TITLE: Locomotor training: Evaluation of a standardized SCI program

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DESCRIPTION: Locomotor training (LT) is a task-specific therapy to promote recovery of sitting, standing, and walking after neurologic injury. For seven years, six rehabilitation centers have provided a standardized out-patient LT program for people with spinal cord injury (SCI) through the Reeve Foundation NeuroRecovery Network (NRN). The Network’s mission is to fast-track scientific and clinical evidence into development and delivery of standardized activity-based rehabilitation. Treatment efficacy is robustly evaluated across function, health and quality of life domains. The NRN integrates the expertise of scientists, physicians, physical and occupational therapists and administrators. This presentation will highlight recent publications of comprehensive program evaluation for LT which guide patient selection, outcomes use, and clinical decision-making. Case videos of patients with SCI, AIS A-D, will demonstrate application of LT principles to optimize recovery across three environments: 1) Retraining on the treadmill, 2) Assessment of skills over ground, and 3) Community integration. Discussion of assistive devices, appropriate assessments and strength-related prediction of outcomes will occur. Such evidence results from a multi-center approach that more rapidly informs clinical practice. Presenters will discuss ways to adapt and apply these approaches in participants’ clinics to advance program evaluation and evidence-based practice across the broader rehabilitation community.

LEARNING OBJECTIVES
Upon completion of this course, you will be able to:

1. Describe the mission of the Reeve Foundation NeuroRecovery Network relative to translation of evidence into practice, application of activity-based therapies, and program evaluation via standardized delivery models.

2. Describe the locomotor training program: patient population and eligibility, intervention, and outcome measures.

3. Describe application of locomotor training to persons with incomplete and complete spinal cord injury, patient progression and clinical decision-making.

4. Compare and contrast existing literature with new scientific evidence from evaluation of the LT program regarding balance and walking outcomes, utility of the Neuromuscular Recovery Scale, relationship between ASIA score and outcomes, longitudinal pattern of recovery, cardiovascular status of population, selection of assistive devices and assessment tools, and standardization benefits.

5. Discuss program evaluation as a means to advance knowledge and evidence to guide clinical decision-making.
6. Identify barriers to standardized program-evaluation for SCI and create solutions for a variety of clinical settings.

**Course/Session Format**

**Session Outline:**
- ~15 min: Overview of the Topic, Course Objectives, and Speakers, Introduction to the NeuroRecovery Network: Mission and Goals, Locomotor Training as an activity-based therapy and standardization
- ~10 min: Case Presentation 1 (video)
- ~20 min: Locomotor Training Program Evaluation I: Balance and Walking Outcomes, Neuromuscular Recovery Scale, relationship between ASIA and outcomes
- ~10 min: Case Presentation 2 (video)
- ~20 min: Locomotor Training Program Evaluation II: longitudinal pattern of recovery, Berg Balance, Balance and ambulation measure different recovery aspects, cardiovascular status, assistive devices
- ~10 min: Strategies and Application
- ~3 min: Program evaluation as an opportunity to advance clinical knowledge, evidence, and practice
- ~7 min: Q & A

1. Introduction – (Behrman, University of Louisville, Kentucky Spinal Cord Injury Research Center)
   - Overview of Locomotor Rehabilitation
     i. Organizational view of Locomotor Rehabilitation
        1. Continuum: Compensation to recovery (activity-based)
           (Behrman and Harkema, 2007)
        2. Impairment-focused to task-specific
        3. Endurance
     ii. Walking Training (activity-based)
        1. Scientific basis and principles
        2. Modes of delivery
           a. Manual-assisted
           b. Robotic-assisted
           c. FES-assisted
           d. Exoskeletons
     iii. Environments
        1. Treadmill-based
        2. Over ground
        3. Community Integration
   - Introduction to the NRN (Harkema et al. 2012)
     i. Mission and Goals
     ii. Organizational Structure
     iii. Program evaluation
        1. Standardization as key
a. Outcomes
   i) NRS Introduction, reliability, validity
b. Intervention

2. Progression

3. Reporting program evaluation
   a. Internal
   b. External

2. Case Presentation Video – (Kern, TIRR Memorial Hermann, NeuroRecovery Network)
   - Video presentation highlighting standardization of NRN evaluation, outcome measures
   - Introduction
   - Patient history
   - Initial Evaluation Outcome Measures
   - Focus of treatment intervention
   - Reevaluation every 20 sessions
   - Discharge and outcomes

3. Locomotor Training Program Evaluation – (Basso and Buehner, The Wexner Medical Center at The Ohio State Univ, NeuroRecovery Network)

People with motor incomplete SCI demonstrate improvement in balance and locomotion with locomotor training regardless of the severity of their initial functional deficits.

