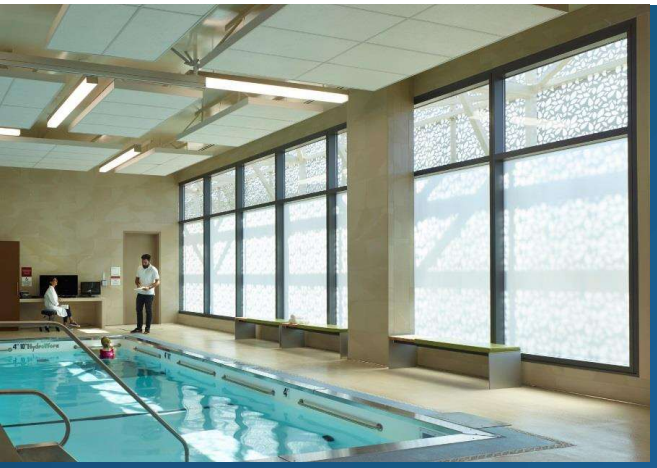
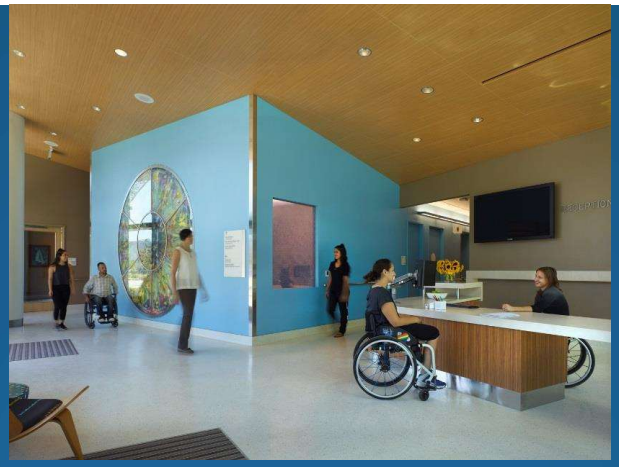
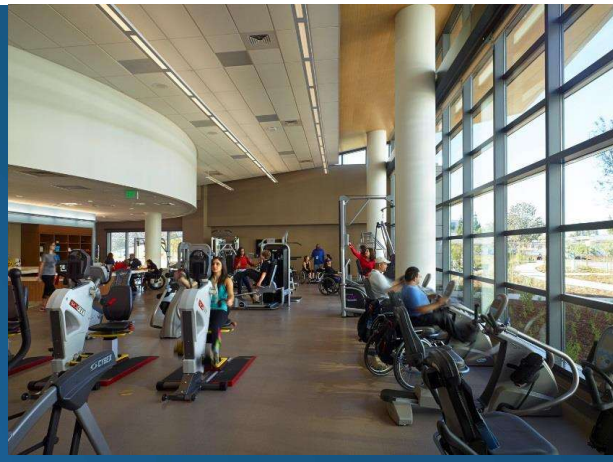




STRENGTHENING AND OPTIMAL MOVEMENT PERFORMANCE IN PERSONS WITH SPINAL CORD INJURY

Lilli Thompson, PT, DPT, NCS
Lisa Haubert, PT, DPT

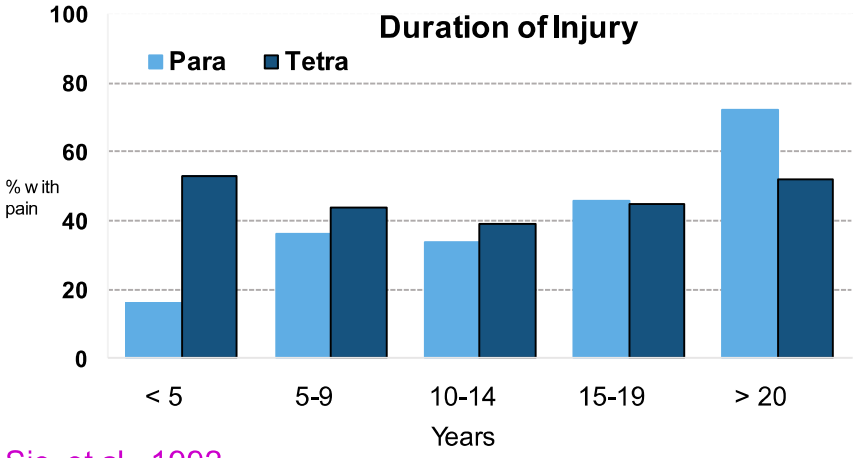
The 2nd Annual Sara J. Mulroy Spinal Cord Injury Symposium
March 2024

Thank you for joining us today as we collaborate with those we serve

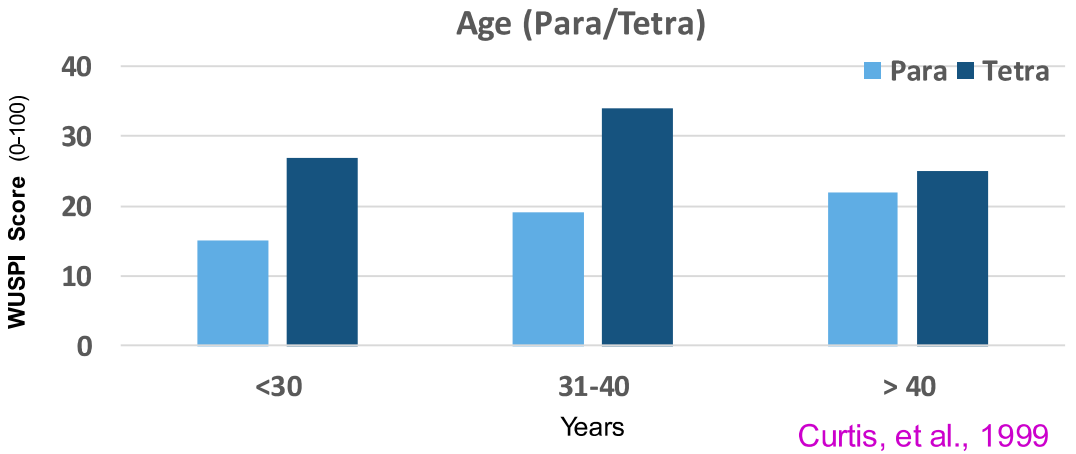
to share our passion and knowledge with the goal to help people not just "live with a disability" but to THRIVE throughout their life

