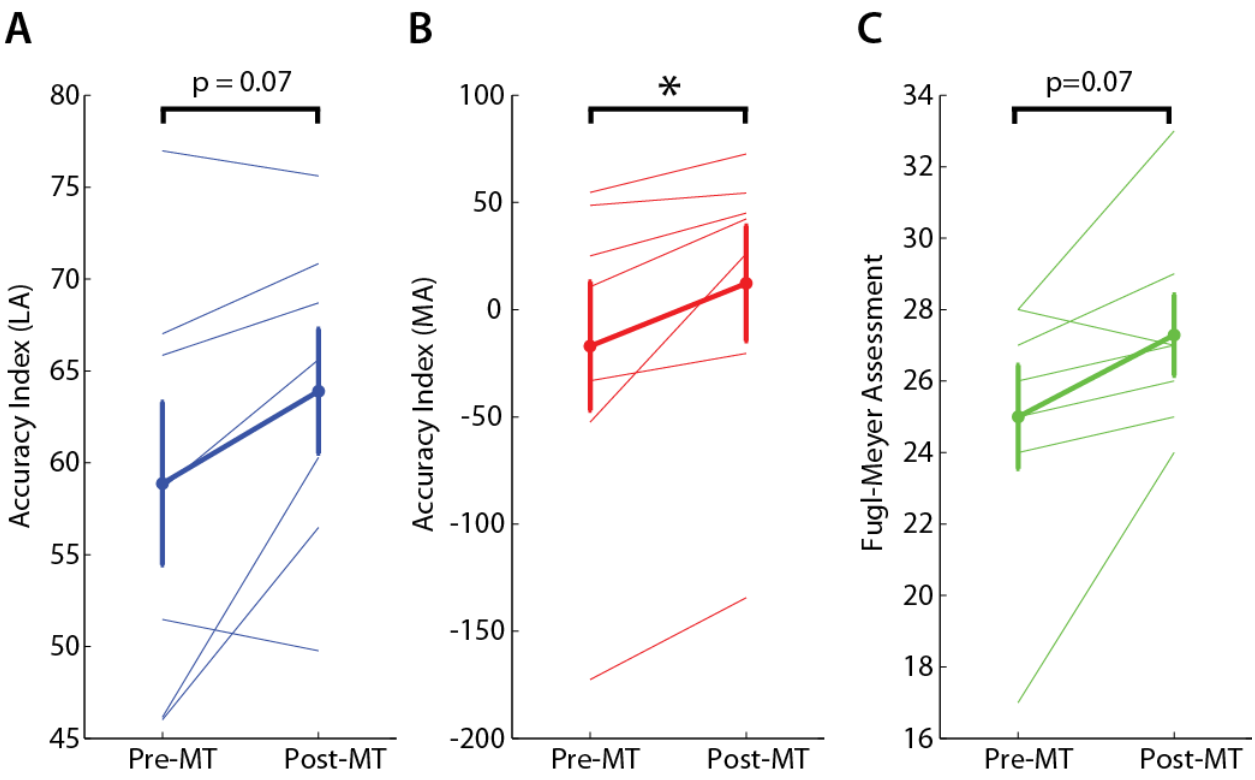
Mirror Therapy (MT) Experimental Paradigm: Orange blocks indicate sessions that were performed in the laboratory. During these sessions, we tested each participant's accuracy index (AI), preferred and fastest walking speeds, and lower limb Fugl-Meyer assessment. Teal blocks show MT practice sessions that were performed at home. During each practice week, participants did the mirror therapy home training DVD for five days, with two 30 min sessions per day. A follow-up test was performed at one month to measure retention. Abbreviations: BL, baseline assessment; Mid, mid-treatment assessment; Post, post-treatment assessment.

