IMPLEMENTATION OF CLINICAL PRACTICE GUIDELINES FOLLOWING ACUTE SPINAL CORD INJURY

by

Laura Ann McClure

B.S. Health Science, Duquesne University, 2003

M.S. Physical Therapy, Duquesne University, 2004

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This dissertation was presented

by

Laura Ann McClure

It was defended on

July 20, 2010

and approved by

Rory Cooper, PhD, Chair of Rehabilitation Science and Technology Department

Alicia Koontz, PhD, Assistant Professor of Rehabilitation Science and Technology Department

Mark Schmeler, PhD/OTR, Assistant Professor of Rehabilitation Science and Technology Department

Lee Kirby, MD, Professor of Physical Medicine and Rehabilitation in the Department of Medicine at Dalhousie University

Dissertation Director: Michael Boninger, MD, Chair of Physical Medicine and Rehabilitation Department

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Laura A. McClure, PhD

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Individuals with spinal cord injuries who use a wheelchair for full time mobility are at high risk for developing upper limb pain and dysfunction, which can negatively impact functional mobility and quality of life. Due to the detrimental effects, the Consortium for Spinal Cord Medicine and the Paralyzed Veterans of America developed a clinical practice guideline (CPG) to educate clinicians on upper limb preservation methods. Past research has found that passive implementation of a CPG does not change clinical practice and a structured program is needed for effective education. In this dissertation, we have developed a strict protocol to implement the CPG and performed a randomized clinical trial to determine if new wheelchair users who were strictly educated on the CPG have better functional mobility skills, wheelchair characteristics and lower pain. During the course of the study, we found no objective method to evaluate the quality of a transfer. Therefore, an original outcome measure was developed. We evaluated the tool and found that it is safe, can be completed in a short amount of time and has a wide range of reliability and validity. Refinements are necessary, but the tool fills a substantial void in the area of transfer evaluation. The newly created outcome measure was used to evaluate the transfer skills of participants in the randomized trial. A trend in the data found that participants who were strictly educated on the CPG performed better transfers at six months post discharge. The same group of participants was evaluated on wheelchair set up, selection and manual wheelchair propulsion skills. No differences were found between groups based on wheelchair set up and

selection; however those strictly educated on the CPG propelled with significantly lower normalized peak resultant forces at six months post discharge. Finally, results found that individuals who were strictly educated on the CPG reported higher pain during movement activities at six months post discharge, although this may be due to increased awareness. The new outcome measure and structured education program are important tools to improve care provided during acute rehabilitation for full time wheelchair users with spinal cord injuries.

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PREFACE

I would like to take the opportunity to thank everyone that has helped through this process. This work was by no means done independently. I have had the wonderful opportunity to work with many very intelligent people who are extremely committed to the area of spinal cord injury research and rehabilitation. I am honored to be in your company.

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1.0 INTRODUCTION

1.1.1 Overview

Full time wheelchair users affected by spinal cord injury (SCI) are at high risk for developing upper limb pain and dysfunction, which can negatively impact functional mobility and quality of life. Due to the detrimental effects, the Consortium for Spinal Cord Medicine and the Paralyzed Veterans of America developed a clinical practice guideline (CPG) to provide recommendations to clinicians on upper limb preservation methods. Research has shown that passive implementation of CPG frequently results in low adherence to the recommendations; therefore a strict and structured program is needed to effectively educate clinicians. The purpose of this dissertation is to 1) develop a strict education protocol to educate clinicians and individuals with new SCI on the clinical practice guidelines, 2) determine if the strict education protocol has a positive impact on transfer skills, wheelchair set-up and selection, manual wheelchair propulsion skills, and pain levels, and 3) develop an objective tool to measure the quality of a transfer. To achieve aim 1, original education materials were created and a strict and structured protocol was developed. To achieve aim 2, a longitudinal randomized clinical trial was conducted with two treatment groups. An intervention group received Physical and Occupational Therapy from clinicians who have been rigorously educated on the CPG. A standard of care group received the status quo treatment. All study participants were first time wheelchair users who were receiving

their initial course of therapy after sustaining a SCI. Individuals were followed for six months after discharge from acute rehab. To achieve aim 3, an original outcome measure was developed. The reliability and validity of the instrument was tested by four Physical Therapists who evaluated 40 full time wheelchair users who performed sitting or standing pivot transfers.

1.1.2 Causes and Frequency of Upper Limb Dysfunction

Many believe that upper limb pain and dysfunction is a consequence of cumulative mechanical stresses on the upper extremity from daily living activities such as transfers, overhead activities, wheelchair propulsion, household chores, dressing, bathing, etc. [1-4]. The shoulder is a joint designed for mobility, not load-bearing. The combination of highly repetitive tasks performed at high frequency throughout the day on a joint that was not designed to tolerate high forces, places the upper limb at a substantial risk for overuse injuries. Manual wheelchair users reported that upper limb pain is the highest when pushing up ramps, lifting objects overhead and performing transfer related activities [5-6]. A frequent cause of chronic shoulder pain is through a disruption of the rotator cuff (often referred to as impingement syndrome)[1, 3, 7-8]. Impingement occurs when the rotator cuff tendon insertions at the greater tuberosity of the humerus are in close proximity to the undersurface of the acromioclavicular joint. If the humerus is moved upward, which often occurs during the weight bearing portion of a transfer, the rotator cuff is compressed under the acromioclavicular joint, causing pain and dysfunction. If the rotator cuff is inflammed from overuse injury, impingement may occur. [9] Another cause of shoulder pain is due to repetitive strain injuries[10]. Repetitive loading of the shoulder, which occurs during manual wheelchair propulsion may lead to acromioclavicular joint abnormalities, coracoacromial ligament thickening

and edema, subacromial spurs, and biceps tendinitis and tears. [1, 11-13] Repetitive movements at the wrist can lead to carpel tunnel syndrome (CTS), causing significant pain and activity limitation[14].

Silfverskiold et al[15] evaluated 60 individuals in the first 6 months of injury and found that 78% of persons with tetraplegia and 35% of persons with paraplegia reported non traumatic shoulder pain and associated functional disability. Similarly, Waring et al's [16], evaluation of 52 persons with tetraplegia found that 75% of participants had shoulder pain in the first six months after injury. Pain has been found to be a factor as soon as 2-3 months after injury. Van Drongelen et al[17], found in 169 people, 55% while still in an acute rehabilitation facility reported shoulder pain. Persons with tetraplegia reported greater pain levels compared to people with paraplegia[17]. Greater reports of pain by persons with tetraplegia early after injury may be due to the presence of neuropathic pain. It is widely believed that upper limb in the long term is caused by repeditive stresses[18]. In the first several months after injury however, neuropathic pain have more of an impact and cause greater problems for individuals with higher level injuries.

Pain is not limited to the first year after injury. Of individuals who have been injured at least 10 years, 31 to 73% report shoulder pain [1-3, 7, 19]. Elbow, wrist, and hand pain was present in 16%, 13%, and 11% of individuals, respectively[2-3, 7, 17]. Alternatively, other studies have shown the prevalence of forearm, wrist, and hand pain to be between 8% and 55% [2]. Carpal tunnel syndrome symptoms were found in 49% to 73% of participants [7, 18, 20-23]. The presence of both acute and chronic pain indicates that there is a significant need for early and continued education on preservation of upper limb function.

1.1.3 Effects of Upper Limb Dysfunction on Quality of Life

Because individuals living with SCI rely extensively on their upper extremities for mobility, any loss of function significantly affects independence.[2, 15, 24-25] In addition, upper limb dysfunction has been found to significantly decrease quality of life and increase financial burden.[26] Twenty-six percent of individuals with upper limb pain reported that they need additional help with ADLs and 28% report independence limitations.[27] Gerhard, et al found upper limb pain to be one of the major reasons for functional decline.[28] Several experts suggest that damage to the upper limbs may be functionally and economically equivalent to a SCI of a higher neurological level.[7] Once an individual acquires pain and/or injury, treatment usually does not provide a significant amount of relief, due to the inability to completely rest the extremity [23]. Prevention of upper limb pain is the best method to preserve functional independence and quality of life.