A. BALANCE: Berg AIS D demonstrates more robust changes in berg balance scores than people with AIS C injuries. (Harkema et al. 2012)
   - Upward curves indicate improvement. For AIS C, improvement occurs in multiple individuals and many of these cases show a sharp rate of change. There is a portion of people with AIS C that show little response to locomotor training and are typically those with very low scores of 7 or below. These people are usually non ambulators, can sit independently and transfer using their hands. This lower range in the berg scale may not be sensitive to postural improvement during sitting and dynamic balance while sitting.
   - For AIS D, large increases in berg balance scores occurred for the majority of participants. Many reached the maximum score of 56 as can be seen by the flat line at the top of the graph. This represents a ceiling effect and suggests that the scale does not capture the full improvement in balance for people with SCI and LT. Interestingly, there is also a small group of people with AIS D that have scores at or below 7 that show little change in scores over time. Typically this occurs in people with high tone and
spasticity. Thus, when evaluating people with an AIS D category of SCI attention should be given to whether ceiling or floor effects impact the rating of recovery.

B. BALANCE AND LOCOMOTION: improvement occurs between initial evaluation and discharge for Berg, 6 minute walk and 10 meter walk tests.

- Line of identity indicates no change from initial evaluation to discharge for Berg, 10mw and 6mw. Any scores above the line of identity means that the discharge performance was better than initial evaluation.

Fig 4. Initial versus final performance. Scatterplot of final evaluation (y-axis) against initial evaluation (x-axis) for the (A) Berg Balance Scale, (B) Six-Minute Walk Test, and (C) 10-Meter Walk Test for patients with AIS grades C (n=60) and D (n=130) enrolled in the NNR. Significant improvement from initial to final evaluation occurred for each measure (P<.001), reflected in the plot as points lying in the left upper half of the plane.
For balance and ambulation, the majority of people that performed LT demonstrated improvement by discharge and the changes were similar across the three outcome measures.

In general, people with AIS C injuries clustered at lower levels for berg and walking measures than people with AIS D BUT IMPROTANTLY there are many cases of robust improvement in AIS C that match that of people with AIS D injuries.

There is a group of people with AIS C and AIS D injuries that start as non-ambulators and go on to walk long distances, up to 300 m, and at fast, community gait speeds.

C. Neuromuscular Recovery Scale & Phases of Recovery compared to Walking Tests (Behrman et al. 2012)

D. Change in ASIA parameters with Locomotor Training (Buehner et al., 2012)

- People with motor incomplete SCI (AIS C and D injuries) demonstrated improvement in walking speed which is considered community ambulation speeds.

Community ambulation speed for SCI is much lower than previously thought – 0.4m/s as shown by van Hedel

- 9% of People that were non-ambulatory at enrollment progressed to either slow or community ambulation speeds by discharge. By discharge, 47% of the group were walking at speeds sufficient for community ambulation.
• What factors about the injury might predict who responds and how much they respond?
  i. We used information from the ASIA exam regarding leg strength, arm strength, sensation, injury classification (AIS C and D) and level of injury (tetraplegia and paraplegia) as determinants for outcome.
  ii. None of the following factors predicted balance or walking recovery measured with Berg Balance scale, 6 Minute walk and 10 meter walk.
     1. Light touch of the lower extremity
     2. Pin prick of the lower extremity
     3. Lower Extremity motor scores (LEMS)

iii. Therefore, the extent of recovery of balance, walking distance or walking speed was independent of general muscle strength and sensation in the legs. We then set out to determine if the strength of specific muscles was an important determinant of gains in walking.

iv. People with AIS C injuries showed the greatest improvement when the number of paralyzed muscles (0 or 1 on the ASIA exam) in the LE was no greater than 40-50%.

v. People with AIS D injuries showed the greatest improvement with LT as the number of muscles with near normal strength was 60+%.

vi. The specific muscles gained strength after Locomotor training. We saw that significantly more hip flexors with near normal strength after training than at initial evaluation. We also saw that less paralysis of hip flexors, and ankle dorsiflexors and plantarflexors occurred after training.