RANCHO LOS AMIGOS
NATIONAL REHABILITATION CENTER

Shoulder Pain with SCI



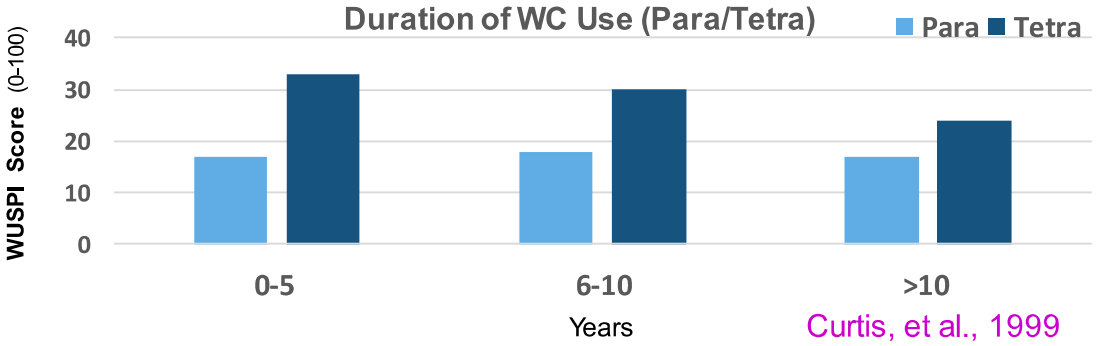
Sie, et al., 1992



Curtis, et al., 1999

- Shoulder pain increases with time post-injury and prevalence is higher than in able-bodied population at every age group.
- Majority of people with SCI will develop significant shoulder pain.
- Most common causes of shoulder pain in persons with chronic SCI are to the rotator cuff.

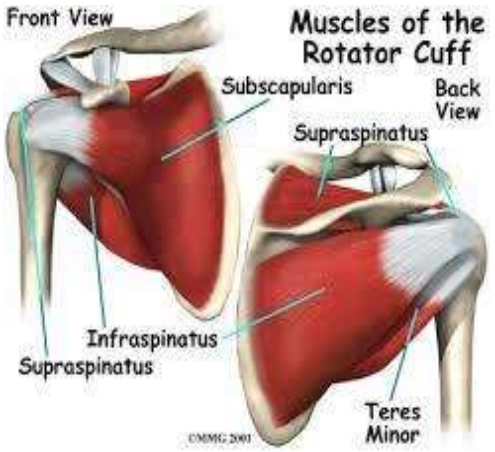
Dyson-Hudson & Kirshblum, 2004

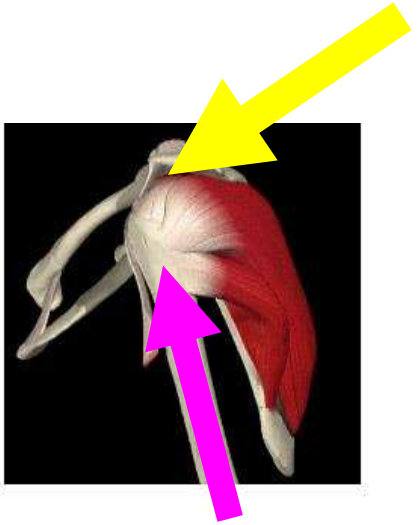


Curtis, et al., 1999

The Weight-Bearing Shoulder

- Shoulder designed for locating the hand in the environment
- Weight-bearing tasks transfer forces to shoulder via the humerus
- Significant risk for impingement of subacromial structures