1.1.4 Publication of the Clinical Practice Guidelines

In response to the high frequency and significant impact of upper limb dysfunction, the CPG: Preservation of Upper Limb Function Following Spinal Cord Injury[29] was developed by the Consortium for Spinal Cord Medicine and Paralyzed Veterans of America (PVA). A CPG is defined as " systematically developed statements to assist practitioners and patients in making decisions about appropriate healthcare in specific circumstances."[30] Healthcare organizations and insurance companies support the use and development of CPG as a method to improve patient care.[31] This specific guideline was developed to educate clinicians who work with individuals

with SCI about the key concepts of prevention of upper limb pain and preservation of function. Specifically, the CPG provides recommendations on the correct methods of performing transfers, wheelchair propulsion and other ADLs in a manner that will not cause pain or deterioration of the upper limb. The CPG was extensively researched, peer reviewed and published by the PVA in 2005 [29].

Prior to the publication of the CPG, no comprehensive document existed on treatment and prevention of upper extremity dysfunction. Clinicians had to review the literature independently and make their own judgments on which recommendations were the most important and based on strong research methodologies. A review of rehabilitation interventions by Kirshblum [32] in 2004 provided an overview of important aspects of treatment and prevention, however; the quality of the research was not evaluated and treatment recommendations were not made by a committee of experts . In addition, the paper did not encompass the full range of treatment and prevention methods that are detailed in the CPG. The CPG is the first document to survey all of the available research on upper limb pain and dysfunction related to SCI, evaluate the quality of the research and provide comprehensive recommendations.

1.1.5 Clinical Practice Guideline Content

Transfers

Transfer activities have been found to have a substantial impact on upper extremity pain and dysfunction. An individual with SCI typically performs 14-18 transfer per day.[33-34] Sixty-five percent of participants with upper extremity dysfunction evaluated by Dalyan, et al[27] reported that pain interfered with their ability to perform transfers. Bayley, et al[1] evaluated intra-articular

shoulder pressure in people with paraplegia and found it to be 2.5 times that of arterial pressure. Bayley hypothesized that the increased pressure may lead to degenerative changes in the shoulder[1]. A sitting pivot transfer is the most common transfer performed.[35] The individual remains in a sitting position, places one hand on the surface he/she is transferring to, and one hand on the current sitting surface. The buttock is lifted and moved to the new surface. While the buttock is lifted, a large amount of the individual's weight is supported by the upper limb.[35-36] The CPG and other recently published studies provides several recommendations on independent and assisted transfer ergonomics.

1. An individual should attempt to alternate which limb they lead with to avoid putting excessive stress on one side. Research has found that horizontal reaction forces were higher in the trailing limb, regardless of seat height.[37]
2. Individuals should attempt to avoid a position of shoulder impingement during the weight-bearing portion of the transfer. This concept has not been evaluated specifically in relation to transfers but has been extensively researched in ergonomic literature[38]. When the shoulder is in a position of impingement (forward flexed, internally rotated and abducted) the rotator cuff tendons are in close proximity to the acromioclavicular joint. During the weight bearing part of the transfer, the humerus is pushed upward and further compresses the tendon.[38] If the tendon is already inflamed, significant pain may ensue.
3. Transfers should be performed to level surfaces, whenever possible. Gagnon, et al reported that when transferring to higher surfaces, the limb on the upper surface performed more work [37] Greater shoulder and elbow joint angle displacements [39] along with increased muscle activity in the biceps, deltoid and pectoralis major, were

found.[40] While it is impossible to avoid performing uneven transfers, wheelchair users should be educated to set up their environment so that frequently performed transfers (to/from bed, toilet sets, car seats) are level.

4. During a transfer, a handgrip should be used whenever possible. How the hand is placed may increase the risk of developing wrist pathology [29]. The combination of extreme range of motion in both the leading and trailing wrists and high forces involved, transfers likely play a role in the development and exacerbation of CTS symptoms [39, 41]. If a grip is not available or would force the user to move his/her upper extremity outside of the base of support, the hand should be placed on a flat surface.