Figure 4:



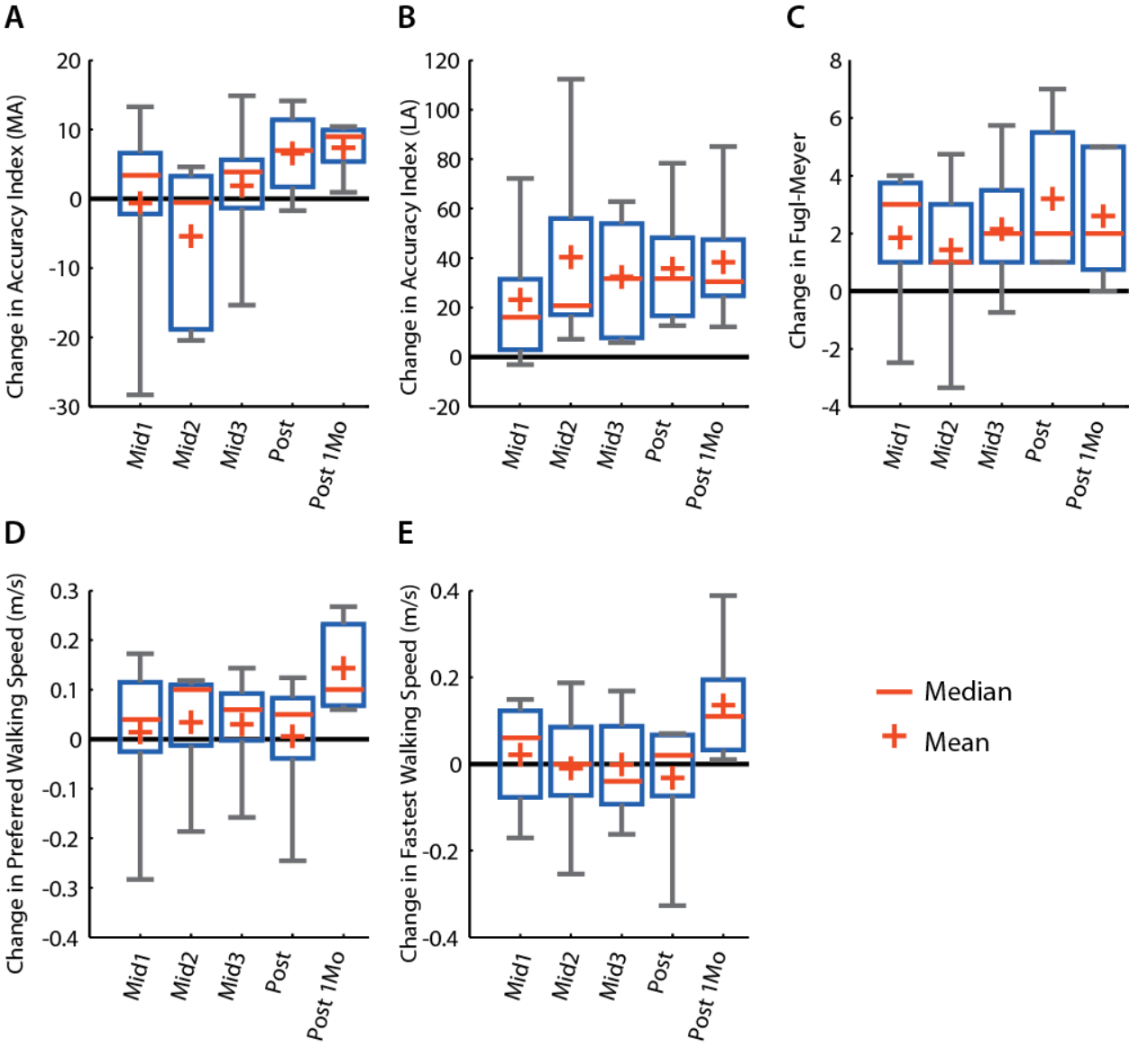
Performance in the ankle tracking task prior to MT (Pretreatment – top) and following 3 weeks of MT (Midtreatment – bottom). The red dotted line shows the position of the target and the blue line shows the potentiometer output corresponding to the participant's ankle angle. Data from the last 30s of each trial are shown.

Figure 5:



Changes in Accuracy Index and Fugl-Meyer Assessment scores before and immediately following 3-4 weeks of MT. Accuracy index is shown for the less affected (LA) and more affected (MA) leg in (A) and (B), respectively. There were significant improvements in the accuracy index on the more affected side (B), suggesting that these participants made significant gains in volitional ankle control on this side. Fugl-Meyer Assessment (C) and Accuracy Index for the less affected side (B) trended towards significance.

