Past, Present, and Future of Neurologic Physical Therapy

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Disclosure Information

Speaker Name: Carolee Winstein

Disclosure of Relevant Financial Relationships
I have the following financial relationships to disclose:

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Disclosure of Off-Label and/or Investigative Use:
I will not discuss off-label use and/or investigational use in my presentation
Some background from someone who began her clinical career in 1973 and her research career in 1987…

- Use the STEP conferences as a framework for the Past

- July, 2016 IV STEP conference reflects the Present through four Ps: prevention, prediction, plasticity and participation

- Based on recent basic and clinical research, identify current trends in the practice of neurorehabilitation

- Imagine the Future of neurorehabilitation for children and adults with movement disorders.

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Celebrate our History

- 50 years ago in Chicago: The Northwestern University Special Therapeutic Exercise Project (NUSTEP) - 4 weeks


- Targeted for PT educators who taught adult and pediatric neurology courses.

- NUSTEP goals: “to analyze older and newer methods of therapeutic exercise and to search for ways to meet future needs of physical therapy students through reconsideration of objectives and curriculum content”

- Neurofacilitation approaches of prevailing gurus: Bobath, Brunnstrom, Knott & Voss, Rood.

- Basic science including: neurophysiology, motor development, motor learning and motor behavior.
Our textbook in PT schools, circa, 1960s-1970s

Margaret Rood—weightbearing for someone who is unable to open their hand sufficiently to weightbear will normalize abnormal tone, pg 921

Notice the angle of the bar which puts more weight on the ulnar side of the hand-stretch to the intrinsic muscles of the ulnar side facilitates shoulder stability
Plantigrade walking: postural supporting responses of the lower extremities are developed at this level.

Bipedal walking diagonally forward to the left requires that left lower extremity advance in second diagonal as the first diagonal is in use with the right lower extremity. Upper extremities are relatively inactive except for extension of right thumb and index finger.
Only paper that mentioned practice and motor learning in the entire 1200 page volume.

Needless to say, this was not considered a very important aspect of therapeutic exercise in 1967.

24 Years Later…

- Pediatric and Neurology Sections of APTA revisited the STEP conference idea.
- 1990 II STEP - 8 day conference (July 6-13th) at University of Oklahoma’s continuing education center, Norman.
- Purpose: “to bring new theory and knowledge arising from the same content areas addressed at NUSTEP to the audience of physical therapy educators who work in both academic and clinical settings.” (p. 2)
- Proceedings published by Foundation for PT in a little known compendium.
Dick Schmidt was the only non-physical therapist on the program at II STEP

Theoretical Issues in Motor Learning
[2.5 hours]
“For me, the problem for physical therapy was an organic one, for want of a better term; this was due, I suppose, to the fact that many of the patients had real, quantifiable injuries that could be “seen” quite clearly with various diagnostic procedures…To use computer terminology, physical therapy seemed to be involved with “hardware” problems…”

“Motor learning, on the other hand, has always been concerned mainly with the acquisition of new skills with practice…Thus the problem was concerned with how the motor system is organized differently after practice…To me, these issues were essentially “software” problems, analogous to understanding the programs that control the hardware’s activities, and they had little in common with the hardware problems of physical therapy.”

“Recently, I have begun to see the relationship between the fields of physical therapy and motor learning somewhat differently, joined (or perhaps led) by numerous others in both fields. The new perspective is this: In a physical therapy session, many different things happen, of course, but one of these things can be regarded as practice. That is, patients are engaged in repeated attempts to produce motor behaviors that are beyond their present capabilities, analogous to a person learning to play a trumpet, for example.” (p 49)
Fifteen Years Later….

• In 2005, Neurology and Pediatric sections organized and presented III STEP (Symposium on Translating Evidence into Practice)

• III STEP included a heightened emphasis on neuroplasticity, motor learning and motivation with a theme of linking movement science to interventions.

• III STEP was specifically aimed at translation

Significant departure from the two previous STEP conferences
1990-2000, Decade of the Brain Revolution in Neuroscience


Neural Substrates for the Effects of Rehabilitative Training on Motor Recovery After Ischemic Infarct

Randolph J. Nudo,* Birute M. Wise, Frank SíFuentes, Garrett W. Milligan

Nudo, Barbay, & Kleim, 2000

Neurorehabilitation

- Neurorehabilitation is a complex medical, cognitive, and psychological process which aims to aid recovery from a nervous system injury, and to minimize and/or compensate for any functional alterations resulting from it.

Train the brain and body

[Wikipedia page created in 2007]
III STEP Papers more accessible than II STEP

• Published in a special series in Physical Therapy (2006-2007).
• Five additional articles based on III STEP presentations as well as a perspective on the impact of the conference appeared in a special issue of the Journal of Neurologic Physical Therapy (JNPT)

Present - IV STEP

• A half-century after NUSTEP, just over a decade after III STEP, the APTA Neurology and Pediatric Sections joined to organize and host IV STEP
• “A summer institute for clinicians, educators, and researchers designed to explore new theory and research evidence related to movement science and to translate this theory and evidence into physical therapy practice for individuals of all ages with neurologic disorders.” (IV STEP 2016. Prevention, prediction, plasticity and participation. http://u.osu.edu/ivstep/ Accessed on July 23, 2015)
IV STEP Objectives

- Explore PTs’ role(s) in preventing disabling conditions among at-risk and pre-clinical populations.
- Evaluate ways to classify individuals’ movement disorders, as well as strategies to link classification with accurate predicted outcomes.
- Summarize critical periods for emergence of neuroplasticity and strategies, including dosage, timing, and technology, for maximizing experience-dependent plasticity.
- Analyze and apply emerging measures and interventions to optimize participation within the patient-centered care model.

Defining the 4 P’s within PT practice and research

- Prevention
- Prediction
- Plasticity
- Participation
PREVENTION

Actions taken to prevent the onset of disease (or disability), to stop its progress, and to minimize its consequences.

- Primary prevention (before it happens)
  - Wearing bicycle helmets can reduce risk of TBI

- Secondary prevention
  - Procedures to detect and treat pre-clinical pathological changes for control of progression to disability, e.g., screening premature infants or prescribing graded aerobic exercise for individuals at risk for stroke due to hypertension

- Tertiary prevention [bread & butter of PT practice]
  - Minimize the impact of movement disorder on individual's activity, participation and QOL, e.g., gait and step perturbation training to reduce falls in the elderly, those with PD, fall prevention training before hospital dc after stroke.

PREDICTION

Prediction of optimal response to intervention choice is fundamental to effective practice; begins with meaningful movement system diagnosis and measurement.

Prediction is also essential as it relates to primary prevention:

- Classification of movement disorders, as well as strategies to link classification with predicted outcomes.
  - Examples include the GMFCS, recently expanded and revised, now GMFCS-E&R (Palisano et al., 2008)
  - Classification of adults with movement disorders into fallers and non-fallers using Berg Balance Scale, Timed up & Go.

- American Spinal Injury Association Impairment Scale (AIS) for persons with SCI has predicted which clients with chronic SCI would most likely respond to activity-based therapy (Jones et al., 2014)

- Stroke upper limb recovery can be predicted using the Predicting Recovery Potential (PREP) algorithm in acute and subacute stroke (Stinear et al., 2012)
PLASTICITY
The capacity of cerebral neurons and neural circuits to change, structurally and functionally in response to experience

- Brain and spinal cord plasticity is critical not only for sensory function maturation during development and behavioral adaptation to the environment but also for CNS repair resulting from injury or disease.
  - Exposure to enriched environments including cognitive, sensory and motor interventions, for example, is one non-invasive approach to enhancing brain plasticity (Morgan et al., 2013)
  - Several recent systematic reviews have provided evidence to support this notion for infants at high-risk for CP and in adults the effects of aerobic exercise on brain changes post-stroke are encouraging.

PARTICIPATION
Most widely known definition is from WHO ICF framework: “involvement of people in all areas of life or the functioning of a person as a member of society. Participation restrictions are problems an individual may experience in involvement in life situations.”

- Less emphasis in rehab research on interventions to affect participation outcomes than on strategies to improve impairments that characterize individuals with movement disorders.
- One 2015 systematic review found few high-quality studies reporting favorable participation results after interventions in children with disabilities.
- The effects of a structured, community-based intervention aimed at enhancing participation in individuals within 5 years of stroke onset found a mean increase across all participants of 1.88 additional hours per week of time spent in meaningful activities. This was less than the target of 3 hours/week, but was not insignificant. (Mayo et al., 2015)
Interdependence of the four P’s

Prediction --- Participation --- Prevention

- Tests, Measures, Classifications, Responders, Appropriate time window, Biomarkers
- Barriers to participation / Soliciting patient experiences and preferences/Patient-Reported Outcomes
- Secondary Prevention, such as: preventing falls, encouraging physical activity

Plasticity

A few examples
Constraint-induced movement therapy improves upper limb activity and participation in hemiplegic cerebral palsy: a systematic review

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KEY WORDS
Constraint palsy
Systematic review
Meta-analysis
Randomized controlled trials
Constraint-induced movement therapy

ABSTRACT
Question: Does constraint-induced movement therapy improve activity and participation in children with hemiplegic cerebral palsy? Does it improve activity and participation more than the same dose of upper limb therapy without restraint? Is the effect of constraint-induced movement therapy related to the duration of intervention or the age of the children? Design: Systematic review of randomized trials with meta-analysis. Participants: Children with hemiplegic cerebral palsy with any level of motor disability. Intervention: The experimental group received constraint-induced movement therapy (defined as restraint of the non-affected upper limb during supervised activity performed with the more affected upper limb). The control group received no intervention, sham intervention, or the same dose of upper limb therapy. Outcome measures: Measures of upper limb activity and participation were used in the analysis; clinical effect of constraint-induced movement therapy was measured using the Children's Upper Extremity Motor Score (CUMS) and Motor Movement Scale (MMS). Both constraint-induced movement therapy and upper limb therapy without restraint were associated with increases in upper limb activity and participation. However, constraint-induced movement therapy was more effective than restraint and was associated with increases in upper limb activity and participation: MMS (95% CI 0.34 to 0.64), CUMS (95% CI 0.34 to 0.64) and participation (MD -0.62, 95% CI -0.34 to 0.31). The effect of constraint-induced movement therapy was not related to the duration of intervention or the age of the children. Conclusion: This review suggests that constraint-induced movement therapy is more effective than restraint, and no more effective than the same dose of upper limb therapy without restraint. Registration: PROSPERO CRD42015024403. (Chiu H-C, Ada L. (2016) Constraint-induced movement therapy improves upper limb activity and participation in hemiplegic cerebral palsy: a systematic review. Journal of Physiotherapy 62: 130-137)

Risk of stroke among patients with cerebral palsy: a population-based cohort study

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AIM The aim of the study was to investigate the risk of stroke in patients with cerebral palsy (CP), based on nationwide data in Taiwan.

METHOD This prospective cohort study was comprised of patients recorded on the Taiwan Longitudinal Health Insurance Database 2005 (LHD2005) who had a diagnosis of CP (n=1975) in records between 1 January 2004 and 31 December 2007. A comparison group (1:1) drawn from the same database was matched for age and sex (n=9475). Each patient was tracked by data until the development of stroke or the end of 2008. Cox proportional-hazards regression analysis was used to evaluate the hazard ratios after adjusting for potential confounding factors.

RESULTS Patients with CP were more likely to suffer stroke than the comparison population, after adjusting for potential confounding factors (adjusted hazard ratio: 2.17; 95% confidence interval [CI]: 1.74-2.69). The hazard ratio of stroke was 4.78 (95% CI: 3.16-7.17) and 1.57 (95% CI: 1.20-2.06) for patients with CP aged 50 years and under, and over 50 years respectively.