<table>
<thead>
<tr>
<th>AIS CLASSIFICATION</th>
<th>BERG</th>
<th>6 Minute Walk</th>
<th>10 Meter Walk test</th>
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<tbody>
<tr>
<td></td>
<td>AIS C</td>
<td>AIS D</td>
<td>AIS C</td>
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<tr>
<td>Light Touch LE</td>
<td>.10</td>
<td>.08</td>
<td>.02</td>
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<td>Pin Prick LE</td>
<td>.18</td>
<td>.07</td>
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<td>LEMS</td>
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<tr>
<th>INJURY LEVEL – TETRAPLEGIA vs PARAPLEGIA</th>
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<td>Tetra</td>
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<td>LEMS</td>
<td>.5*</td>
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4. Transition Care to AIS A and B – Case Presentation Video – (Wojciehowski, Kessler Institute for Rehabilitation, NeuroRecovery Network)
   - Video presentation on “Sit” changes with one specific C 5 AIS B patient enrolled at Kessler

5. Locomotor Training Program Evaluation – (Forrest and Wojciehowski, Kessler Foundation Research Center, Kessler Institute for Rehabilitation, NeuroRecovery Network)
   - Evidence from correlation paper and unique features of 6 vs 10 MW vs Berg vs MFR (Forrest et al. 2012)

i. Correlations for two walk tests and Balance

![Fig. 1 Scatterplot matrix depicting relationships among assessments of Berg Balance Scale, Modified Functional Reach, 6 Minute Walk, and 10 Meter Walk. Panels to the lower left of the diagonal are plots of the outcome measurements themselves (performance), while panels to the upper right of the diagonal depict scatterplots of evaluation-to-evaluation changes in outcome measures (change). Measurements of phase 1 patients are in red (open circles), phase 2 in green (crosses), and phase 3 in blue (diamonds).]

1. Figures show that speed, distance of walking, and standing balance were strongly related for total sample and within Phase groups.
2. These results are expected, as the tests were performed on the same day and on the same person, using the same assistive device.

3. Strong correlations among measures describe the trend between two measures and does NOT describe the recovery.

Modified Functional Reach

4. Modified Functional Reach assessment is not related or reflected in the performance on standing postural balance or walking for patients enrolled in the NRN.

5. Modified Functional Reach is a very unique and independent measure of balance recovery that does not parallel any of the other three measures in performance.

   ii. Correlation of Change in Performance: Determinants of Recovery

1. Change correlations for overall sample and within Phases groups are weak for speed, endurance and balance.

2. Recovery of these functions occur at different rates, at different times and are non-uniform and asynchronous. 6 MWT and 10MWT are not redundant.

   iii. Effect of Assistive Devices

![Figure 2. Scatterplot of differences between assessments of the 6 Minute Walk (left panel) and 10 Meter Walk (right panel) with patients' enrollment devices and current-use devices. Differences in distance/speed are on the y-axis and distance/speed with the device at enrollment on the x-axis](image)
1. Walking device affects recovery of walking capacity. For example, slower walking speeds accompanying a progression to a less restrictive ambulatory device may be falsely interpreted as less recovery.

- Discuss development of new outcomes or modifications
  - Respiratory testing
  - Timed sitting test
  - Forward reach and grasp
  - Overhead Press
  - Door pull and open

- Single case evidence from one center showing outcomes for AIS A or B
  i. Highlight different objectives for this type of injury, different outcome measures
  ii. Video on ambulation gains for T7 AIS A enrolled at Kessler
  iii. OG standing test

Refer to FIGURE in presentation.

iv. 6 minute and 10 meter walk test

v. EMG


- Options for practical integration into comprehensive rehab program
  i. Interdisciplinary collaboration, including case management and other therapies
  ii. Inpatient to outpatient continuum
  iii. Education for, and support of patient and family
  iv. Philosophical bases of using throughout daily routines - in and out of therapy

- How to implement standardized treatment within a single center
  i. Facility/space requirements
ii. Equipment needs
iii. Personnel management – staff mix, creative scheduling, training, etc.
iv. Clinical protocols, including inclusion criteria and discharge algorithms
v. Financials – billing/reimbursement, documentation, cost analysis
vi. Marketing

• How to implement standardized program evaluation within a single center
  i. Based on your standardized clinical protocols
  ii. What Outcome measures would you choose?
     1. What categories of outcome measures to collect
     2. Feasibility of performance – time requirement, training, equipment needs, documentation, etc
     3. ‘Best bang for buck’
     4. How often to incorporate into program to be effective
     5. Regular therapy philosophy on use of outcome measurement within your documentation

• Seek to establish collaborative networks
  i. Within your system; across systems; across continuum
  ii. Greater generalizability
  iii. Faster knowledge about rehab efficacy because can accrue patients more quickly

3. Program evaluation applied to other rehab strategies – (Schmidt Read)
   • Appropriate program evaluation for other rehabilitation strategies
   • Alignment between rehabilitation strategies and expected outcomes

4. Questions and Answers from the Audience – ALL

References:


