Innovations in Technology: Maximizing Outcomes in Neurologic Rehabilitation

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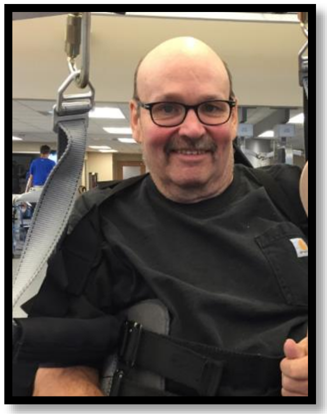
Objectives:

- Review the perspectives of key stakeholders in terms of return on investment when implementing advanced technologies in neurorehabilitation
- Review translational science literature focused on promoting recovery of walking in SCI, TBI and stroke
- Discuss the clinician's regarding deploying advanced technologies to facilitate recovery after neurologic injury
- Review case studies to evaluate maximizing outcomes after SCI and the return on investment (payor perspective)



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So What?

ROI: Lifetime Cost

Life Care Planning Projections for Individuals With Motor Incomplete Spinal Cord Injury Before and After Locomotor Training Intervention: A Case Series

Sarah A. Morrison, PT, Jamie L. Pomeranz, PhD, CRC, CLCP, Nami Yu, MHS, CRC, Mary Schmidt Read, PT, DPT, MS, Sue Ann Sisto, PT, MA, PhD, and Andrea L. Behrman, PT, PhD, FAPTA

Background/Purpose: We present a retrospective case series of 2 individuals with motor-incomplete spinal cord injury (SCI) to examine differences in lifetime cost estimates before and after participation in an intensive locomotor training (LT) program. Sections of a life care plan (LCP) were used to determine the financial implications associated with equipment, home renovations, and transportation for patients who receive LT. An LCP is a viable method of quantifying outcomes following any therapeutic intervention.

Case Description: The LCP cases analyzed were a 61-year-old woman and a $4\frac{1}{2}$-year-old boy with motor-incomplete SCI and impairments classified by the American Spinal Injury Association Impairment Scale (AIS) as AIS D and AIS C, respectively.

Interventions: Each patient received an intensive outpatient LT program 3 to 5 days per week. The 61-year-old woman received 198 sessions over 57 weeks and the $4\frac{1}{2}$-year-old boy received 76 sessions over 16 weeks.

Outcomes: The equipment, home renovation, and transportation costs of an LCP were calculated before and after LT. Prior to the implementation of LT, the 61-year-old woman had estimated lifetime costs between \$150 247.00 and \$199 654.00. Following LT, the estimated costs decreased to between \$2010.00 and \$2446.00 (a decrease of \$148 237.00 and \$197 208.00). Similarly, the 4-year-old boy had estimated lifetime costs for equipment, home renovation, and transportation between \$535 050.00 and \$771 665.00 prior to LT. However, the estimated costs decreased to between \$97 260.00 and \$200 047.00 (a decrease of \$437 790.00 and \$571 618.00) following LT.

Discussion: The lifetime financial costs associated with equipment, home renovations, and transportation following a motor-incomplete SCI were decreased following an intensive LT program for the 2 cases presented in this article. The LCP, including costs of rehabilitation and long-term medical and personal care costs, may be an effective tool to discern cost benefit of rehabilitation interventions.

Key Words: *body weight–supported treadmill, life care plan, locomotor training, motor incomplete spinal cord injury*

(*JNPT* 2012;36: 144–153)

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INTRODUCTION

Individuals who sustain spinal cord injury (SCI) experience a significant economic burden due to the immediate and long-term medical expenses associated with this injury. Significant medical and other expenses are incurred to allow the individual to return to home, school, and/or his or her preinjury community. In addition, the financial implications resulting from loss of gainful employment amplify these financial concerns. This economic burden is estimated to be \$9.7 billion annually.[1] One method of determining the lifetime medical and rehabilitative costs associated with an SCI is through the development of a life care plan (LCP).

An LCP is defined as a dynamic document based upon published standards of practice, comprehensive assessments, data analysis, and research.[2] Life care plans are often performed for litigation purposes within arenas such as personal injury and worker's compensation. The methodology is also used for case management, special needs trusts, and geriatric care management. The LCP provides an organized concise map for current and future needs with associated costs for individuals who have experienced catastrophic injury or have chronic health care issues.[2] There are 14 common topics that are covered by an LCP that encompasses a wide range of injury-related needs and services to consider. Table 1 describes each topic area and gives examples for each.

The LCP serves as a guide to ensure the provision of quality care and services throughout the lifespan of an individual with a disability. It involves a multidimensional, dynamic methodology based upon the actual needs of the individual and can serve both as a "roadmap" for case managers as an educational tool for the individual with a disability, his

Outcomes: The equipment, home renovation, and transportation costs of an LCP were calculated before and after LT. Prior to the implementation of LT, the 61-year-old woman had estimated lifetime costs between \$150 247.00 and \$199 654.00. Following LT, the estimated costs decreased to between \$2010.00 and \$2446.00 (a decrease of \$148 237.00 and \$197 208.00). Similarly, the 4-year-old boy had estimated lifetime costs for equipment, home renovation, and transportation between \$535 050.00 and \$771 665.00 prior to LT. However, the estimated costs decreased to between \$97 260.00 and \$200 047.00 (a decrease of \$437 790.00 and \$571 618.00) following LT.

Severity of Injury	Estimated Lifetime Cost if Injured at 25 yo
High Tetraplegia (C1-C4) AIS ABC	\$4,724,181
Low Tetraplegia (C5-C8) AIS ABC	\$3,451,781
Paraplegia AIS ABC	\$2,310,104
Motor functional at Any Level D	\$1,578,274

Life Care Planning Projections

- 3 case studies modeled after what was published in the literature (Morrison et al 2012)

  - Certified life care planner did not assist in developing this information
- 3 specific components of the LCP were chosen for this report
  - Equipment Needs/Transportation
  - Architectural renovation: VA guidelines
  - Personal Care

[a] According to the Veteran's Administration, an individual who sustains a loss of use of one lower extremity together with other disabilities that preclude locomotion without the aid of braces, crutches, canes, or a wheelchair qualifies for up to $50 000 in architectural renovations.

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Sherown

Age: 31
Diagnosis: C4 AIS C SCI as a result of wrestling accident.
Goals:

- Play with kids
- Independent with ADLs
- Walk Independently
- Return to work

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Discharge from Inpatient Rehabilitation

Functional Independence Measure

Task	Score	Assist
Grooming	3	Mod A
Bathing	3	Mod A
UE Dressing	3	Mod A
LB Dressing	2	Max A
Toileting	1	Total A
Bed/wheelchair	2	Max A
Toilet	2	Max A
Tub/shower	2	Max A
Walk	1	Total A
Stairs	1	Total A

Pre-Intensive Therapy

Assumptions:

- Life Expectancy: 31y + 47.5y = 78.5y

Equipment

Item	Freq of Replacement (yrs)	Cost
Hospital Bed	3-12.5 y	$2000-2700
Air Mattress	1-6 y	$250-800
Portable Lift	1-5 y	$3,000
Manual w/c	5-7 y	$2000-3500
Power w/c with tilt	5-7 y	$20,000
Shower Chair	5-7 y	$3000
w/c cushion	1-3 y	$450-550
w/c parts	1 y	$575-2000
Total		**$362,893-381,453**

Transportation

Item	Freq of Replacement (yrs)	Cost
Driving Evaluation	1 x	$1,000
Wheelchair Accessible Van	1 x	$45,000
Van maintenance & Adaptation	1y	$28,500
Total		**$74,500**

Architectural Needs

Item	Freq of Replacement (yrs)	Cost
Renovation	1 x	$50,000
Total		**$50,000**

Total: $487,393 – 505,953

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Pre-Intensive Therapy

Assumptions:

- **Ave personal care hours for motor incomplete SCI: 39.9 hours/week**
  (French et al 2007)

Personal Care

Item	Hours/week & cost/hour	Cost
Personal Care	39.9 hours/week at $13/hour	$26972.4
Total	*47.5y	$1,281,189

Totals

Equipment, Architecture, Transportation	**$487,393**	**$505,953**
Personal Care	**$1,281,189**	**$1,281,189**
Total	**$1,768,582**	**1,787,142**

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French, D. D., Campbell, R. R., Sabharwal, S., Nelson, A. L., Palacios, P. A., & Gavin-Dreschnack, D. (2007). Health care costs for patients with chronic spinal cord injury in the Veterans Health Administration. *The journal of spinal cord medicine*, *30*(5), 477-481.

