DESCRIPTION OF STUDY:

**Research design:** LEAPS was a phase-III, single-blinded, multi-site (5 sites), randomized controlled rehabilitation trial that has prospectively followed 408 persons with stroke from 5-30 days to 1-year. Participants were stratified by moderate (0.4-<0.8m/s) or severe (<0.4m/s) walking impairment two months post-stroke and randomly assigned to one of three groups.

**Primary outcome:** The purpose of the LEAPS phase-III, single-blinded, randomized controlled trial is to compare two different individualized, therapeutic exercise programs provided by a physical therapist to improve walking after stroke: 1) a specialized locomotor training program (LTP) that included stepping on a treadmill with partial body weight support and overground training; and 2) progressive strength and balance exercises provided by a physical therapist in the patient's home (HEP).

**Secondary outcomes:** To determine if the timing of LTP delivery and severity of walking disability at stroke onset would affect walking speed at 1 year.

The trial was specifically designed to answer 3 clinical questions concerning physical therapy interventions for walking recovery after stroke:

1. At the end of 1 year post-stroke, is an intense, task-specific walking rehabilitation that includes a specialized locomotor training program more effective than progressive strength and balance exercises for improving walking speed and distance?
2. Does the timing (2 mos or 6 mos post-stroke) of the locomotor training program affect walking outcomes? How does severity (severe or moderate walking impairment) or timing post-stroke interact with the interventions to influence outcomes? For example, do individuals with severe stroke perform better if an intense walking rehabilitation program is provided later, at the 6 month time point, after stroke?
3. What is the optimal dose (12-, 24-, or 36-sessions) to achieve clinically meaningful changes in walking speed?
SELECTED BIBLIOGRAPHY


WALKING RECOVERY AFTER STROKE: 
MESSAGE TO CLINICIANS FROM THE LEAPS TRIAL

2012 CPTA ANNUAL CONFERENCE
Santa Clara, California
Friday, September 28, 2012 - Saturday, September 29, 2012
Katherine J Sullivan, PT, PhD, FAHA
University of Southern California

Multi-Site Phase III Randomized Trial of Physical Therapy Interventions To Improve Walking Recovery Post Stroke

Funding Acknowledgement: National Institute of Neurological Diseases and Stroke
National Center for Medical Rehabilitation Research
Trial registration: NCT00243919

Pamela W Duncan, PT, PhD, FAPTA, FAHA
Principal Investigator

Katherine J Sullivan, PT, PhD, FAHA
Co-Principal Investigator

Andrea L Behrman, PhD, FAPTA
Co-Principal Investigator
Walking Speed Predicts Function Level and Survival

- Community mobility requires walking speed > 0.8 m/s (.8m/sec =1.8 mph)
- Short community walks are feasible at 0.4 - 0.8 m/s (.4m/sec=.9mph)
- Walking is limited to the home at <0.4 m/s
- Walking speed is associated with survival in older adults

Studenski S, et al. Gait Speed and Survival in Older Adults. JAMA 2011; 305(1):50-58
Defining the “black box” of rehabilitation

Whyte & Hart, 2003

Define the content and process of rehabilitation interventions:

– Population
  • Stroke severity
  • Stroke acuity (time post-stroke)
  • Demographic and comorbid factors
– Intervention (independent variable)
  • Specificity - Type of exercise intervention:
    – force, power, endurance, task-specific
  • Dose – specificity, intensity, frequency duration
– Outcomes (dependent variables)
  • Primary; secondary

LEAPS POPULATION:

**Inclusion Criteria**

- Age ≥ 18 years;
- Stroke within 45 days and living in the community at 2 months post stroke
- Residual paresis in the lower extremity;
- Ability to walk 10 feet with no more than 1-person assistance and self-selected 10 meter walking speed less than 0.8 m/s;
- Physician approval for participation
- Successfully pass an exercise tolerance test

**Exclusion Criteria**

- Dependent in ADLs prior to stroke
- Pre-existing neurological disorders
- Multiple co-morbidities that would be contraindications for exercise programs
- Inability travel to a treatment site
- Walking faster than .8m/sec
LEAPS POPULATION:

Total Screened

4,909 chart screened/
3,137 excluded

Excluded by 2 mos

1,364 excluded physical
screen

19 did not pass ETT

Randomized

Early HE
N = 126

Early LT
N = 139

Late LT
N = 143

LEAPS ACTUAL POPULATION:

Baseline demographics:

• 62±12.7 mean age
• 54.9% Male
• 22.1% Black or African American
• 83% Ischemic
• 99.5% Modified Rankin 2 – 4
• 63.8 days post-stroke at randomization

Baseline mobility:

• Mean Walking Speed
  – 0.38±0.22 m/sec
• 53.4% Severe impairment
  (< 0.4 m/sec)
• 46.6% Moderate impairment
  (0.4 - 0.8 m/sec)
LEAPS INTERVENTIONS:

2 Types of physical therapy interventions:

- **TASK-SPECIFIC**
  - Locomotor training program (LTP)

- **PROGRESSIVE EXERCISE**
  - Strength, balance exercise (TherEx)

<table>
<thead>
<tr>
<th>Type</th>
<th>Specificity</th>
<th>Intensity</th>
<th>Frequency</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>TherEx</td>
<td>Strength exercises</td>
<td>• Progression: repetitions, activity, balance challenge, resistance</td>
<td>1.5 hrs session</td>
<td>12 wks</td>
</tr>
<tr>
<td></td>
<td>Balance exercises</td>
<td>• Encouragement to walk</td>
<td>3x per week</td>
<td>36 total sessions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Goal at 20-30 min at 2 mph on TM with BWS</td>
<td>1.5 hrs session</td>
<td>12 wks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Endurance, speed, BWS, independence, adaptability</td>
<td>3x per week</td>
<td>36 total sessions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Followed by walking practice off the treadmill</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 intervention provided at early (2 mos) or later (6 mos) post-stroke onset.
LEAPS OUTCOMES:

Define the content and process of rehabilitation interventions:

– Outcomes (dependent variables)
  • Primary - RCT test of superiority at 1 year post-stroke
  • Secondary – What do clinicians want to know?
Body-Weight–Supported Treadmill Rehabilitation after Stroke

Abstract

Locomotor training, including the use of body-weight support in treadmill stepping, is a physical therapy intervention used to improve recovery of the ability to walk after stroke. The effectiveness and appropriate timing of this intervention have not been established.

Conclusions

Locomotor training, including the use of body-weight support in stepping on a treadmill, was not shown to be superior to progressive exercise at home managed by a physical therapist. (Funded by the National Institute of Neurological Disorders and Stroke and the National Center for Medical Rehabilitation Research; LEAPS ClinicalTrials.gov number, NCT00243919.)

Figure 1. Timing of Locomotor Training and Changes in Walking Speed 1 Year after Stroke.

Screening (Set 1) was performed at a mean (±SD) of 26.0±11.6 days after stroke. Randomization was performed at baseline. 2 months after stroke. I, control group; HE, home exercise; LT, locomotor training; and PT, physical therapy. Assessments at weeks 12, 24, and 36 respectively.
Walking speed trajectory by intervention group and severity at screening, 2-(baseline), 6-, and 12-months post-stroke*

* Screening at 26.0±11.6 days post-stroke. 2-month baseline = point of randomization. The bars indicate 95% confidence interval.

6-mo outcomes

Proportion change  Gait speed change
Preplanned Secondary Analysis of 6 Month Outcomes

Late-LTP (usual care) experienced approximately **HALF** the improvement of early intervention groups

<table>
<thead>
<tr>
<th>Item</th>
<th>LTP (n=139)</th>
<th>HEP (n=126)</th>
<th>UC (n=143)</th>
<th>Overall p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfortable Walking Speed (m/sec)</td>
<td>0.25±0.21</td>
<td>0.23±0.20</td>
<td>0.13±0.14</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>6 minute Walking Distance (m)</td>
<td>81.8±62.8</td>
<td>75.9±69.3</td>
<td>41.0±47.4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Step Activity Monitor (SAM) – Median of average number steps/day [25th - 75th percentile]</td>
<td>1017 [-102, 2209]</td>
<td>1357 [84, 3382]</td>
<td>566 [-362, 2043]</td>
<td>0.0367</td>
</tr>
<tr>
<td>Stroke Impact Scale (SIS) Participation (range = 0-100)</td>
<td>11.8±26.7</td>
<td>14.6±22.9</td>
<td>7.7±20.5</td>
<td>0.0384</td>
</tr>
<tr>
<td>SIS ADL/IADL (range = 0-100)</td>
<td>9.8±17.2</td>
<td>13.0±16.9</td>
<td>7.0±17.8</td>
<td>0.0516</td>
</tr>
<tr>
<td>SIS Mobility (range = 0-100)</td>
<td>15.3±21.4</td>
<td>14.9±20.0</td>
<td>7.0±15.7</td>
<td>0.0006</td>
</tr>
<tr>
<td>Fugl-Meyer LE Score (range = 0-34)</td>
<td>2.2±3.4</td>
<td>2.4±4.1</td>
<td>1.3±3.3</td>
<td>0.1196</td>
</tr>
<tr>
<td>Berg Score (range = 0-56)</td>
<td>8.8±8.1</td>
<td>7.9±8.5</td>
<td>5.3±7.0</td>
<td>0.0018</td>
</tr>
<tr>
<td>Activities Specific Balance Confidence Score (range=0-100)</td>
<td>13.8±20.8</td>
<td>15.6±19.4</td>
<td>6.2±20.2</td>
<td>0.0013</td>
</tr>
</tbody>
</table>

What comprises usual care visits in 2-6 mos post-stroke for patients with moderate to severe walking disability?