- Limits mobility
- Limits self-care
- Unable to rest

Repetitive High - Force Shoulder Demands

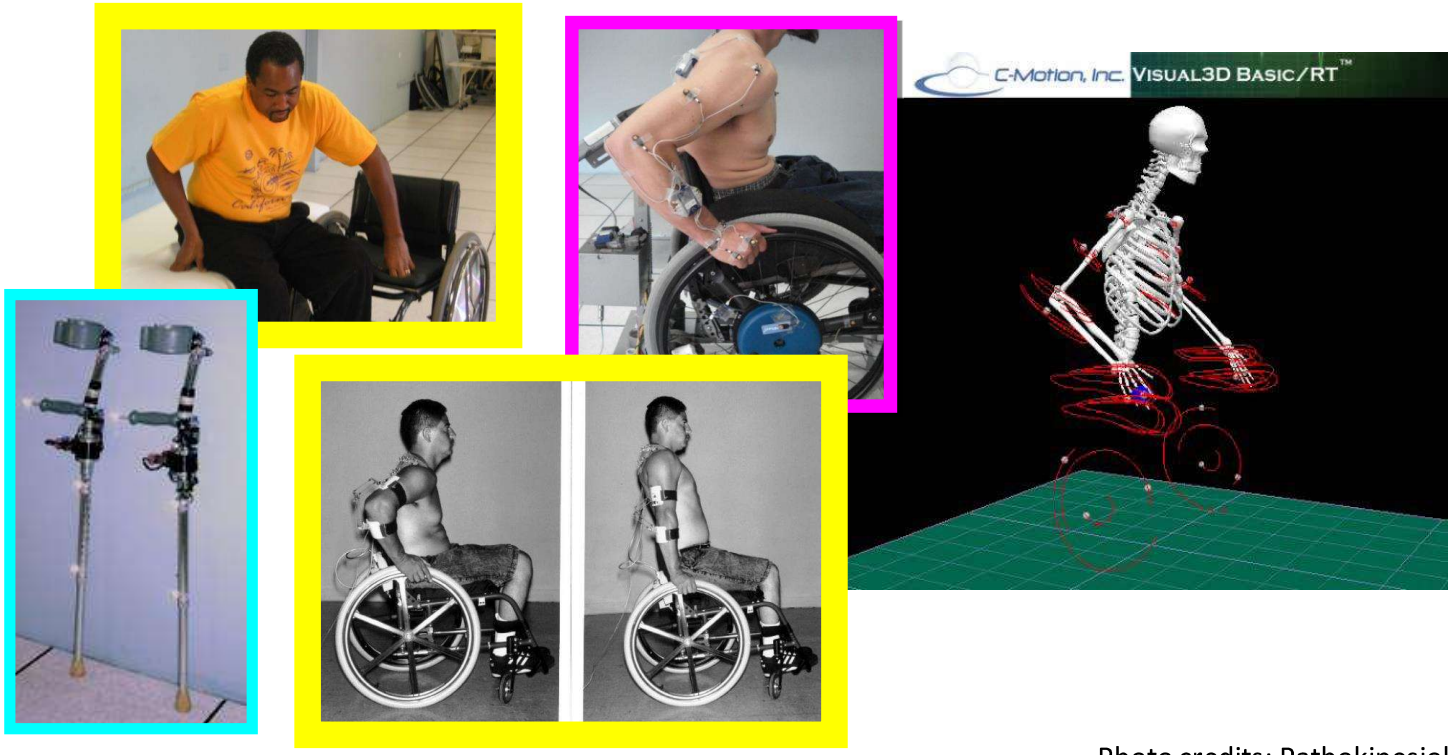


Photo credits: Pathokinesiology Laboratory,
Rancho Los Amigos National Rehabilitation Center

What predisposes persons with SCI to increased potential for shoulder pain development and what can we do about it?

Comorbidities or secondary conditions? Muscle imbalances? Altered use/demands? Neuropathic issues? Suboptimal techniques and/or equipment?
Problem Solving Approach

- **Movement Analysis! How are activities performed? How are people moving?**
- **Impairment testing to identify potential contributors.**
- **Assess equipment and set up.**
  Does it support functional needs?
- **Can we optimize muscle function, movement mechanics, and equipment to reduce pain and improve function?**

STOMPS

Strengthening and Optimal Movements for Painful Shoulders in Chronic SCI:

Evaluation of Outcomes and Implications for Practice

STOMPS Research Team:

Sara Mulroy, PT, PhD	Lilli Thompson, PT, NCS	Bryan Kemp, PhD
Patricia Hatchett, DPT	Craig Newsam, DPT	Dee Gutierrez, PT,
Tingting Ge, MS	Lisa Haubert, MSPT	Valerie Eberly, PT, NCS
Stanley Azen, PhD	Carolee Winstein, PT, PhD, FAPTA	

Rehabilitation Research and Training Center: Aging with a Disability
Physical Therapy Clinical Research Network (PTClinResNet)
Pathokinesiology Laboratory, Rancho Los Amigos National Rehabilitation Center

Specific Aim

To investigate the effectiveness of a home-based treatment program combining shoulder exercises with movement optimization in reducing shoulder pain for individuals with paraplegia from SCI.