Locomotor Training

Evaluation

55 min Treadmill Training BWS

30 min Community Mobility

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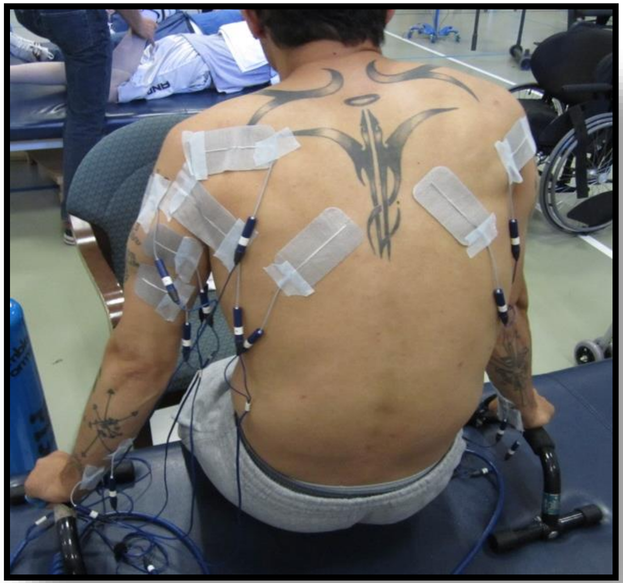
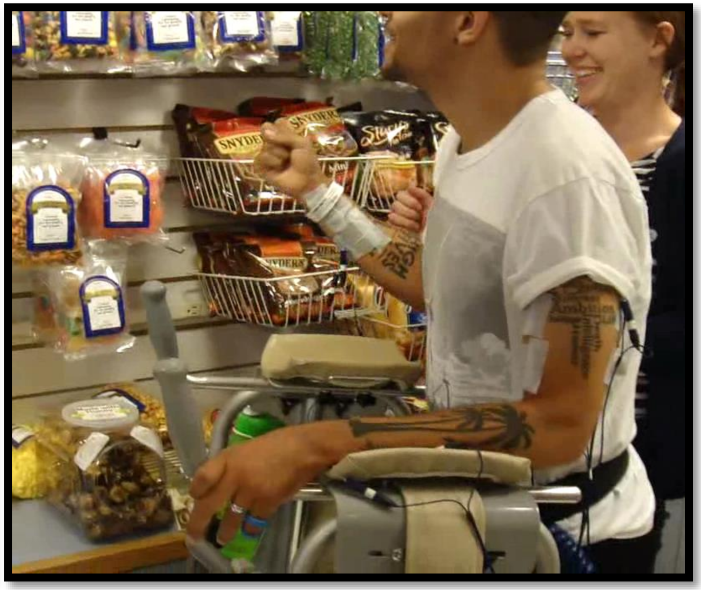
Upper Extremity Training

NMES to trunk and UEs



Task Specific Training with NMES

Community Integration



Intensive Therapy Outcomes

80 PT and OT Sessions

Functional Independence Measure

	Inpatient D/C FIM	FIM D/C NRN	Assist Level
Grooming	3	6	Modified Indep
Bathing	3	3	Mod A
UE Dressing	2	6	Modified Indep
LB Dressing	2	6	Modified Indep
Toileting	2	3	Mod A
Bed/wheelchair	1	6	Modified Indep
Toilet	1	6	Modified Indep
Tub/shower	1	5	Supervision
walk	1	6	Modified Indep
Stairs	1	5	Supervision

120 PT and OT Sessions

Outcome Measure Improvement

Outcome Assessment	Initial Assessment	Discharge Assessment
10 Meter Walk Test	Non-Ambulatory	0.43 m/s
6 Minute Walk Test	Non-Ambulatory	500 ft
Berg Balance Measure	3/56	42/56
Neuromuscular Recovery Scale	1B	2C

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Post Intensive Therapy

Assumptions:

- **Life Expectancy: 31y + 47.5y = 78.5y**

Equipment

Item	Freq of Replacement (yrs)	Cost
Hospital Bed	3-12.5 y	NA
Air Mattress	1-6 y	NA
Portable Lift	1-5 y	NA
Manual w/c	5-7 y	NA
Power w/c	5-7 y	NA
Padded Bench	**5-7 y**	**$300**
W/c cushion	1-3 y	NA
w/c parts	1 y	NA
Rollator	**1y**	**$150**
Forearm Crutches	**1y**	**$130**
Total		**$13,420 - $24,072**

Transportation

Item	Freq of Replacement (yrs)	Cost
Driving Evaluation	**1 x**	**$1,000**
Wheelchair Accessible Van	1 x	NA
Van maintenance & Adaptation	1y	NA
Total		**$1,000**

Architectural Needs

Item	Freq of Replacement (yrs)	Cost
Renovation	1 x	NA
Total		**NA**

Total: $14,420 – $25,072

Post Intensive Therapy

Assumptions:

- Life Expectancy: 31y + 47.5y = 78.5y
- Ave personal care hours for bathing/toileting: 2 hours/day

Personal Care

Item	Hours/week & cost/hour	Cost
Personal Care	14 hours/week at $13/hour X 1 year	$6,760
Total	*47.5y	$449,540

Totals

Equipment, Architecture, Transportation	$13,420	$24,072
Personal Care	$449,540	$449,540
Total	$463,960	$474,612

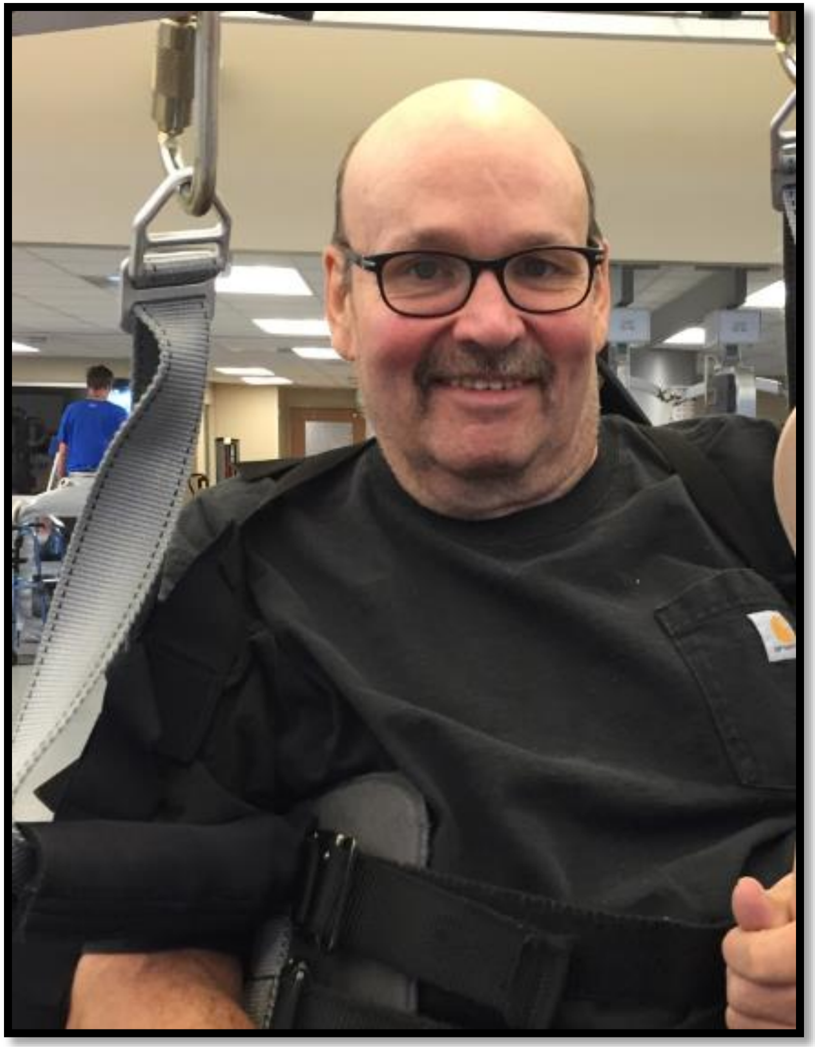
Return on Investment

	Pre Intensive Therapy	Post Intensive Therapy
Total Cost	**$1,787,142**	**$474,612**

Cost Reduction ~ $1,312,530
Outpatient Therapy Costs: $150k
Total Savings: ~$1.16 million dollars

Pete

- 54 y.o. Boilermaker, Rural Montana
- C4 AIS C: Fall in the home
- Goals
  - Return to his home vs. SNF
  - Stand up and walk independently
  - Transfer into a car
  - Use a manual WC vs. Power WC

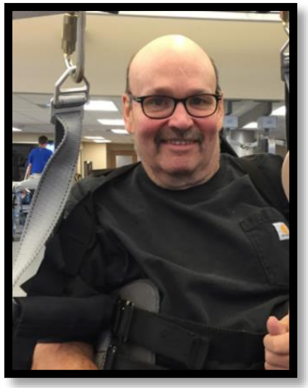


Discharge from Inpatient Rehabilitation

Functional Independence Measure

Task	Score	Assist
Grooming	6	Mod I
Bathing	2	Max A
UE Dressing	2	Max A
LB Dressing	1	Total A
Toileting	1	Total A
Bed/wheelchair	2	Max A
Toilet	2	Max A
Tub/shower	2	Max A
Walk	1	Total A
Stairs	1	Total A

Pre-Intensive Therapy



Assumptions:

- **Life Expectancy: 54y + 22.7y = 76.7**

Equipment

Item	Freq of Replacement (yrs)	Cost
Hospital Bed	3-12.5 y	$2000-2700
Air Mattress	1-6 y	$250-800
Portable Lift	1-5 y	$3,000
Manual w/c	5-7 y	$2000-3500
Power w/c with tilt	5-7 y	$23,000
Shower Chair	5-7 y	$3000
W/c cushion	1-3 y	$450-550
w/c parts	1 y	$675-2100
Total		**$179,366-206,539**

Transportation

Item	Freq of Replacement (yrs)	Cost
Driving Evaluation	1 x	$1,000
Wheelchair Accessible Van	1 x	$45,000
Van maintenance & Adaptation	1y	$28,500
Total		**$74,500**

Architectural Needs

Item	Freq of Replacement (yrs)	Cost
Renovation	1 x	$50,000
Total		**$50,000**

Total: $303,866-$331,039

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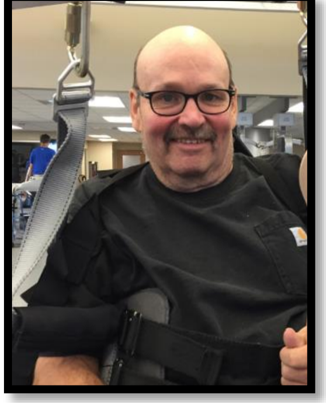
Pre-Intensive Therapy