**For 408 total:**

Median number of PT visits = 10.5

[0 to 70 visits]

Mean 14±14
Relationship Between Number of UC (n=143) PT Visits and Change in Gait Speed

Logistic regression adjusting for age and baseline walking speed:

- positive association between gait speed change and number of PT visits \( (p = 0.049) \)

- Association was not modified by baseline severity \( (p = 0.79) \).

Usual Care is Highly Variable

- 18% received no physical therapy after 2 months post-stroke
- Median number of visits - 11 (0 to 70 visits)
- Approximately 60 minutes per therapy session
- Older participants received fewer therapy sessions
“UNWARRANTED VARIABILITY”

WHAT CONTRIBUTES TO VARIABILITY IN PT INTERVENTION EFFECTIVENESS?

Define the content and process of rehabilitation interventions:

– Population
  • Stroke severity
  • Stroke acuity (time post-stroke)
  • Demographic and comorbid factors

– Intervention (independent variable)
  • Specificity - Type of exercise intervention:
    – force, power, endurance, task-specific
  • Dose – specificity, intensity, frequency duration

– Outcomes (dependent variables)
  • Primary; secondary

Defining the “black box” of rehabilitation

Whyte & Hart, 2003
LEAPS INTERVENTION FACTORS

• Hypothesis-driven
  – Based upon the mechanisms of the hypothesized treatment effect
• Defines the “active ingredient”
• Defines the dose response
  – Frequency, intensity, duration
• Defines the content of the experimental treatment compared to the comparison treatment
• Defines procedures to ensure adherence to treatment protocol
  – Standardization of therapists & blinded assessors
  – Maintaining competence across the trial
  – Defining protocol and progression

PROGRESSIVE, STRUCTURED INTERVENTIONS:
TherEx and LT are effective and superior than UC:

• Therapeutic exercise programs:

Module 9. Mobility and the Lower Extremity.
PROGRESSIVE, STRUCTURED INTERVENTIONS:
TherEx and LT are effective and superior than UC:

- Task-specific walking programs:

**Conclusions Regarding Task-Specific training**

- There is conflicting (Level 4) evidence that treadmill training without body weight support is superior to conventional therapy. However, when treadmill training was combined with other gait specific activities, improvement in gait was noted.

- There is strong (Level 1a) evidence that task-specific gait training techniques can be used to improve gait post stroke.

**EVIDENCE ON USUAL CARE:**

**USUAL CARE VARIABILITY FACTORS:**

- **Population**
  - Stroke severity
  - Stroke acuity (time post-stroke)
  - Demographic and comorbid factors
  - Intervention (independent variable)

- **Type of exercise intervention:**
  - Resistive, power, endurance, task-specific
  - Dose

<table>
<thead>
<tr>
<th>EXERCISE</th>
<th>TYPE</th>
<th>INTENSITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FUNCTIONAL TRAINING</strong></td>
<td>Task-specific</td>
<td>Number of repetitions of practice</td>
</tr>
<tr>
<td><strong>CIRCUIT TRAINING</strong></td>
<td>Strength or power</td>
<td>Level of resistance by repetition</td>
</tr>
</tbody>
</table>

EVIDENCE ON USUAL CARE:

USUAL CARE VARIABILITY FACTORS:

Population
- Stroke severity
- Stroke acuity (time post-stroke)
- Demographic and comorbid factors
- Intervention (independent variable)

Type of exercise intervention:
- Resistive, power, endurance, task-specific
- Dose

USUAL CARE:

DO PEOPLE WITH STROKE GET THE PHYSICAL THERAPY THEY NEED TO RECOVER TO A CLINICALLY IMPORTANT LEVEL OF FUNCTION?

EXERCISE TYPE INTENSITY

- Number of repetitions
- Level of resistance
- Number of repetitions


PART II:

What does the LEAPS secondary analyses tell physical therapists about patient- and family-centered care?
What do physical therapists need to know about walking recovery after stroke?