Demographics and Design

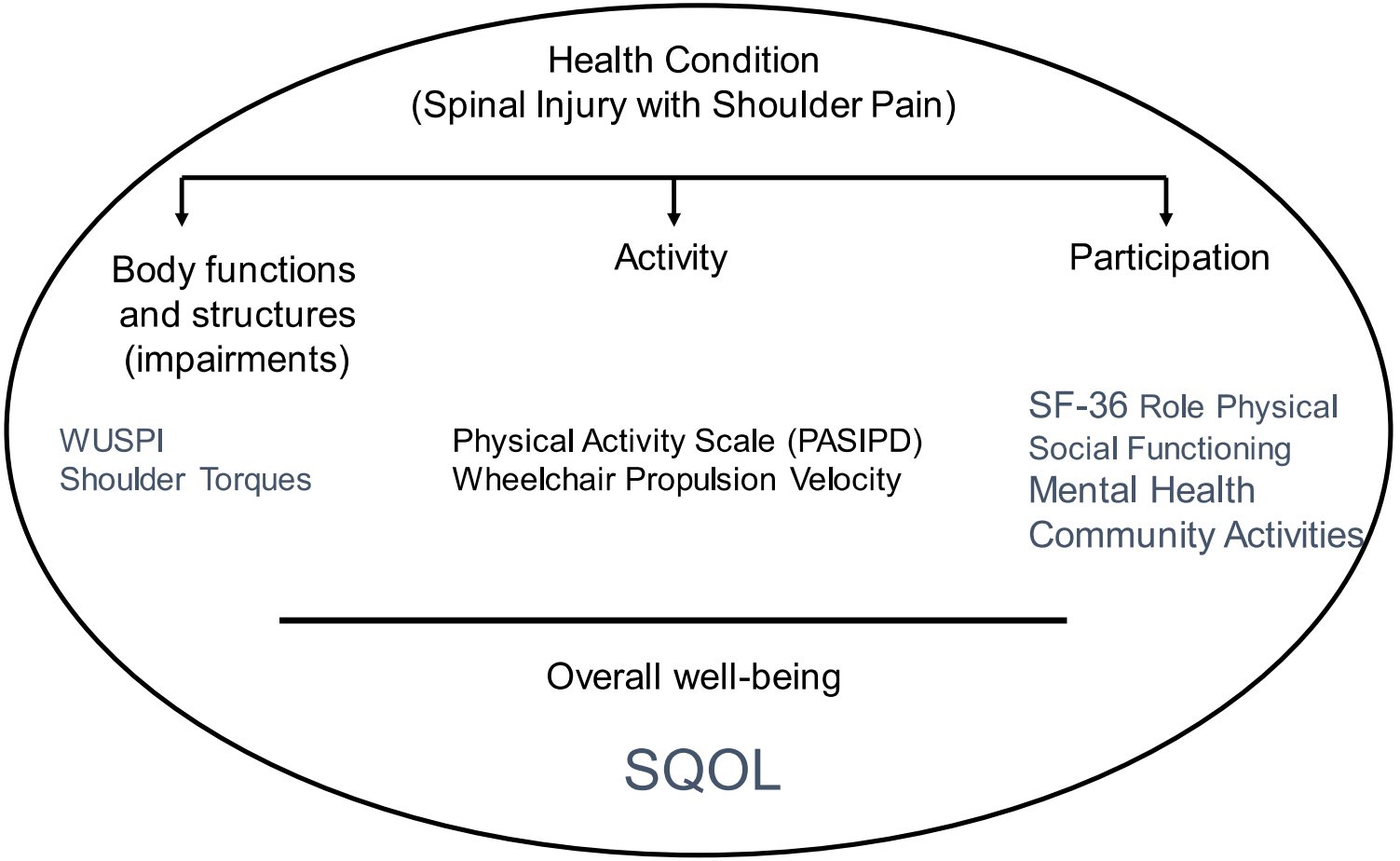
Participants: n = 80 (Men=58, Women=22)

- Complete (n= 65), Incomplete (n=15)
- Age = 44.7 ± 11.1 years, Duration of SCI = 20 ± 11 years
- **Duration of shoulder pain = 5 ± 5 years**

Randomized to 1 of 2 groups: Experimental vs. Control

- Attention Control : 1- hour educational video + Diary
  n = 33/40 Completed
- Experimental: Home Program - 3 days/wk x 12 wks
  n = 27/40 Completed
- Measurements: 0, 12 wks (follow-up @ 4 wks post)

Impact of Strengthening Intervention



Wheelchair Users Shoulder Pain Index[5]

Over the past week, how much shoulder pain have you experienced with the following activities:

15 Items:

- Transfers
- Wheelchair Propulsion
- ADL'S
- Overhead Reaching
- Sleeping
- Etc.

Response options range on a 10cm scale with anchors:

No pain (0) ------W*orst pain ever experienced (10)*

Score = Total / # of items x 15 (Max = 150)

EMG Analysis of Shoulder Muscles in Persons with Paraplegia During Transfers and Wheelchair Propulsion

Mulroy SJ, Gronley JK, Newsam CJ, Perry J. Electromyographic activity of shoulder muscles during wheelchair propulsion by paraplegic persons. Arch Phys Med Rehabil. 1996;77:187-193.

Mulroy SJ, Gronley JK, Newsam CJ, Perry J. Electromyographic activity of shoulder muscles during depression transfers in subjects with low-level paraplegia Arch Phys Med Rehabil. 1996;77:350-355.

EMG Analysis of Shoulder Muscles in Persons with Paraplegia During Wheelchair Propulsion

Mulroy et al, 1996

PHASE	MUSCLE ACTIVITY	ACTIONS
PUSH	**Supraspinatus** Anterior Deltoid **Sternal Pectoralis Major** Infraspinatus Serratus anterior Long head Biceps	Shoulder flexion and scapular protraction Supraspinatus = ER and protecting the anterior superior wall of shoulder joint from humeral head abutment
RECOVERY	Middle and Posterior Deltoid Subscapularis **Supraspinatus** Middle Trapezius Rhomboids (low level)	Extension, Abduction, scapular retraction Supraspinatus = ABD

EMG Analysis of Shoulder Muscles in Persons with Paraplegia During Wheelchair Propulsion

TAKE HOME MESSAGES FOR WHEELCHAIR PROPULSION

- Identified the phasing and intensity of shoulder muscles during wheelchair propulsion to identify muscles at risk for fatigue and overuse.
- Push and Recovery phases of propulsion cycle were differentiated
- Shoulder rehabilitation should emphasize specific muscle strengthening to address the different demands of wheelchair propulsion.
- Rotator cuff: all 3 muscles studied had a specific role requiring peak intensities of 44% or greater of maximal muscle contraction for at least 30% of the cycle

******Special attention needed for Supraspinatus (67% of Max peak intensity and multiple roles):**

- **SUPRASPINATUS was active in both push and recovery phases**
- **SUPRASPINATUS most vulnerable to fatigue creating risk for impingement if deltoid begins to take over**
- **Pectoralis Major strengthening in the adduction role (NON-WEIGHT BEARING) to avoid G-H impingement risk**
- **Endurance training for recovery muscles since all are active for more than half the propulsion cycle (56-68% of cycle)**

Mulroy SJ, Gronley JK, Newsam CJ, Perry J. Electromyographic activity of shoulder muscles during wheelchair propulsion by paraplegic persons. Arch Phys Med Rehabil. 1996;77:187-193.