Assumptions:

- **Ave personal care hours for motor incomplete SCI: 39.9 hours/week** (French et al 2007)

Personal Care

Item	Hours/week & cost/hour	Cost
Personal Care	39.9 hours/week at $13/hour	$26972.4
Total	*22.7	$612,273

Totals

Equipment, Architecture, Transportation	**$303,866**	**$331,039**
Personal Care	**$612,273**	**$612,273**
Total	**$916,139**	**$943,312**

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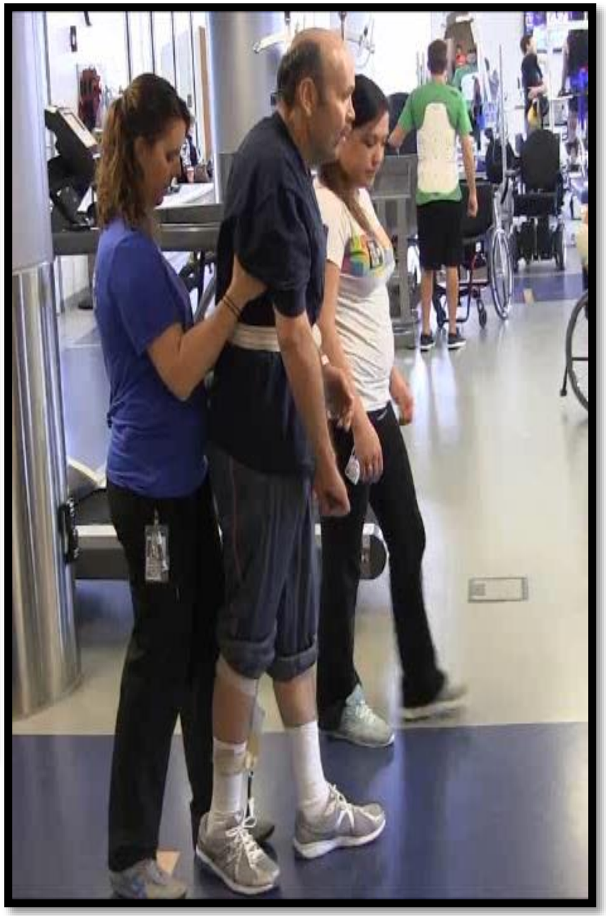
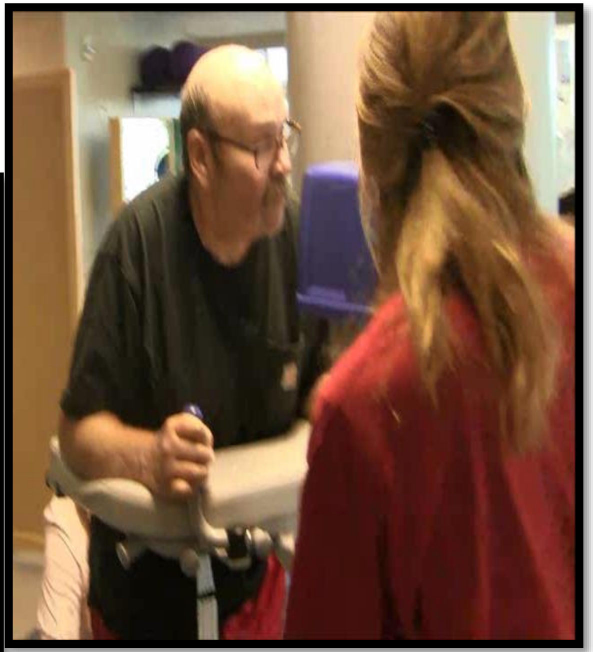
Locomotor Training Progression

Outpatient Therapy



Outpatient Therapy



Inpatient DC

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Standing Progression

Initial Eval
6/1/15

1st Re-eval (20 sessions)
7/2/15

Discharge eval (120 sessions)
12/11/15

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Discharge Outpatient Therapy

Discharge Intensive Therapy

120 PT and OT Sessions

Functional Independence Measure

	Inpatient D/C FIM	FIM D/C NRN	Assist Level
Grooming	6	6	Modified Indep
Bathing	2	4	Min A
UE Dressing	2	4	Min A
LB Dressing	1	6	Modified Indep
Toileting	1	3	Mod A
Bed/wheelchair	2	6	Modified Indep
Toilet	2	6	Modified Indep
Tub/shower	2	5	Supervision
walk	1	6	Modified Indep
Stairs	1	5	Mod A

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Outcome Measure Improvement

Outcome Assessment	Initial Assessment	Discharge Assessment
10 Meter Walk Test	Non-Ambulatory	0.61m/s
6 Minute Walk Test	Non-Ambulatory	662 feet
Berg Balance Measure	4/56	36/56
Neuromuscular Recovery Scale	1C	2C

Discharge Disposition: Home

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Post Intensive Therapy

Assumption:

- **Life Expectancy: 54y + 22.7y = 76.7y**

Equipment

Item	Freq of Replacement (yrs)	Cost
Hospital Bed	3-12.5 y	NA
Air Mattress	1-6 y	NA
Portable Lift	1-5 y	NA
Manual w/c	5-7 y	$2,000-3,500
Power w/c	5-7 y	NA
Activaid 202	**5-7 y**	**$500**
W/c cushion	1-3 y	$450-550
w/c parts	1 y	$675-2,100
Rolling Walker	**1y**	**$150**
Forearm Crutches	**1y**	**$130**
Total		**$43,402-67,442**

Transportation

Item	Freq of Replacement (yrs)	Cost
Driving Evaluation	**1 x**	**$1,000**
Wheelchair Accessible Van	1 x	NA
Van maintenance & Adaptation	1y	NA
Total		**$1,000**

Architectural Needs

Item	Freq of Replacement (yrs)	Cost
Renovation	1 x	NA
Total		**NA**

Total: $44,402-68,442

Post Intensive Therapy

Assumptions:

- **Ave personal care hours for bathing/toileting: 2 hours/day**

Personal Care

Item	Hours/week & cost/hour	Cost
Personal Care	14 hours/week at $13/hour X 1 year	$9464
Total	*22.7y	$214,832

Totals

Equipment, Architecture, Transportation	$44,402	$68,442
Personal Care	$214,832	$214,832
Total	$259,234	$283,274

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Return on Investment

	Pre Intensive Therapy	Post Intensive Therapy
Total	**$943,312**	**$283,274**
Cost Reduction: $660,038 **Outpatient Therapy Costs: $150k** **Total Savings: ~$510,038**		

****Planned skilled nursing facility discharge before Intensive outpatient therapy program**

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Rick

60 y.o. male, recently retired

C4 AIS C: Water Skiing accident

Goals:

- Walk independently
- Independent with ADL's
- Live at home independently (feed himself, empty leg bag, access water)

Discharge from Inpatient Rehabilitation

Functional Independence Measure

Task	Score	Assist
Grooming	3	Mod A
Bathing	3	Mod A
UE Dressing	2	Max A
LB Dressing	2	Max A
Toileting	2	Max A
Bed/wheelchair	1	Total A
Toilet	1	Total A
Tub/shower	1	Total A
Walk	1	Total A
Stairs	1	Total A

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Pre-Intensive Therapy

Assumptions:

- **Life Expectancy: 60y + 17.7y = 77.7**

Equipment

Item	Freq of Replacement (yrs)	Cost
Hospital Bed	3-12.5 y	$2000-2700
Air Mattress	1-6 y	$250-800
Portable Lift	1-5 y	$3,000
Manual w/c	5-7 y	$2000-3500
Power w/c with tilt	5-7 y	$23,000-25,000
Shower Chair	5-7 y	$500
W/c cushion	1-3 y	$450-550
w/c parts	1 y	$675-2100
Total		**$133,663-152,196**

Transportation

Item	Freq of Replacement (yrs)	Cost
Driving Evaluation	1 x	$1,000
Wheelchair Accessible Van	1 x	$45,000
Van maintenance & Adaptation	1y	$28,500
Total		**$74,500**

Architectural Needs

Item	Freq of Replacement (yrs)	Cost
Renovation	1 x	$50,000
Total		**$50,000**

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Total: $258,163-$276,696

Pre-Intensive Therapy

Assumptions:

- **Life Expectancy: 60y + 17.7y = 77.7y**
- **Ave personal care hours for motor incomplete SCI: 39.9 hours/week**
  (French et al 2007)

Personal Care

Item	Hours/week & cost/hour	Cost
Personal Care	39.9 hours/week at $13/hour	**$26972.4**
Total	***17.7**	**$477,411**

Totals

Equipment, Architecture, Transportation	**$258,163**	**$276,696**
Personal Care	**$477,411**	**$477,411**
Total	**$735,754**	**$754,107**