INTERPRETATION Cerebral palsy is a risk factor or marker for stroke that is independent of traditional stroke risk factors. Further research in this area is warranted.
Testing Prognostic Classification and Treatment Responsiveness

Effects of Unilateral Upper Limb Training in Two Distinct Prognostic Groups Early After Stroke: The EXPLICIT-Stroke Randomized Clinical Trial

Gert Kwakkel, PhD, Caroline Winters, MSc, Erwin E. H. van Wegen, PhD, Rinse H. M. Nijland, PhD, Annette A. A. van Kuik, MD, PhD, Anne Visser-Meily, MD, PhD, Jurrian de Groot, PhD, Erwin de Vlugt, PhD, J. Hans Arendzen, MD, PhD, Alexander C. H. Geurts, MD, PhD, and Carol G. M. Meskers, MD, PhD, on behalf of the EXPLICIT-Stroke Consortium

Barriers to Participation using Patient Reported Outcome Questionnaire

Barriers to Exercise in People With Parkinson Disease

Terry Ellis, Jennifer K. Boudreau, Tammara R. DeAngelis, Lisa E. Brown, James T. Cavanaugh, Gammon M. Earhart, Matthew P. Ford, K. Bo Foreman, Leland E. Oltina

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T.E. DeLisle, PT, PhD, ATC, Department of Physical Therapy, University of Utah.
Future advances will come from:

- True merging of psychological and social science with physiological science (new theoretical models; mindfulness)
- Leveraging the power of new technologies (e.g., body worn sensors)
- Big Data (e.g., PhysioNet, Connectome)
- A more patient-centered approach that includes listening to our patients (PRO)
- Global perspective--International collaborations and consensus building
Ellen Langer is a social psychologist at Harvard and is considered by many as the mother of mindfulness.


Technology, Artificial Intelligence and the Future:

- Exponential advances across myriad technological fields are conspiring to usher in an era of profound change

  TO BE HONEST, MR. JOBS, THE LAST TIME AN APPLE CAUSED SO MUCH EXCITEMENT AROUND HERE INVOLVED ADAM, EVE AND A SNAKE...

- Never underestimate an exponential. --Carl Sagan
Ray Kurzweil

The Law of Accelerating Returns

An analysis of the history of technology shows that technological change is exponential, contrary to the common-sense "intuitive linear" view.

KurzweilAI.net

Ray Kurzweil

The Law of Accelerating Returns

So we won't experience 100 years of progress in the 21st century – it will be more like 20,000 years of progress (at today's rate).

KurzweilAI.net
Evidence of AI and Technology

- Self-driving cars are not far off
- Amazon—order verification and payment; drone delivery
- Google Glass technology
- GPS systems for directions; SIRI, WAYZ integrating current conditions that affect our choices
- Exoskeletons and ‘intelligent’ fabrics like soft exosuits for assisting locomotion in the community
Validity and reliability of an IMU-based method to detect APAs prior to gait initiation

Martina Mancini, Lorenzo Chiari, Lars Holmstrom, Arash Salarian, Fay B. Horak

Journal homepage: www.elsevier.com/locate/gaitpost

Mobility Lab to Assess Balance and Gait with Synchronized Body-worn Sensors

Martina Mancini, Laurie King, Arash Salarian, Lars Holmstrom, James McNames, and Fay B Horak

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APDM Inc. Portland, OR 97201 USA
Gait dynamics of Interstride Interval

Interstride Interval Recordings for Several Diseases

- Parkinson’s Disease (PD)
- Huntington’s Disease (HD)
- Amyotrophic Lateral Sclerosis (ALS)
- Healthy Control (CO)

http://www.datavyu.org/features.html
Centralized Open-Access Rehabilitation database for Stroke (SCOAR)

Asking New Questions with Old Data: The Centralized Open-Access Rehabilitation Database for Stroke

Keith R. Lobley,1* Sydney Y. Schaefer,1†, Adam C. Raikes,1 Lars A. Boyd,1 and Catherine E. Laro2,3,4
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Background: This paper introduces a tool for streamlining data integration in rehabilitation science, the Centralized Open-Access Rehabilitation database for Stroke (SCOAR), which allows researchers to quickly visualize relationships among variables, efficiently share data, generate hypotheses, and enhance clinical trial design.