Figure 6:



Changes from baseline in accuracy index (A & B), Fugl-Meyer Assessment scores (C), preferred walking speed (D) and fastest walking speed (E) during mirror therapy training. Values from the second baseline test (BL2) were subtracted from all subsequent values to quantify change. Therefore, performance at BL2 is equivalent to zero. Positive values indicate improvement. Mean and medians are shown in red; blue boxes indicate the 25th – 75th percentiles and whiskers (grey lines) show the range of all the data. Abbreviations along x-axis are defined in Figure 3. MA: more affected leg; LA: less affected leg.

18. Extent of Clinical Activities Initiated and Completed. Items 18(A) and 18(B) should be completed for all research projects. If the project was restricted to secondary analysis of clinical data or data analysis of clinical research, then responses to 18(A) and 18(B) should be "No."

18(A) Did you initiate a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

___X___Yes
_____No

18(B) Did you complete a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

___X___Yes
_____No

If "Yes" to either 18(A) or 18(B), items 18(C) – (F) must also be completed. (Do NOT complete 18(C-F) if 18(A) and 18(B) are both "No.")

18(C) How many hospital and health care professionals were involved in the research project?

__1____Number of hospital and health care professionals involved in the research project

18(D) How many subjects were included in the study compared to targeted goals?

___8___Number of subjects originally targeted to be included in the study
___11___Number of subjects enrolled in the study

Note: Studies that fall dramatically short on recruitment are encouraged to provide the details of their recruitment efforts in Item 17, Progress in Achieving Research Goals, Objectives and Aims. For example, the number of eligible subjects approached, the number that refused to participate and the reasons for refusal. Without this information it is difficult to discern whether eligibility criteria were too restrictive or the study simply did not appeal to subjects.

18(E) How many subjects were enrolled in the study by gender, ethnicity and race?

Gender:
___9___Males
___2___Females
___0___Unknown

Ethnicity:
____0__Latinos or Hispanics
____0__Not Latinos or Hispanics
___11___Unknown

Race:
____0__American Indian or Alaska Native

____1__Asian
____7__Blacks or African American
____0__Native Hawaiian or Other Pacific Islander
____1__White
____0__Other, specify:_____
____2__Unknown

18(F) Where was the research study conducted? (List the county where the research study was conducted. If the treatment, prevention and diagnostic tests were offered in more than one county, list all of the counties where the research study was conducted.)
Montgomery County

19. Human Embryonic Stem Cell Research. Item 19(A) should be completed for all research projects. If the research project involved human embryonic stem cells, items 19(B) and 19(C) must also be completed.

19(A) Did this project involve, in any capacity, human embryonic stem cells?
_____Yes
___X___ No

19(B) Were these stem cell lines NIH-approved lines that were derived outside of Pennsylvania?
_____Yes
_____ No

19(C) Please describe how this project involved human embryonic stem cells:

20. Articles Submitted to Peer-Reviewed Publications.

20(A) Identify all publications that resulted from the research performed during the funding period and that have been submitted to peer-reviewed publications. Do not list journal abstracts or presentations at professional meetings; abstract and meeting presentations should be listed at the end of item 17. **Include only those publications that acknowledge the Pennsylvania Department of Health as a funding source** (as required in the grant agreement). List the title of the journal article, the authors, the name of the peer-reviewed publication, the month and year when it was submitted, and the status of publication (submitted for publication, accepted for publication or published.). Submit an electronic copy of each publication or paper submitted for publication, listed in the table, in a PDF version 5.0.5 (or greater) format, 1,200 dpi. Filenames for each publication should include the number of the research project, the last name of the PI, and an abbreviated title of the publication. For example, if you submit two publications for Smith (PI for Project 01), one publication for Zhang (PI for Project 03), and one publication for Bates (PI for Project 04), the filenames would be:

Project 01 – Smith – Three cases of isolated
Project 01 – Smith – Investigation of NEB1 deletions
Project 03 – Zhang – Molecular profiling of aromatase
Project 04 – Bates – Neonatal intensive care

If the publication is not available electronically, provide 5 paper copies of the publication.

Note: The grant agreement requires that recipients acknowledge the Pennsylvania Department of Health funding in all publications. Please ensure that all publications listed acknowledge the Department of Health funding. If a publication does not acknowledge the funding from the Commonwealth, do not list the publication.