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Standing Progression

Initial Evaluation

Discharge Evaluation

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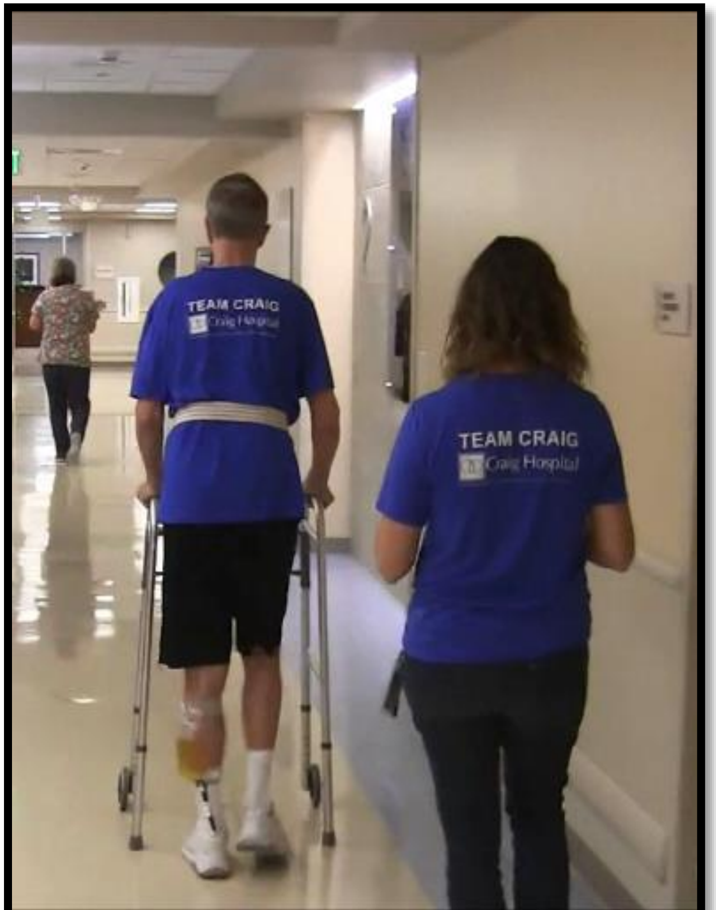
Discharge Intensive Therapy



Functional Independence Measure

	Inpatient D/C FIM	FIM D/C NRN	Assist Level
Grooming	3	**6**	Modified Indep
Bathing	3	**3**	Mod A
UE Dressing	2	**6**	Modified Indep
LB Dressing	2	**6**	Modified Indep
Toileting	2	**3**	Mod A
Bed/wheelchair	1	**6**	Modified Indep
Toilet	1	**5**	Supervision
Tub/shower	1	**5**	Supervision
walk	1	**6**	Modified Indep
Stairs	1	**5**	Supervision

Completed 120 PT and OT Sessions

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Post Intensive Therapy

Assumptions:

- **Life Expectancy: 60y + 17.7y = 77.7y**

Equipment

Item	Freq of Replacement (yrs)	Cost
Hospital Bed	3-12.5 y	NA
Air Mattress	1-6 y	NA
Portable Lift	1-5 y	NA
Manual w/c	5-7 y	$2,000-3,500
Power w/c	5-7 y	NA
Activaid 202	**5-7 y**	**$500**
w/c cushion	1-3 y	$450-550
w/c parts	1 y	$675-2,100
Carbon Fiber AFO	**1y**	**$800-1,000**
Forearm Crutches	**1y**	**$130**
Total		**$36,792-$55,545**

Transportation

Item	Freq of Replacement (yrs)	Cost
Driving Evaluation	**1 x**	**$1,000**
Wheelchair Accessible Van	1 x	NA
Van maintenance & Adaptation	1y	NA
Total		**$1,000**

Architectural Needs

Item	Freq of Replacement (yrs)	Cost
Renovation	1 x	NA
Total		**NA**

Total: $37,792-$56,545

Post Intensive Therapy

Assumptions:

- **Ave personal care hours for bathing/toileting: 2 hours/day**

Personal Care

Item	Hours/week & cost/hour	Cost
Personal Care	14 hours/week at $13/hour X 1 year	$9464
Total	*17.7y	$167,512

Totals

Equipment, Architecture, Transportation	$37,792	$56,545
Personal Care	$167,512	$167,512
Total	$205,304	$224,057

Outcome Measure Improvement

Outcome Assessment	Initial Assessment	Discharge Assessment
10 Meter Walk Test	Non-Ambulatory	0.71m/s
6 Minute Walk Test	Non-Ambulatory	549 feet
Berg Balance Measure	8/56	39/56
Neuromuscular Recovery Scale	2B	3B

Discharge Disposition: Home with wife

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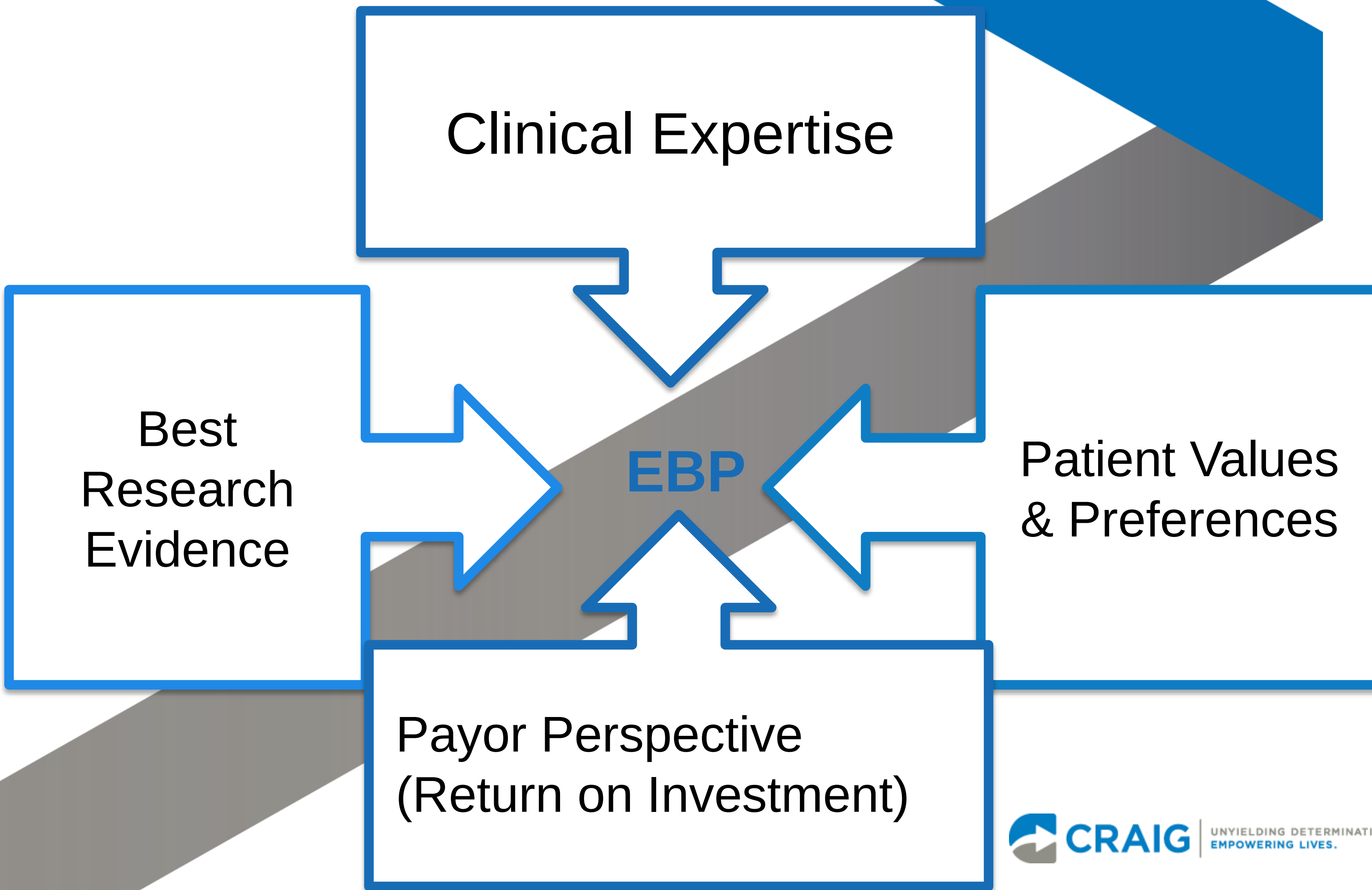
Return on Investment