Value of Patient Reports

- Self-report can provide insight into an inner state of respondents’ behaviors, attitudes, and personal experiences such as feeling, pain, emotion, and perceived health.1
- However, the use of PRO is not widely accepted and still underused.2
- In fact, researchers and clinicians may believe more in objective outcomes than PRO.3

“While the limitation of self-report measures are clearly acknowledged, less apparent is attention to the potential limitation of their ‘objective’ counterparts leading to the assumption that objectivity results in more robust and scientifically valid measurement tools.”

References:
2Rumsfeld et al. (2013)
3Kayes and McPherson (2010)
**Problem: Non-Use Phenomenon in Stroke**

- Limited use of the paretic hand after stroke can severely constrain an individual’s daily function.

- The non-use phenomenon (sub-optimal use) describes the discrepancy between recovered motor capability and actual daily hand use.

  *Rheumatology and Rehabilitation, 1979, 18, 43*

  **STROKE RECOVERY: HE CAN BUT DOES HE?**

  By KEITH ANDREWS AND JEAN STEWART*

  University Hospital of South Manchester, Manchester M20 8LR

- The presence of the non-use phenomenon underscores the fact that motor capability, while a necessary factor, may not be the only factor influencing paretic hand use after stroke.


**What might some of those ‘other factors’ be?**

- Social-cognitive factors, which characterize an individual’s psychological needs and perceptions, play an essential role in functioning after stroke.

  - **Self-Efficacy**
    - A task-specific confidence of an individual’s capability.

  - **Affect**
    - Positive affect is a well-known factor that enhances motivation and leads to greater engagement in activities.

  - **Social Support**
    - A socially supportive environment has been associated with beneficial outcomes.

Example of using Ecological Momentary Assessment (EMA) for Rehabilitation

- **Ecological Momentary Assessment (EMA)**
  - A mobile-based prompt methodology.
  - It has been successfully used to assess:
    1. chronic pain\(^1\),
    2. physical activity level in non-disabled older adults,\(^2\)
    3. post-stroke depression symptoms.\(^3\)

- EMA allows for **simultaneous real-time** assessments of behavioral (arm use) and psychological (self-efficacy, affect, social support) variables in a natural setting.

\(^1\) Stone AA, et al., 2004
\(^2\) Dunton GF, et al., 2009.
\(^3\) Johnson EI, et al., 2009.

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Patient-reported outcome movement

- Dynamic assessment of patient-reported chronic disease outcomes

1. [NIH](http://www.nihpromis.org)
2. [PCori](http://www.pcori.org)
3. [USC Dornsife Center for Self-Report Science](https://static.usc.edu/css/mission)
Global Collaborations and Consensus Statements

Moving rehabilitation research forward: Developing consensus statements for rehabilitation and recovery research

Julie Bernhard, Karen Borschmann, Lara Boyd, S Thomas Carmichael, Dale Corbett, Steven C Cramer, Tammy Hoffmann, Gert Kwakkel, Sean L Savitz, Gustavo Saposnik, Marion Walker and Nick Ward

“Rethinking the nature and delivery of rehabilitation and restorative therapies…”

• Pre-Clinical Recovery Research—Addressing the first translational gap
• Recovery Biomarkers-Mechanisms, Therapeutic Targets and Prognosis
• Intervention: Developing, Monitoring and Reporting
• Measurement in Clinical Trials

Countdown to Singularity*

*After Kurzweil
Thank you

Los Angeles Premier of Interstellar, After Party