Title of Journal Article:	Authors:	Name of Peer-reviewed Publication:	Month and Year Submitted:	Publication Status (check appropriate box below):
1.				☐Submitted ☐Accepted ☐Published
2.				☐Submitted ☐Accepted ☐Published
3.				☐Submitted ☐Accepted ☐Published

20(B) Based on this project, are you planning to submit articles to peer-reviewed publications in the future?

Yes_____ No___X_____

If yes, please describe your plans:

21. Changes in Outcome, Impact and Effectiveness Attributable to the Research Project. Describe the outcome, impact, and effectiveness of the research project by summarizing its impact on the incidence of disease, death from disease, stage of disease at time of diagnosis, or other relevant measures of outcome, impact or effectiveness of the research project. If there were no changes, insert "None"; do not use "Not applicable." Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

None

22. Major Discoveries, New Drugs, and New Approaches for Prevention Diagnosis and Treatment. Describe major discoveries, new drugs, and new approaches for prevention, diagnosis and treatment that are attributable to the completed research project. If there were no major discoveries, drugs or approaches, insert "None"; do not use "Not applicable." Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

We have identified a promising home-based treatment that may help improve hemiparetic ankle control and walking speed in people with stroke. The data are preliminary at this time, but we hope that these data will support a larger-scale randomized control trial which will provide more definitive information about efficacy of mirror therapy treatment.

23. Inventions, Patents and Commercial Development Opportunities.

23(A) Were any inventions, which may be patentable or otherwise protectable under Title 35 of the United States Code, conceived or first actually reduced to practice in the performance of work under this health research grant? Yes_____ No ___X___

If "Yes" to 23(A), complete items a – g below for each invention. (Do NOT complete items a - g if 23(A) is "No.")

a. Title of Invention:

b. Name of Inventor(s):

c. Technical Description of Invention (describe nature, purpose, operation and physical, chemical, biological or electrical characteristics of the invention):

d. Was a patent filed for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?
Yes_____ No___

If yes, indicate date patent was filed:

e. Was a patent issued for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?
Yes_____ No___
If yes, indicate number of patent, title and date issued:
Patent number:
Title of patent:
Date issued:

f. Were any licenses granted for the patent obtained as a result of work performed under this health research grant? Yes_____ No___

If yes, how many licenses were granted?_____

g. Were any commercial development activities taken to develop the invention into a commercial product or service for manufacture or sale? Yes_ No___

If yes, describe the commercial development activities:

23(B) Based on the results of this project, are you planning to file for any licenses or patents, or undertake any commercial development opportunities in the future?

Yes_____ No___X_____

If yes, please describe your plans:

24. Key Investigator Qualifications. Briefly describe the education, research interests and experience and professional commitments of the Principal Investigator and all other key investigators. In place of narrative you may insert the NIH biosketch form here; however, please limit each biosketch to 1-2 pages. *For Nonformula grants only – include information for only those key investigators whose biosketches were not included in the original grant application.*

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

NAME	POSITION TITLE
Vasudevan, Erin Virginia Lamont	Assistant Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	MM/YY	FIELD OF STUDY
University of Alberta, Edmonton, Canada	B.Sc. (Honors)	04/01	Physiology
University of Alberta, Edmonton, Canada	Ph.D.	08/07	Neuroscience
Johns Hopkins School of Medicine and Kennedy Krieger Institute, Baltimore, MD	Postdoctoral	07/10	Motor Learning and Rehabilitation

Positions and Employment

2002-2003 Instructor, Dept. of Physical Education, University of Alberta (Edmonton, Canada)

2006 Instructor, School of Physical Education, University of Victoria (Victoria, Canada)

2010-2014 Institute Scientist, Motor Learning Laboratory, Moss Rehabilitation Research Institute, Albert Einstein Healthcare Network (Elkins Park, PA)

2014-present Assistant Professor, Physical Therapy, School of Health Technology and Management, SUNY Stony Brook University (Stony Brook, NY)

Other Experience

2009-2010 President, Johns Hopkins School of Medicine Postdoctoral Association (Baltimore, MD)

2009-2010 Founding Member and VP Communications, Association for Women in Science Greater Baltimore Chapter (Baltimore, MD)