	Pre Intensive Therapy	Post Intensive Therapy
Total	$754,107	$224,058

Cost Reduction $530,049
Outpatient Therapy Costs: $150k
Total Savings: ~$380,049



Evidence Based Practice



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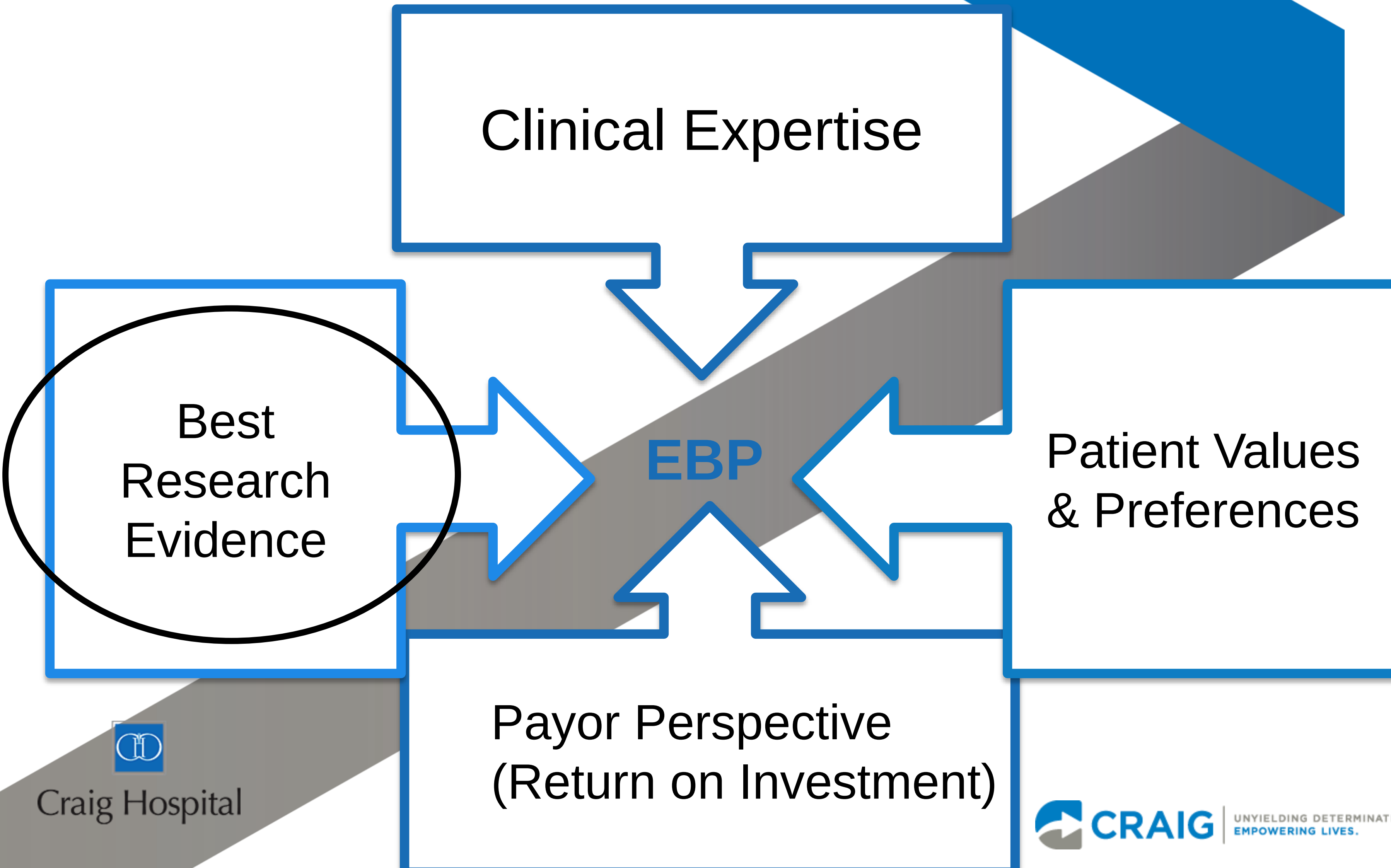
Evidence Based Practice



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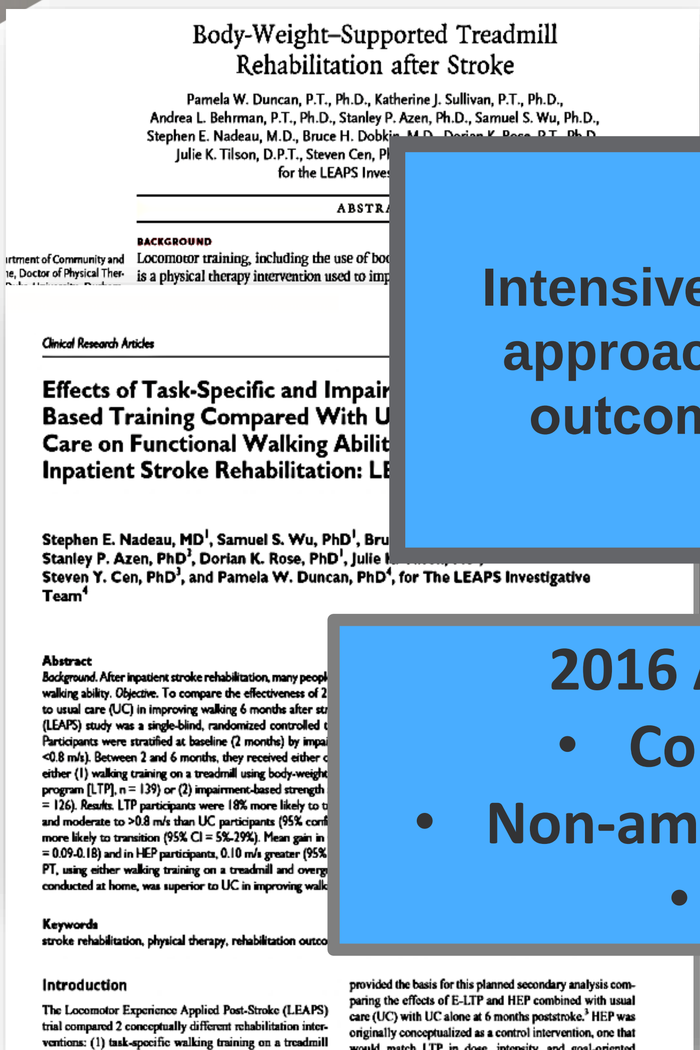
Evidence: SCI

Walking improvements demonstrated in acute and chronic SCIs using various forms of locomotor training…

Cochrane Conclusion (2012): There is insufficient evidence to conclude that any one approach to locomotor training is more effective than another for improving walking function in people with spinal cord injury.

Meta-Analysis Conclusion (Cheung 2017): Lower limb robotic training was also found to be as effective as other types of body-weight-supported training

Evidence: Stroke



Body-Weight–Supported Treadmill Rehabilitation after Stroke

Pamela W. Duncan, P.T., Ph.D., Katherine J. Sullivan, P.T., Ph.D., Andrea L. Behrman, P.T., Ph.D., Stanley P. Azen, Ph.D., Samuel S. Wu, Ph.D., Stephen E. Nadeau, M.D., Bruce H. Dobkin, M.D., Dorian K. Rose, P.T., Ph.D., Julie K. Tilson, D.P.T., Steven Cen, Ph…
for the LEAPS Inves…

ABSTRA…

BACKGROUND

Locomotor training, including the use of bod… is a physical therapy intervention used to imp…

Clinical Research Articles

Effects of Task-Specific and Impair… Based Training Compared With U… Care on Functional Walking Abilit… Inpatient Stroke Rehabilitation: LE…

Stephen E. Nadeau, MD[1], Samuel S. Wu, PhD[1], Bru… Stanley P. Azen, PhD[3], Dorian K. Rose, PhD[1], Julie … Steven Y. Cen, PhD[3], and Pamela W. Duncan, PhD[4], for The LEAPS Investigative Team[4]

Abstract

Background. After inpatient stroke rehabilitation, many peopl… walking ability. Objective. To compare the effectiveness of 2… to usual care (UC) in improving walking 6 months after st… (LEAPS) study was a single-blind, randomized controlled t… Participants were stratified at baseline (2 months) by impai… <0.8 m/s). Between 2 and 6 months, they received either … either (1) walking training on a treadmill using body-weight… program [LTP], n = 139) or (2) impairment-based strength… = 126). Results. LTP participants were 18% more likely to t… and moderate to >0.8 m/s than UC participants (95% conf… more likely to transition (95% CI = 5%-29%). Mean gain in … = 0.09-0.18) and in HEP participants, 0.10 m/s greater (95%… PT, using either walking training on a treadmill and overg… conducted at home, was superior to UC in improving walk…

Keywords

stroke rehabilitation, physical therapy, rehabilitation outco…

Introduction

The Locomotor Experience Applied Post-Stroke (LEAPS) trial compared 2 conceptually different rehabilitation interventions: (1) task-specific walking training on a treadmill …

provided the basis for this planned secondary analysis comparing the effects of E-LTP and HEP combined with usual care (UC) with UC alone at 6 months poststroke.[3] HEP was originally conceptualized as a control intervention, one that would match LTP in dose, intensity, and goal-oriented …

Locomotor Experience Applied Post-Stroke
LEAPS Trial

…training, …eight support in …**s not shown to** …**e exercise at** …al therapist.

Intensive therapy (regardless of approach) may result in better outcomes than usual care…

…**icipants had increased functional walking ability.**

2016 AHA/ASA Guidelines

- **Combination (Priming)**
- **Non-ambulatory/low ambulatory**
- **Virtual Reality**

…eadmill and …**or to usual** …ess of severity

Evidence: TBI

Original Research—CME

A Comparison of Locomotor Therapy Interventions: Partial-Body Weight—Supported Treadmill, Lokomat, and G-EO Training in People With Traumatic Brain Injury

Alberto Esquenazi, MD, Stella Lee, MPA, Amanda Wikoff, BS, Andrew Packel, MSPT, Theresa Toczylowski, MPT, John Feeley, PT