1. TYPE:
   - At the end of 1 year post-stroke, is an intense, task-specific walking rehabilitation that includes a specialized locomotor training program more effective than progressive strength and balance exercises for improving walking speed and distance?

2. TIMING:
   - Are walking outcomes at 1 year different if the walking training occurs early (2 mos) or later (6 mos) after stroke?

3. SEVERITY:
   - Do individuals with severe stroke perform better if an intense walking rehabilitation program is provided early or later, at the 6 month time point, after stroke?

4. DOSE:
   - What is the optimal dose (12-, 24-, or 36-sessions) to achieve clinically meaningful changes in walking speed?

LEAPS POPULATION:

Clinical relevance – What is response to type, timing, & dose?

359 completed full dose

HE 113
- Severe 55
- Moderate 58

LT (2 mo) 121
- Severe 65
- Moderate 56

LT (6 mo) 125
- Severe 63
- Moderate 62
How much change in gait speed is needed to be clinically important?

**Reference value – How much is enough?**

- **Minimal Clinically Important Difference (MCID):**
  - Minimal change needed to detect a beneficial effect
  - MCID: ≥ 0.16 ms change gait speed
  - Likelihood of decrease in disability level (MRS)
    - 74% sensitivity; 57% specificity

[Reference: Tilson, Sullivan, Cen et al. 2010]

**Context-dependent:**

**Patient-Family perspective**

- Improvement in ability; decrease burden on caregiver:
  - “It is less difficult to do activities at home.”
    (Stroke Impact Scale)

**Clinician perspective**

- Clinical target to gauge intervention effectiveness:
  - “Our goal is for you to be able to walk 10 meters in 21 secs compared to the 33 sec it took you today.”
    (Gait Speed from .30 m/s to .46 m/s; household to limited-community ambulator)

**Clinician scientist perspective**

- Clinical not statistical significance of group differences:
  - “What is the magnitude of change needed to be clinically important?”
    (Achievement of sustainable, meaningful change vs superiority test)
Type (HE, LT) x Severity (severe, mod) x Time (pre, post, 1 yr FU)

SEVERITY IS SIGNIFICANT FACTOR (3-way, p = 0.05)
Both progressive exercise and LT resulted in clinically important walking improvements by 6-mos.
Gains made with early PT intervention were maintained at 1 year.
LT more effective for participants with stroke baseline speed of 0.04 -0.08 ms.

MCID gait speed 0.16 ms

Timing (2 mos, 6 mos) x Severity (severe, mod) x Time (pre, post, 1 yr FU)

SEVERITY IS SIGNIFICANT FACTOR (3-way, p = 0.03)
Early LT decreased walking disability at 6 mos not realized by usual care.
LT provided later was effective; achieved improved walking ability level comparable to early group.
LT provided at 2 mos is superior for participants with stroke baseline speed of 0.04 -0.08 ms; increase ability earlier in recovery year.
Dose effects:
(HE, LT) x Severity (severe, mod) x Sessions (post-12, -24, -36)

For severe walking impairment (<0.40 ms), both HE and LT resulted in MCID in 24-36 sessions.
For moderate walking impairment (0.04-0.08 ms), LT superior to HE; MCID exceeded by 24 sessions.

Dose effects:
Timing (2-, 6-mo) x Severity (severe, mod) x Sessions (post-12, -24, -36)

For severe walking impairment (<0.40 ms), early LT resulted in MCID in 24-36 sessions; NOTE: not achieved with delayed LT.
For moderate walking impairment (0.04-0.08 ms), early LT superior to later LT; MCID exceeded by 24 sessions for early LT.
What do physical therapists need to know about walking recovery after stroke?

**TYPE:**
- At the end of 1 year post-stroke, is an intense, task-specific walking rehabilitation that includes a specialized locomotor training program more effective than progressive strength and balance exercises for improving walking speed and distance?

**INTRODUCTION TYPE:**
- Both progressive strength and balance exercises and specialized LT using treadmill with BWS at 2-6 mos post-stroke were equally effective at 1-year.
- Magnitude of improvement for LT was superior for walking impairment 0.40 – 0.80
- Both were more effective than usual & customary care.
- Functional ability occurred sooner at 6-mos; compared to later was in the 1st year post-stroke.

**WHY?**
- Therapeutic exercise addresses sensorimotor *impairment.*
- Task-specific training and overground training addresses *walking-activity restriction.*
What do physical therapists need to know about walking recovery after stroke?

TIMING:
- Are walking outcomes at 1 year different if the walking training occurs early (2 mos) or later (6 mos) after stroke?

TIMING EFFECT -
- Timing matters.
  - Physical therapy interventions that are progressive and standardize results in decrease level of disability (MCID associated with change in Rankin disability score)
  - LTP provided later was also effective.

HOWEVER -
- Usual & customary care not as effective as structured physical therapy programs of adequate dose.
  - Why?
    - Variability in PT practice.
    - High variability in treatments provided; up to 30% of groups received NO PT visits.

SIGNIFICANCE: Recovery potential extends throughout 1-yr regardless of severity
What do physical therapists need to know about walking recovery after stroke?

SEVERITY:
- Do individuals with severe stroke perform better if an intense walking rehabilitation program is provided early or later, at the 6 month time point, after stroke?

Severity matters.
- People with more severe walking impairment (<0.04 ms) improve from household to limited-community ambulator.
- Experience higher number of injurious falls.

Severity and LT interact:
- People with moderate walking impairment (0.40 - 0.80) responded best to LTP early or later.
- Functional walking improved from limited-community to unlimited community ambulator.

Significance:
- People with high severity should receive a program that builds strength and balance capacity prior to starting a high intensity locomotor training program.
What do physical therapists need to know about walking recovery after stroke?

**DOSE:**
- What is the optimal dose (12-, 24-, or 36-sessions) to achieve clinically meaningful changes in walking speed?

Severity affects dose-response.

For intervention provided early at 2-6 mos, more severely involved participants required 36 sessions to achieve MCID.

**Dose, moderate severity, and treatment type interact:**
- People with moderate walking impairment who receive LTP at 2-mos made clinically meaningful gains by 24 sessions and sustained these gains at 1-yr

**Significance:**
- Interventions should be selected based on impairment severity; all stroke survivors with walking impairment ≤ 0.80 ms should receive at least 24 – 36 sessions of physical therapy.
HOPE AFTER STROKE

POTENTIAL FOR RECOVERY AFTER STROKE:

• Challenge to conventional wisdom; intense task-specific programs and therapeutic exercise are both effective for different reasons
• Recovery extends through the 1st year after stroke
• LEAPS secondary analyses guides clinical practice.

32 yr old mother; after ischemic RCVA

First participant from STEPS, 2002,
Sullivan et al., 2007

HOPE AFTER STROKE

MESSAGE TO PHYSICAL THERAPISTS

• Value of structured, progressive therapeutic exercise and task-specific programs after stroke
• Do not need expensive equipment
• Do need to apply principles of exercise (specificity & intensity)
• Manage health risks both the benefits of exercise (cardiovascular) and risks of mobility (falls)
How do we translate clinical research to practice?

KNOWLEDGE-TO-ACTION FRAMEWORK

Clinical assumptions drive our clinical decisions:

Clinical question:
Do our PT interventions contribute to improvements in participation?

Effective treatments:

IMPAIRMENT-focused?

ACTIVITY-focused?
Clinical assumptions drive our clinical decisions:

Clinical assumptions: AGREE or DISAGREE?

Should clinical measurements be selected to represent the ICF categories?

Should clinical measurements be selected based on psychometric properties?
  - Reliable, valid, sensitive to change, clinically meaningful
Principles ABLEMENT & DISABLEMENT:

*MCA Stroke* – damage to primary motor areas of the cortex that affect force production

![Diagram of capacity and capability](image1)

MCA Stroke - primary motor neurons project to convergent and divergent motor neuron pools in the spinal cord

Nudo & Dancause (2007)

What do the LEAPS findings tell us as clinicians?

*Build capacity* in the impairments that affect a functional skill through therapeutic exercise.

![Diagram of capacity and capability](image2)

Principles of rehabilitation can be as “simple” or “difficult” as riding a bike.

*Build capability* in performance of skills through task-specific training.

Sullivan & Cen, PTJ Dec 2011
It takes a village to complete a multi-site RCT

Thank-you!
MAY WE NEVER FORGET OUR PROFESSIONAL RESPONSIBILITY

This presentation is dedicated to all the stroke survivors who have not seen a physical therapist but needed one.
LA County: Level I, II, III, IV Trauma Centers:

SOURCE: 2009 data from California Healthcare Atlas presented by the Office of Statewide Health Planning and Development (OSHPD)
http://gis.oshpd.ca.gov/atlas/healthcareatlas/mapframeset.aspx

LA County: Hospitals

SOURCE: 2009 data from California Healthcare Atlas presented by the Office of Statewide Health Planning and Development (OSHPD)
http://gis.oshpd.ca.gov/atlas/healthcareatlas/mapframeset.aspx