2009 Invited Participant, NIH Workshop: Promoting Generalization in Stroke Rehabilitation (Bethesda, MD)

2012 Grant Reviewer, Innovational Research Incentives Scheme, Netherlands Organisation for Scientific Research (NWO).

2013 Invited Speaker, Forum for Indian Neurological Education: Workshop on gait and posture disorders. Mumbai, India

2013 Local Organizing Committee, International Conference on Virtual Rehabilitation. Philadelphia, PA

2014 Grant Reviewer, MFSR Study Section (Temporary Member), NIH

Selected Publications (out of 17 total)

1. Yang JF, **Lamont EV**, Pang MYC (2005). Split-belt treadmill stepping in human infants reveals organizational principles of the pattern generator for walking. *Journal of Neuroscience* 25; 6869-6876.
2. **Lamont EV**, Zehr EP (2006). Task-specific modulation of cutaneous reflexes expressed at functionally relevant gait cycle phases during level and incline walking and stair climbing. *Experimental Brain Research* 173:185-92.

3. **Lamont EV**, Zehr EP (2007). Earth-referenced hand rail contact facilitates interlimb cutaneous reflexes during locomotion. *Journal of Neurophysiology* 98: 433-442.
4. **Vasudevan EV**, Bastian AJ (2010). Split-belt treadmill adaptation shows different functional networks for fast and slow walking. *Journal of Neurophysiology* 103: 183-91. PMC2807217
5. **Vasudevan EV**, Torres-Oviedo G, Morton SM, Yang JF, Bastian AJ (2011). Younger is not always better: development of locomotor adaptation from childhood to adulthood. *Journal of Neuroscience* 31: 3055-65. PMC3084584
6. **Vasudevan EV**, Zehr EP (2011). Multi-frequency arm cycling reveals bilateral locomotor coupling to increase movement symmetry. *Experimental Brain Research* 211: 299-312.
7. Malone LA, **Vasudevan EV**, Bastian AJ (2011). Motor Adaptation Training for Faster Relearning. *Journal of Neuroscience* 31: 15136-15143. PMC3209529
8. Handzic I, Barno EM, **Vasudevan EV**, Reed KB (2011). Design and pilot study of a gait enhancing mobile shoe. *Paladyn Journal of Behavioral Robotics* 2: 192-201.
9. **Vasudevan EV** (2014). One step backwards, two steps ahead: Amplifying movement errors to improve walking post-stroke. *Clinical Neurophysiology.* 125: 869-71.
10. **Vasudevan EV**, Glass RN, Packel AT (2014). Effects of traumatic brain injury on locomotor adaptation. *Journal of Neurologic Physical Therapy* 38: 172-82.

Research Support

Ongoing Research Support

American Heart Association
National Scientist Development Grant PI: Vasudevan 07/01/12-06/30/16
Optimizing Locomotor Adaptation for Rehabilitation Post-Stroke
The projects in this grant will test several methods which we hypothesize will improve the retention and generalization of learned gait patterns in people who have had a stroke.

Completed Research Support

Pennsylvania Dept of Health PI: Vasudevan 01/01/13-06/30/14
Home Based Mirror Therapy for Lower-Limb Rehabilitation Post-Stroke
The purpose of this study is to investigate whether a home-based form of Mirror Therapy is an effective treatment for lower limb hemiparesis.

Albert Einstein Society Research Award PI: Vasudevan 07/01/11-06/30/12
Development of a Curved-Bottom Shoe for Gait Rehabilitation
This project will develop and test a device – a curved-bottom shoe – that we hypothesize will change interlimb coordination while walking over ground.

NIH R21 HD0662200 PI: Reed 09/13/10-08/31/12
Gait Enhancing Mobile Shoe for Rehabilitation
The objective of this research is to design, evaluate, and optimize a passive mechanical shoe capable of long-term correction of asymmetric walking patterns (e.g. hemiparetic gait) due to stroke.
Role: Co-Investigator

F32 NS063542 PI: Vasudevan 08/15/08-07/15/10
Optimizing Locomotor Adaptation
Individual Postdoctoral Fellowship: The goal of this project was to test new ways to facilitate the transfer of a learned locomotor pattern to everyday walking activities.