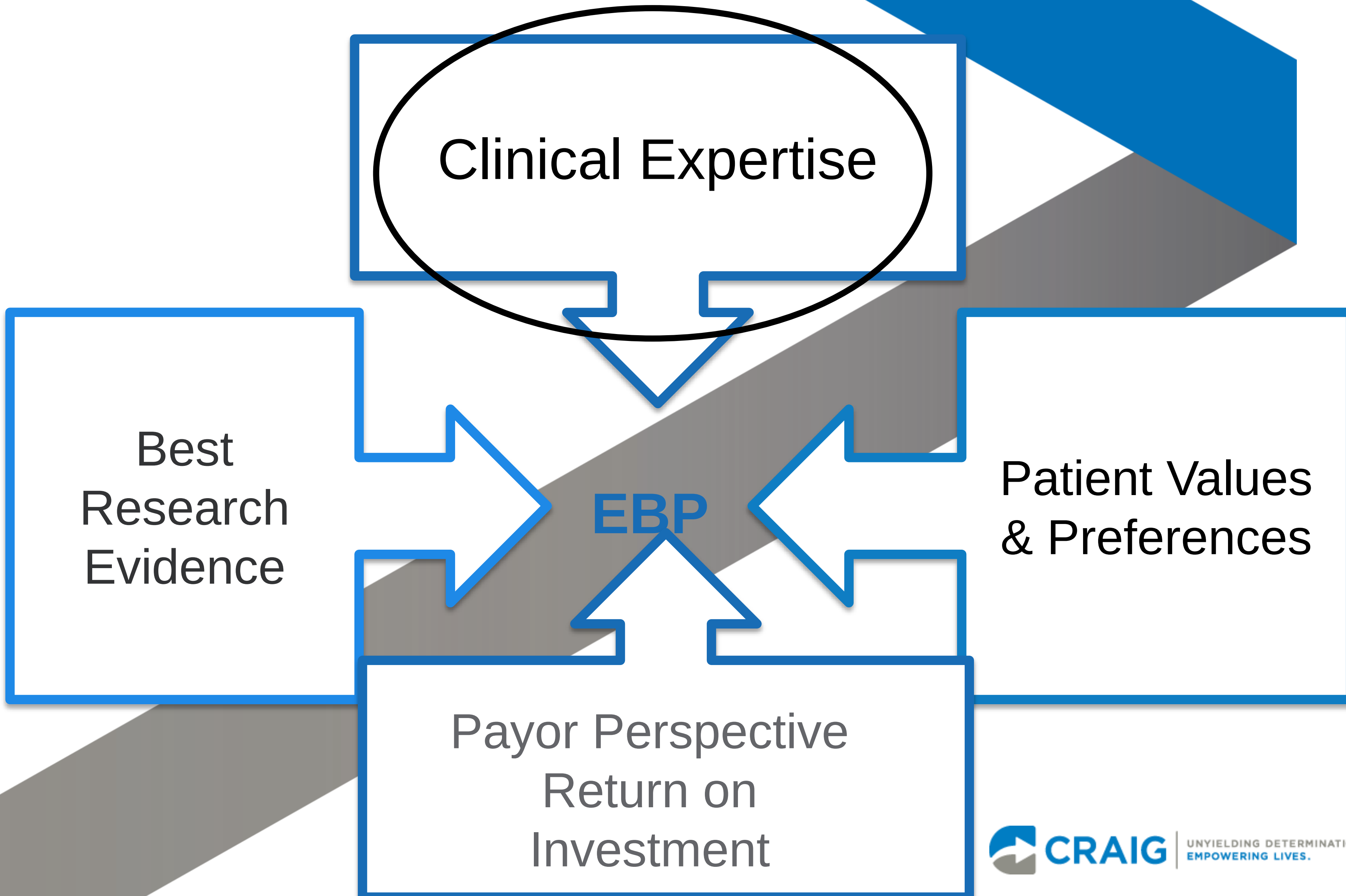
Esquenazi et al 2017
N=22
Results: Statistically significant increases in speed for all groups; between group differences not significant; G-EO and manual LT significant improvements in 6MWT; MSIS significant in Lokomat group;
Conclusion: No significant differences in symmetry in any of the groups; Staffing was the least for Robotic group

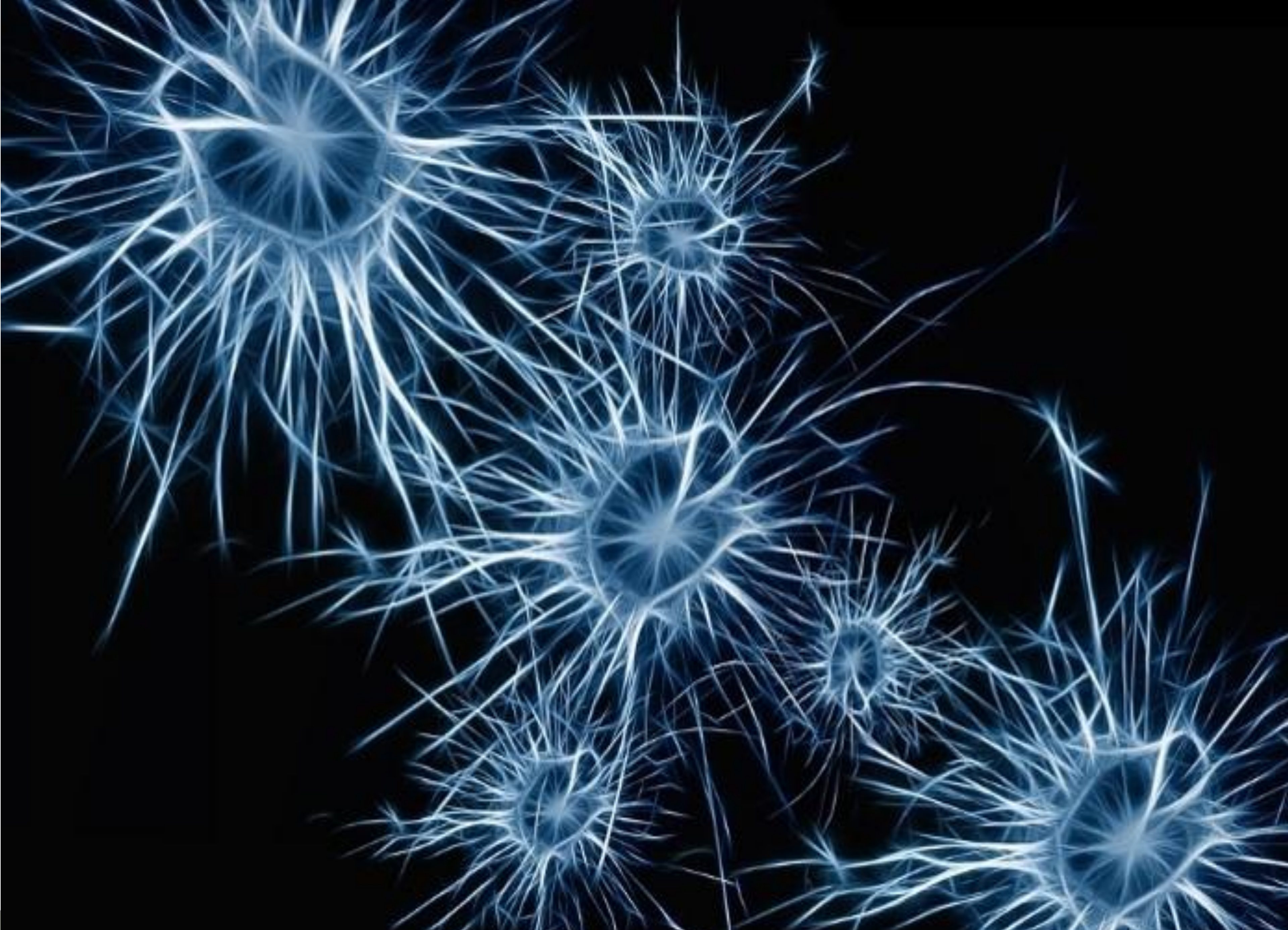
Original Research

A Randomized Comparative Study of Manually Assisted Versus Robotic-Assisted Body Weight Supported Treadmill Training in Persons With a Traumatic Brain Injury

Esquenazi et al 2013; N=16
Results: No statistically significant between group differences; speed increased 49% for robotic group; 31% for manual group; Step length symmetry improved 31% for Robotic group; 9% for manual group;
Conclusion: Greater improvements in symmetry and walking speed for robotic group; Improvements from both interventions in chronic TBI.
Less staff used for Robotic Group

Clinical Expertise





Dolbow et al 2015; Sadowsky et al 2009; Dunlop 2008; Kleim et al 2011; Winchester et al 2005; Ruff et al 2008

Priming

Primed CNS → More responsive to training

- **Homeostatic Plasticity**
- **Gating**

1. **Stimulation-Based Priming**
2. **Sensory-Based Priming**
3. **Movement-Based Priming**
4. Motor imagery and action observation-Based Priming
5. Pharmacology-Based Priming

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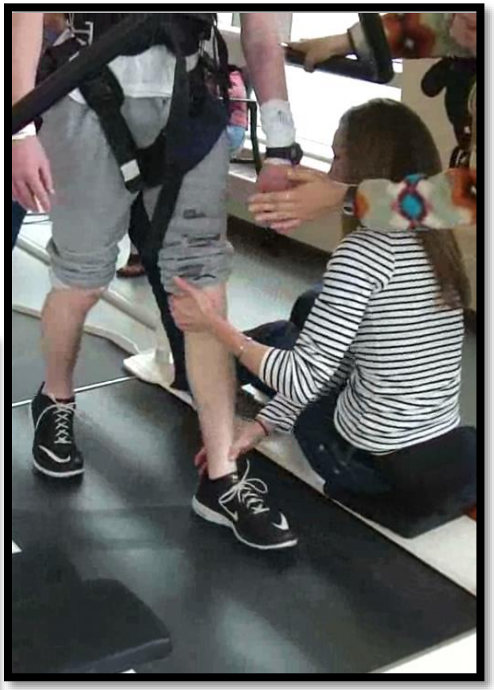
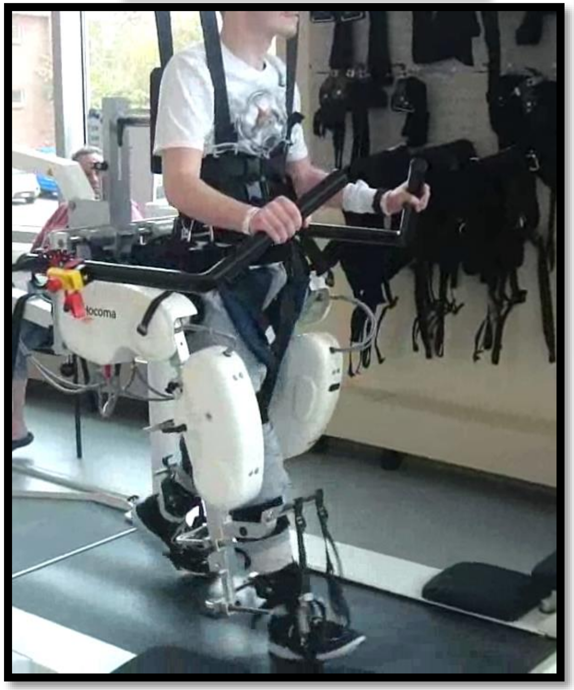
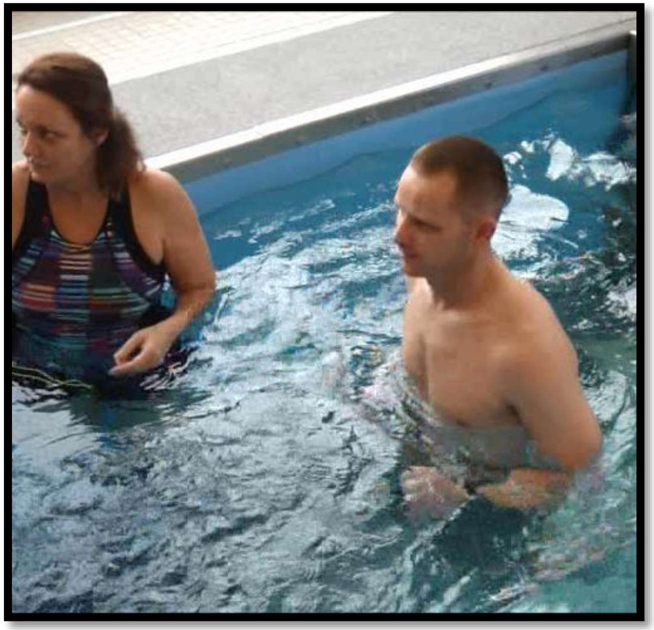
Stoykov, M. E., & Madhavan, S. (2015). Motor priming in neurorehabilitation. *Journal of neurologic physical therapy: JNPT*, *39*(1), 33.

Locomotor Training Options







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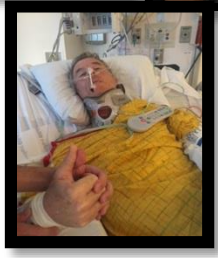
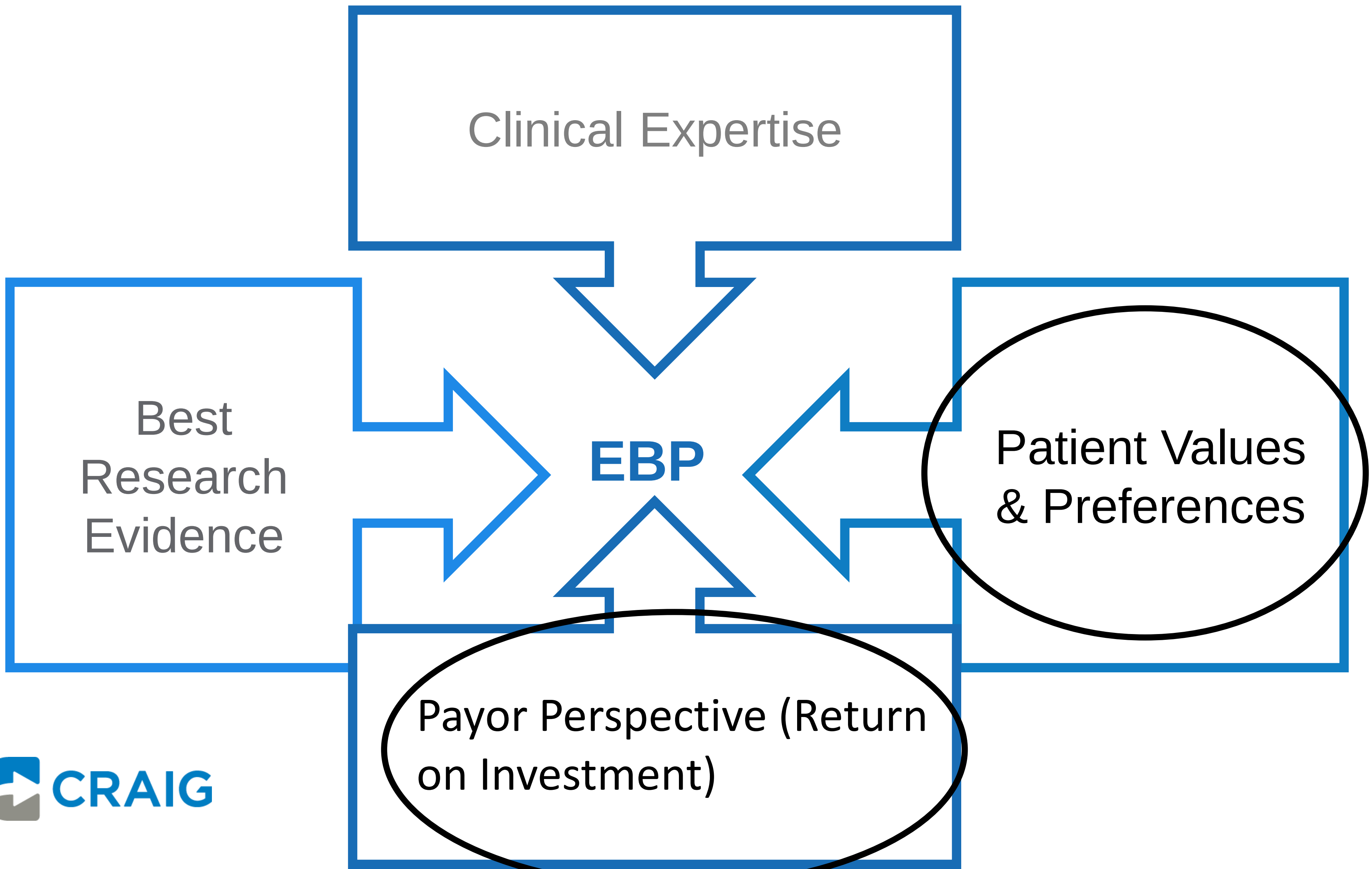
Access to Technology



SCI Rehab Data: Jacqueline LaBarbera

Patient Values



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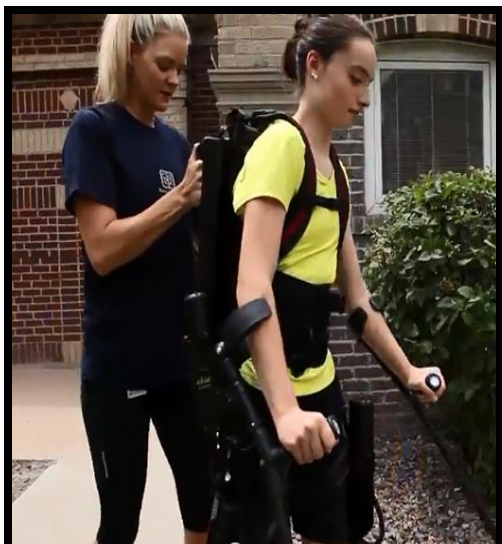
Patient Values

- <u>100%</u> of prospective patients/families with SCI ask about technology opportunities
- 85% of patients/families with TBI ask about technology opportunities.
- Patient Values and Preferences include technology as a priority.




Is Walking Important?

Shavelle et al 2015

- Model Systems Data
- AIS Ds
- Independent walking associated with **longer survival**
- ↑ Mortality associated with incontinence
- **Life Expectancy ~90% of normal for Independent walking and continent vs. < 75% of normal**

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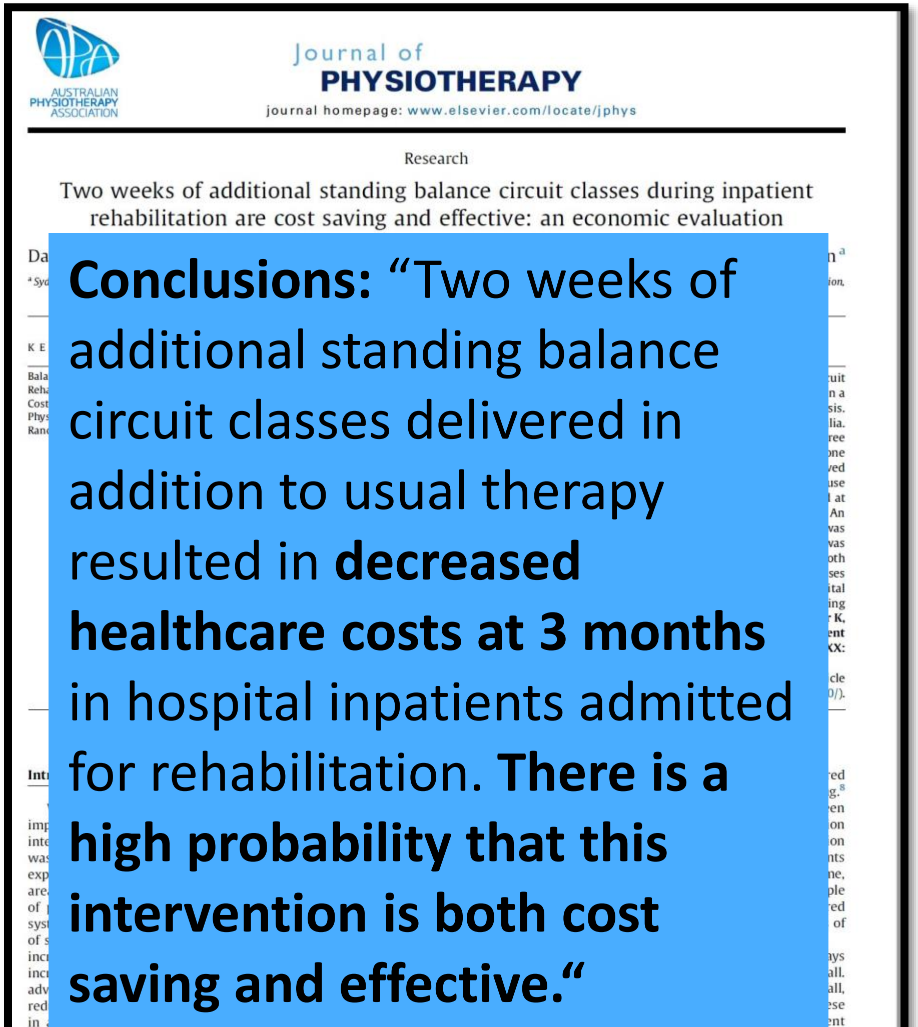
ROI: Health Care Costs



AUSTRALIAN PHYSIOTHERAPY ASSOCIATION

Journal of PHYSIOTHERAPY

journal homepage: www.elsevier.com/locate/jphys

Research

Two weeks of additional standing balance circuit classes during inpatient rehabilitation are cost saving and effective: an economic evaluation

Conclusions: "Two weeks of additional standing balance circuit classes delivered in addition to usual therapy resulted in **decreased healthcare costs at 3 months** in hospital inpatients admitted for rehabilitation. **There is a high probability that this intervention is both cost saving and effective.**"

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ROI: Health Care Costs

ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation
journal homepage: www.archives-pmr.org
Archives of Physical Medicine and Rehabilitation 2013;94(4 Suppl 2):S87-97

ORIGINAL ARTICLE

Rehospitalization in the First Year of Traumatic Spinal Cord Injury After Discharge From Medical Rehabilitation

Conclusions: Re-hospitalization rates among individuals with SCI in the first post-injury year remain high..... Re-hospitalization risk was associated with younger age, being a woman, unemployment, retirement, and Medicaid coverage.

Those who had more intensive physical therapy had lower odds of re-hospitalization.

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So What…

- Research supports intensive therapy interventions may facilitate recovery after neurologic injury
- Intensive therapy may reduce life time care costs:
  - Sherown: ~$1.15 million dollars
  - Pete: ~ $500,000
  - Rick: ~$380,000
- Decreased 1 year re-hospitalization rates and health care costs associated with intensive therapy
- New technologies on the horizon….

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Exoskeletons

- Walking speed .03-.45m/s (max .55m/s) Esquinazi 2012, Yang 2015, Louie 2015, Tefertiller et al 2017
- Reports of improvements in pain, bowel, bladder function and spasticity, enjoyment Esquinazi 2012, Miller 2016
- Metabolic cost of walking 3.5-4.3 METS/light to moderate exercise Evans 2015, Kozlowski 2015
- Training completed with CGA/close supervision Esquinazi 2012, Kozlowski 2015

Neuromodulation of the CNS

ACRM
American Congress of Rehabilitation Medicine
Archives of Physical Medicine and Rehabilitation
journal homepage: www.archives-pmr.org
Archives of Physical Medicine and Rehabilitation 2015;96(4 Suppl 2):S138-44

CLINICAL NOTE

Preliminary Guidelines for Safe and Effective Use of Repetitive Transcranial Magnetic Stimulation in Moderate to Severe Traumatic Brain Injury

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From the [a]Department of Physical Medicine and Rehabilitation, The Ohio State University Wexner Medical Center, Columbus, OH; [b]Department of Psychiatry, The Ohio State University Wexner Medical Center, Columbus, OH; and [c]Department of Radiology, The Ohio State University Wexner Medical Center, Columbus, OH.
Current affiliation for McKnight, Creighton University School of Medicine, St. Joseph's Hospital and Medical Center, Phoenix, AZ.

Non-invasive brain stimulation for the treatment of symptoms following traumatic brain injury

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Department of Psychiatry, University of Manitoba, Winnipeg, MB, Canada

Clinical Research Article

Epidural Electrical Stimulation for Stroke Rehabilitation: Results of the Prospective, Multicenter, Randomized, Single-Blinded *Everest* Trial

Neurorehabilitation and Neural Repair
2016, Vol. 30(2) 107–119
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DOI: 10.1177/1545968315575613
nnr.sagepub.com
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Robert M. Levy, MD, PhD[1], Richard L. Harvey, MD[2,3], Brett M. Kissela, MD[4], Carolee J. Winstein, PhD[5], Helmi L. Lutsep, MD[6], Todd B. Parrish, PhD[2], Steven C. Cramer, MD[7], and Lalit Venkatesan, PhD[8]

Effects of Lumbosacral Spinal Cord Epidural Stimulation for Standing after Chronic Complete Paralysis in Humans

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J Neurophysiol 113: 834–842, 2015.
First published November 5, 2014; doi:10.1152/jn.00609.2014.

Initiation and modulation of locomotor circuitry output with multisite transcutaneous electrical stimulation of the spinal cord in noninjured humans

Yury Gerasimenko,[1,5] Ruslan Gorodnichev,[2] Aleksandr Puhov,[2] Tatiana Moshonkina,[1] Aleksandr Savochin,[1] Victor Selionov,[3] Roland R. Roy,[5,6] Daniel C. Lu,[4] and V. Reggie Edgerton[4,5,6]
[1]Pavlov Institute of Physiology, St. Petersburg, Russia; [2]Velikie Luky State Academy of Physical Education and Sport, Velikie Luky, Russia; [3]Institute for Information Transmission Problems, Russian Academy of Science, Moscow, Russia; [4]Departments of Neurosurgery University of California, Los Angeles, California; [5]Integrative Biology and Physiology, University of California, Los Angeles, California; and [6]Brain Research Institute, University of California, Los Angeles, California

Submitted 14 August 2014; accepted in final form 3 November 2014

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Redefining Possible for People with Spinal Cord and Brain Injuries

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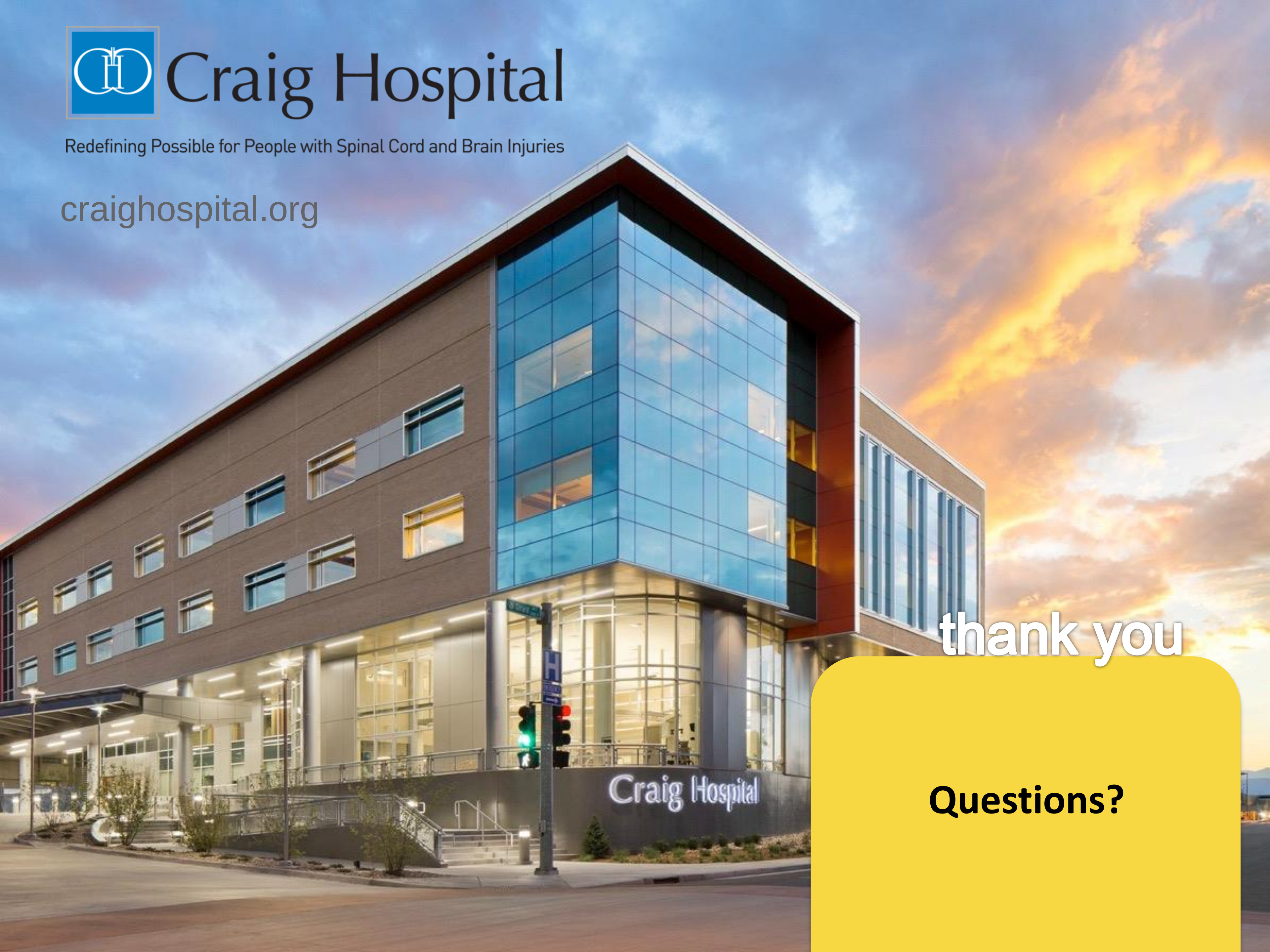

thank you

Questions?