EMG Analysis of Shoulder Muscles in Persons with Paraplegia During Depression Transfers

Mulroy et al, 1996

PHASE	POSITION	MUSCLE ACTIVITY (% OF MAX EMG)
Preparation	**Leading arm** on mat in ABD, extended, IR **Trailing arm** on chair in ABD (less) extended, IR	**sternal pec major (33%)** subscapularis (26%) long head biceps (26%) sternal pec major (31%), latissimus dorsi, lower serratus, infraspinatus (21%)
Lift	**Leading** shoulder flexion, ADD, ER **Trailing** shoulder flexion, ABD, decreasing IR	**sternal pec major (81%)**, serratus (47%), latissimus dorsi(40%), infraspinatus (37%), long head biceps (28%) **serratus ant (54%), sternal pectoralis major (49%),** infraspinatus (45%), ant deltoids (44%), supraspinatus, latissimus dorsi (25%)
Descent	**Leading** ADD, extension **Trailing** ABD, flexion, (scaption)	**Sternal pec major (36%),** latissimus dorsi(26%) **Sternal pec major (39%),** lower serratus ant (34%)

EMG Analysis of Shoulder Muscles in Persons with Paraplegia During Transfers

TAKE HOME MESSAGE FOR DEPRESSION TRANSFERS

- Identified & compared the intensity of selected shoulder muscle activity during transfers.
- Provides insights into the key shoulder muscles active in the leading & trailing arms during depression transfers.
- **Sternal Pectoralis Major was consistently active at *moderate to high intensity* in both shoulders during all 3 transfer phases.**
- **Thoraco-humeral muscles**: Sternal Pec & Latissimus Dorsi in combination elevate the trunk by transferring the body weight to the arms.

******STRENGTHEN FOR POWER IN A NON-WT BEARING POSITION TO REDUCE RISK OF IMPINGEMENT**

- **Scapular muscles**: Lower serratus ant is critical to resist upward rotation thrust of scapula and to stabilize the scapula on the thorax.
- **Glenohumeral muscles**: Different muscle demands between leading & trailing arms.
- LEADING ARM = subscapularis in prep, infraspinatus in lift phases
- **TRAILING ARM = Infraspinatus high demand in all phases, supraspinatus had an increased demand in lift due to internal rotation of the shoulder.**

****** ROTATOR CUFF PATHOLOGY IN ONE SHOULDER SUGGESTS USING THE IMPAIRED ARM AS LEADING ARM TO REDUCE LOADS AND PROMOTE HEALING**

Mulroy SJ, Gronley JK, Newsam CJ, Perry J. Electromyographic activity of shoulder muscles during depression transfers in subjects with low-level paraplegia. Arch Phys Med Rehabil. 1996;77:350-355.

Hypertrophy Exercises – 8RM

Diagonal Pull-down

- Pectoralis major
  - Propulsion power
  - Active in transfers
  - Non-weight bearing

External Rotation

- Infraspinatus
  - PUSH Phase of WC propulsion
  - Active in transfers

Endurance Exercises – 15RM

Scaption

- Supraspinatus
  - Active in both PUSH & RECOVERY phases of WC propulsion

Scapular Retraction

- Rhomboids
  - RECOVERY phase of WC propulsion - 62% duration

Stretching Program

Movement Optimization

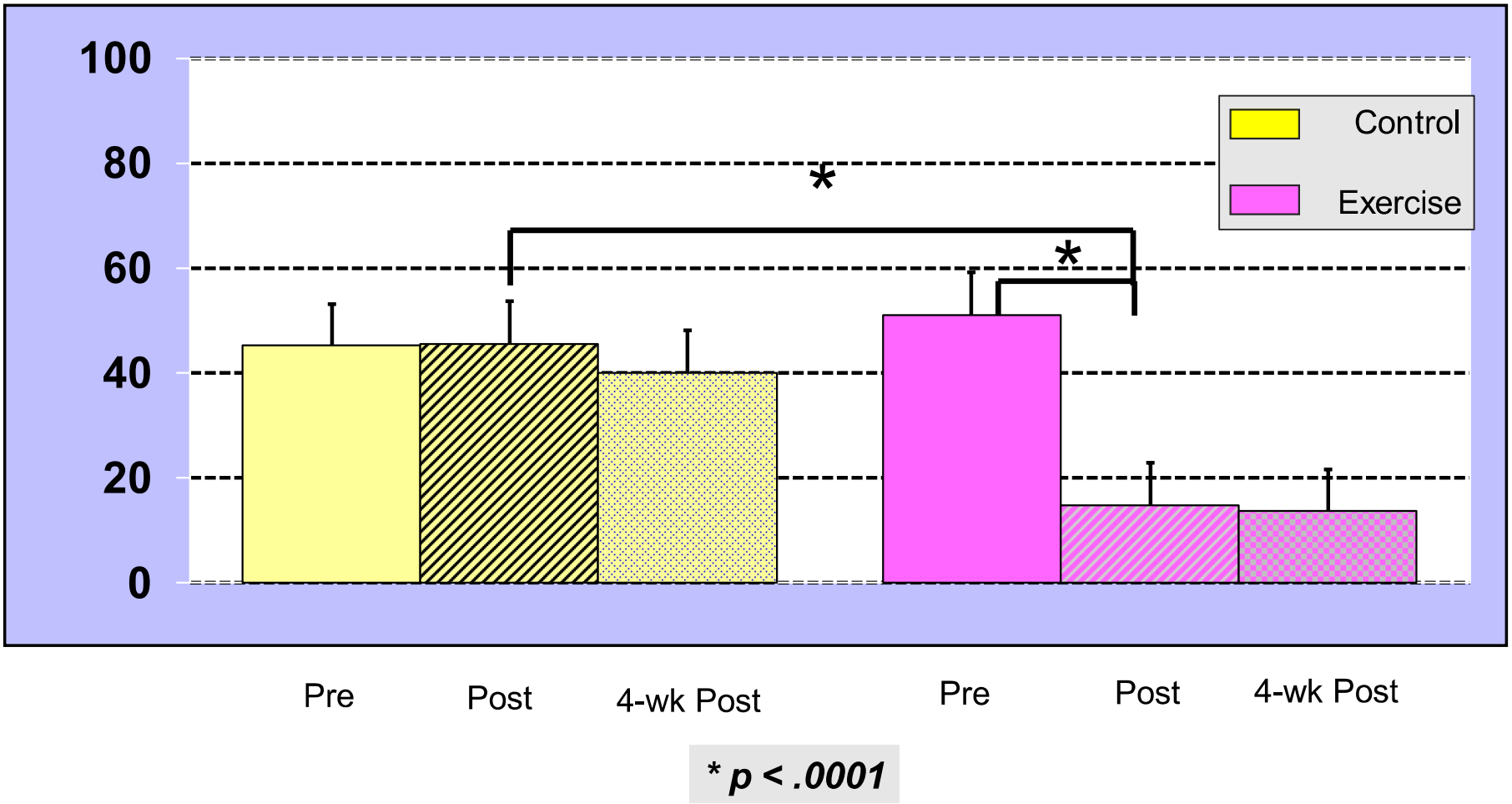
- **Transfers & Raises**

  10 recommendations
  - Modify height of transfer surface
  - Hand & arm position
  - 8 included in PVA Guidelines

- **WC Propulsion**

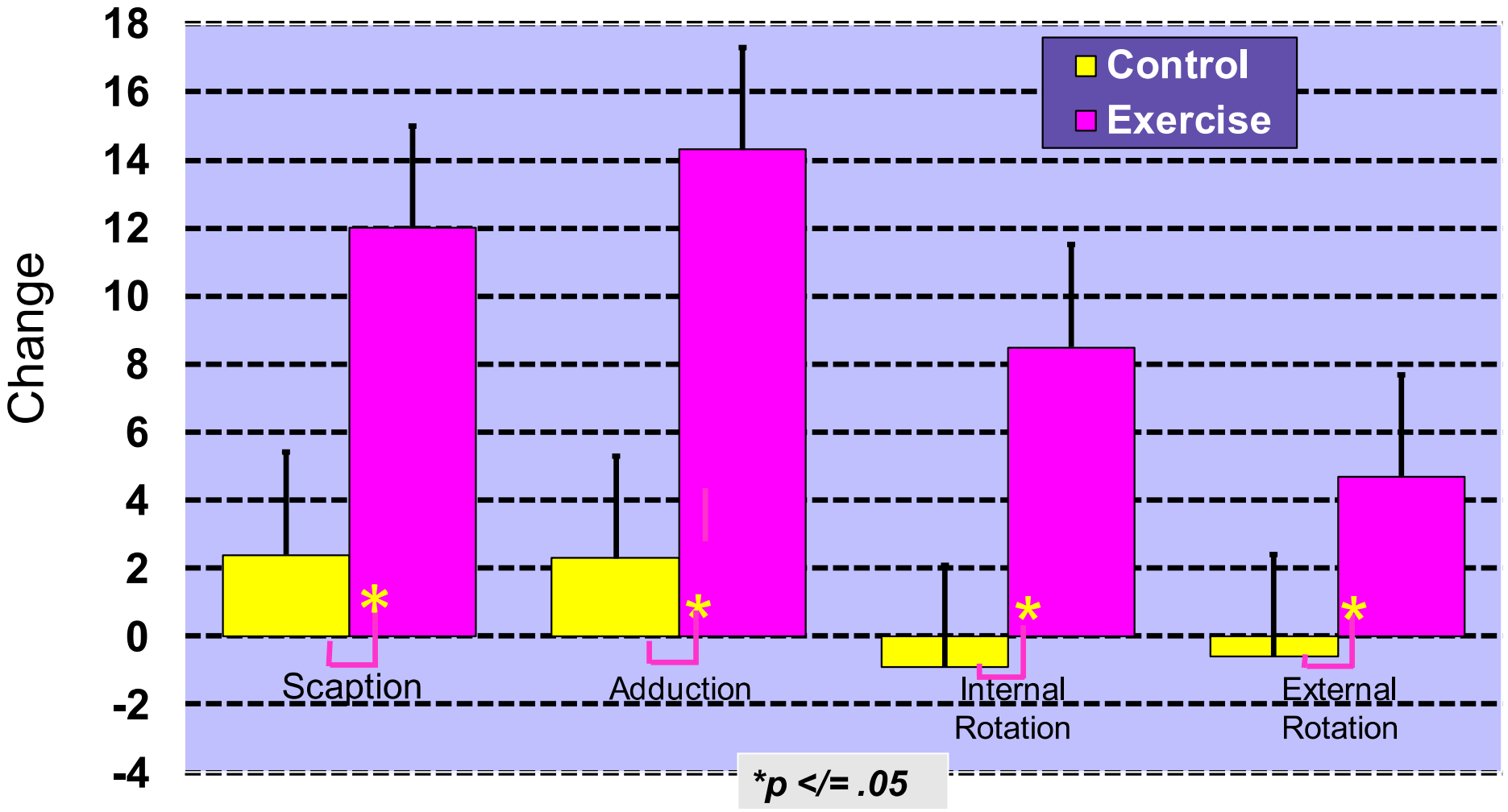
  9 recommendations
  - Propulsion technique
  - Energy conservation
  - 3 included in PVA Guidelines

Shoulder Pain - WUSPI

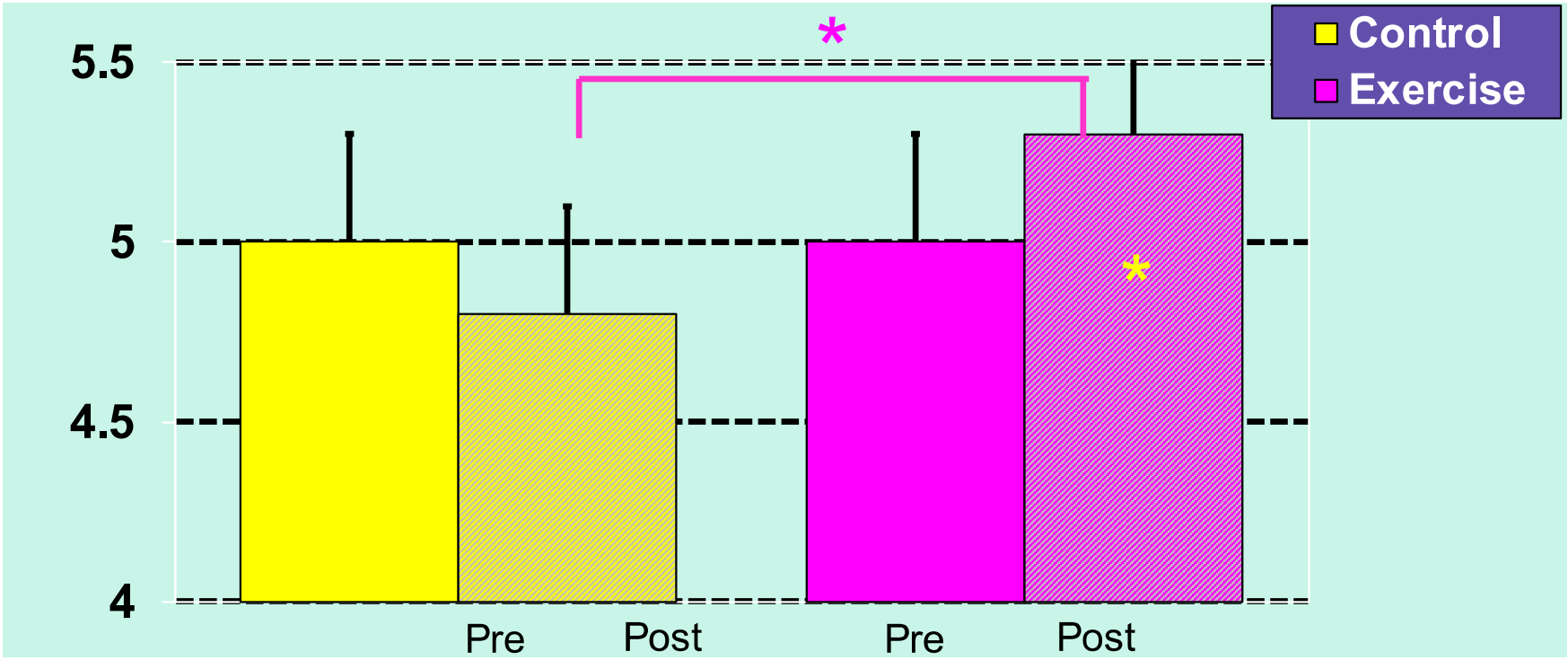


*** p < .0001***

Isometric Torques



Subjective Quality of Life



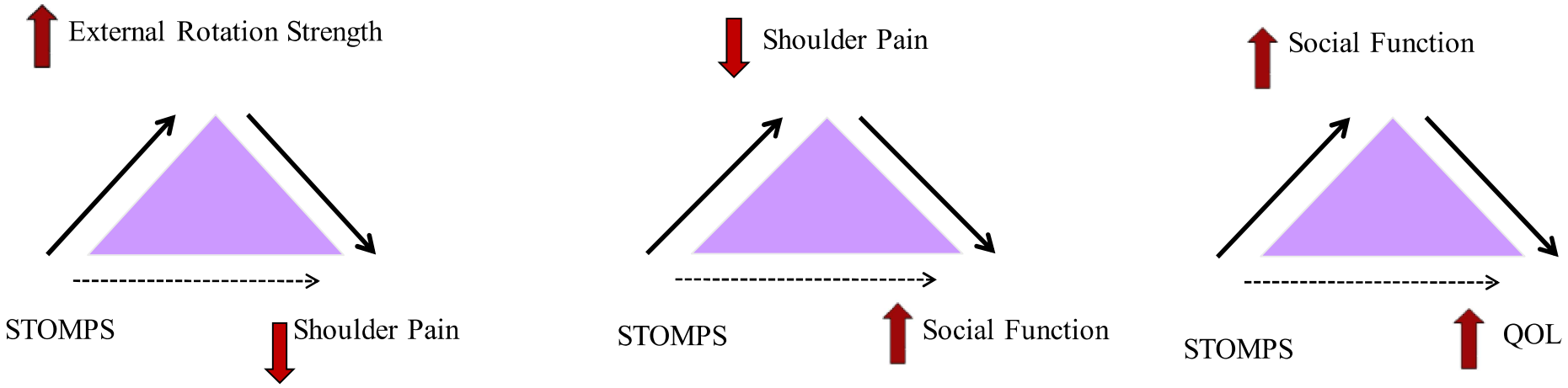
*p <0.05

Causes (Mediators) of Improved Shoulder Pain/Social Function/QOL

Publication: Secondary Mediation Analysis
Mulroy, et. al. *Physical Therapy*, 2011

With STOMPS intervention:

Increased External Rotation Strength – Partial mediator decreased Shoulder Pain
Decreased Shoulder Pain – Mediator of increased Social Function
Increased Social Function – Mediator of improved overall Quality of Life



Secondary Mediation and Regression Analysis of PTCLINRESNET Database: Determining Causal Relationships Among the ICF for Four PT Intervention Trials
Mulroy, et. al. *Physical Therapy*, 2011

Shoulder Pain in SCI: A Longitudinal Study

- N= 223 individuals with paraplegia, no pain at study entry
- Assessments at:
  - Baseline
  - 18 months
  - 36 months
- Predictors
  - Wheelchair propulsion biomechanics
  - Muscle Strength
  - Daily WC Propulsion/Transfers
- Follow onset of shoulder pain – WUSPI

Activity levels were either lower in participants that developed shoulder pain than in those who remained pain-free or were similar in the 2 groups (Tab. 3). Average speed of propulsion was slower in participants who developed shoulder pain (2.4 km/h, SD0.9) than in those who remained pain-free (2.8 km/h, SD1.5). Participants who eventually developed shoulder pain performed fewer car transfers per day prior to pain onset (X4.0, SD3.3) compared with those who remained pain-free (X5.1, SD3.5). D

NIH #HD049774

Predictors of Shoulder Pain in Manual W/C Users

n=102

- Longitudinal study to identify if there are specific biomechanical measures related to wheelchair propulsion that predict shoulder pain development in manual W/C users.
- **PREDICTORS:**

  Weaker Adductors,

  Higher positive shoulder joint work during recovery phase

  Less trunk flexion

Walford SL, Requejo PS, Mulroy SJ, Neptune RR. *Clinical Biomechanics.* 2019: May; 65:1-12

SCIMS Site Specific Project:
An RCT to Evaluate Two Shoulder Pain Prevention Programs (SPPPs) for Manual Wheelchair Users with Paraplegia from Spinal Cord Injury

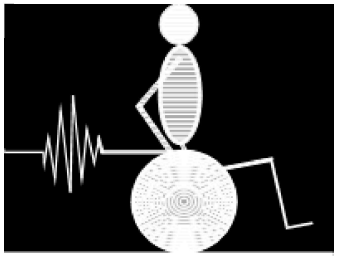
SPPP: N=86 Completed of 100 Enrolled **(86%)**

- **48 Traditional STOMPS Enrolled**
  - 45 completed 18-Mo Eval (94%)
  - **41 completed 3-Yr Eval** (85% of BL)
- **52 Enhanced STOMPS Enrolled**
  - 43 completed 18-Mo Eval (83%)
  - **45 completed 3-Yr Eval** (87% of BL)

*__Historical Control: N=199 Completed__ of 220 Enrolled **(91%)**

- 203 completed 18-Mo Eval (92%)
- **199 completed 3-Yr Eval**

Pathokinesiology Laboratory



Rancho Los Amigos
National Rehabilitation Center

NIDILRR Grant: 90S15010; **NIH Grant**: R01 HD049774

➢ DOING THE EXERCISES!

➢ INCORPORATING THE MOVEMENT RECOMMENDATIONS!

- **Shoulder pain incidents** were **significantly** ↓ at **18-Mo** & **3-Yrs** with SPPPs vs. Controls **(*p<0.05)** (although similar between Traditional & Enhanced STOMPS SPPP delivery formats)

	Control	SPPPs	Traditional STOMPS (SPPP)	Enhanced STOMPS (SPPP)
18-Mos	26%	*11%	11.1%	11.6%
3-Yrs	38%	*23%	24.4 %	22.2%

- **Exercise frequency** reported in 1st 4-Mos was **significantly** ↓ in **participants who developed shoulder pain** at 18-Mos & 3-Yrs (3.0 vs. 2.0, p<0.05) (although similar between the SPPP groups).

- **Exercise Adherence** → **most important factor related to the outcomes** (vs. intervention format)**.**

Outcomes from this study indicate that PERFORMING THE EXERCISES was the PRIMARY PREDICTOR for REDUCING the DEVELOPMENT OF SHOULDER PAIN in persons originally without shoulder pain.

Question: If we automatically brush our teeth 2x/day to prevent cavities & tooth decay, isn't exercising 3x/week a reasonable time investment to preserve shoulder health, functional mobility, social function/participation & quality of life?

Haubert LL, Mulroy SJ, Eberly VJ, Gronley JK, Hatchett PE, Conners SG. Top Spinal Cord Inj Rehabil. 2021 Fall;27(4):40-52

NIDILRR Grant: 90S15010; **NIH Grant**: R01 HD049774

Thank you for joining up so we can all now share our expertise to help those we serve have the best quality of life throughout the whole of their life

Please remember to complete your survey ☺

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