Other aspects of transfers not evaluated by research have been incorporated into the education materials. These recommendations have come from the clinical experience of a panel of experts who have worked with individuals with SCI for several years, wheelchair users and a recently published guideline on transfer education[42]. Clinically base recommendations include, set up the transfer to be as easy as possible, decrease the distance of the transfer and consider the use of a transfer device (such as a transfer board or lift) in the presence of weakness or obesity.

Finley, et al[34] found that wheelchair users with a history of shoulder impingement syndrome performed transfers with reduced thoracic flexion, increased scapular internal rotation, and increased humeral rotation compared to those without impingement.[34] This position typically leads to further injury and pain. Therefore, once an individual develops upper limb pain, it is difficult for them to recover from the impairment.

Little research has been conducted on dependent transfer ergonomics; therefore the majority of recommendations come from expert opinion. Individuals who are transferred in a dependent

manner typically have higher, cervical level injuries. Seventy-eight percent (78%) of individuals with tetraplegia report shoulder pain [15] therefore it is even more critical that these individuals are transferred in the correct manner. During a dependent transfer, the upper extremity needs to be well supported. Individuals with SCI, particularly higher level injuries, often have significant muscle imbalances, leading to shoulder subluxation [43]. Allowing the upper extremity to hang in a dependent position during a transfer can cause pain and damage to the shoulder anatomy. In addition, caregivers must not pull on the upper extremity. Pulling can disrupt many of the tendons and ligaments in the upper extremity leading to increased pain and dysfunction.

Wheelchair Set Up and Selection

An important and often overlooked component of upper extremity preservation is the proper set up and selection of a mobility device. Both manual and power wheelchairs have pros and cons that should be considered prior to selection. Often the option of power mobility is not discussed with MWC users until persistent upper extremity pain is present. At this time it is often too late to prevent permanent damage from occurring. The pros and cons of both devices should be discussed at the on-set of wheelchair selection to allow the individual to make an informed initial choice and to be aware that if upper extremity pain begins, power mobility maybe necessary to prevent permanent damage.

If a MWC is chosen, the user must be aware of the signs and symptoms of upper extremity injury and educated to notify a clinician if problems arise before it becomes debilitating. In addition, the chair should be optimally configured for the user. The CPG and other recently published literature provides many recommendations on manual wheelchair set up and selection.

1. **Chair Weight:** A MWC user should have the lightest possible wheelchair that can be adjusted to his/her specific needs.[44] A lighter chair will reduce rolling resistance, which in turn reduces the forces the individual must use during propulsion [45]. Increased weight (along with a posterior axle position) has also been found to correlate with increased peak forces[46]. Individuals should be educated that additional accessories added to the chair, such as backrests, arm rests, and wheels locks add weight.
2. **Adjustability:** Ultra light chairs also allow for adjustability of axle position that is not available in lightweight or depot style manual wheelchairs. Moving the rear axle as far forward as the user can safety tolerate, reduces rolling resistance and forces during propulsion.[47-48] The vertical position of the rear axle also has an impact on propulsion efficiency. If full elbow extension is 180 degrees, when the user's hand is at the top dead-center of the wheel, the elbow angle should be between 100-120 deg.[29] If the user's elbow angle is >120 deg., the amount of the pushrim which can be contacted is reduced[49-50] and a higher stroke frequency must be used[50]. If the elbow is <100 deg., the individual must place his/her arms in a position of extreme abduction, increasing the risk of shoulder impingement syndrome. [48]

If the wheelchair users has weak upper extremity muscular function (either due to injury level or prior athletic conditioning), upper extremity injuries (either prior to injury or since injury), lives in a challenging environment (one with multiple hills, difficult terrain to traverse, etc), is obese, or is affected by other pre-morbid conditions that may make wheelchair propulsion difficult and inefficient, a power wheelchair is the correct choice. Power wheelchairs also must be set up correctly to preserve upper limb function.

1. **Upper extremity support:** An individual with weak shoulder musculature should have sufficient upper extremity support to prevent shoulder subluxation. An arm trough, tray or a wide armrest can be utilized.
2. **Tilt-in-space and Recline Power Seat Functions:** Tilt-in-space and recline systems are necessary to reduce the amount of stress placed on the shoulder to perform a weight shift. Coggrave & Rose[51] reported that for compressed tissue to return to unloaded levels, a pressure relief should be performed for two minutes. Performing a wheelchair pushup for two minutes is impractical and places a significant amount of stress on the shoulders, leading to repetitive strain injury.[1,9] Using power seat functions to perform a weight shift instead of a wheelchair push-up reduces the amount of stress placed on the shoulder. The use of power seat functions also reduces the number of transfers performed. Instead of transferring out of his/her chair to change position, an individual can use the tilt-in-space and/or recline seat functions to increase comfort.
3. **Power seat elevators:** A seat elevator decreases the amount of overhead activities the user must perform. Research has found a significant relationship between overhead activity and the development of shoulder pain. [52] If the individual is trying to reach an item on a high shelve, he/she can rise up to the level of the item, instead of performing an overhead reach. A seat elevator also reduces the number of uneven transfers performed.[53]

Manual Wheelchair Propulsion:

Manual wheelchair users will push with their upper limb 2500 times per day[54] with a stroke cycle time less than a second[55]. During propulsion, a high amount of force is placed on the shoulder, most commonly in the posterior direction.[55-56] Research has found that particular components of a wheelchair propulsion stroke, namely cadence, magnitude of force and hand pattern during the non-propulsive portion of the stroke are related to injury. [44] Educating an individual how to properly propel a wheelchair is a realistic method to decrease upper extremity injury. Boninger, et al stated in his 1999 study that "It may be that simple training to incorporate smooth, low impact strokes would reduce the chance of median nerve injury.[57]" The CPG recommends that wheelchair users **decrease the number of propulsion strokes**. Decreasing the frequency of propulsion will diminish the prevalence of repetitive strain injuries at the shoulder and wrist[58-63]. Boninger et al[57] found that the more often the pushrim was contacted, the less healthy the median nerve. To decrease the number of strokes taken, MWC users are educated to **use long, smooth strokes**. By taking long, smooth strokes, the user will minimize the amount of force used. Both cross-sectional and longitudinal studies have found that high forces correlate with injuries and/or pain at the wrist[58-59, 61] and shoulder[64-65].

1.1.6 Implementation of Clinical Practice Guidelines

Effective utilization of a CPG is complex. Research has shown that distribution of guidelines without additional implementation efforts is not effective[66] and structured strategies are needed to make changes in clinical care.[67] Goetz, et al found poor clinician adherence when guidelines were passively published and distributed[68].

The type of educational materials utilized and environment in which the guidelines are implemented have an impact on how well clinicians learn and retain information. Single-strategy approaches (using only one form of instruction) are not related to improvement. [67] In contrast, multi-faceted approaches were found to be effective. Some of the most effective include identification of specific barriers to guideline implementation, use of detailed education materials[69], and use of multiple forms of education [67].

In preparation for the study, original materials were developed to educate both clinicians (Appendix A) and patients (Appendix B) on the CPG. A multi-faceted implementation strategy served as the basis of the protocol.

1. *Identification of barriers:* Identification of barriers is comprised of assessing the clinician's environment to determine what is preventing him/her from utilizing a guideline to the full extent. Such barriers usually consist of time constraints, work overload and lack of financial backing.[70] The largest barrier associated with the GPG is that the information is presented in a 36 page booklet. This relative length is typical of most CPG. Reading a 36 page booklet can be a daunting task for a clinician with a full patient load. To overcome this barrier, the format of the guideline was modified and broken down into educational modules. The modules were grouped by areas of education and re-formatted into a clinically friendly version. In total, nine modules were created. Within each module, specific tasks defined by the CPG were identified. For each task, performance criteria were identified in an attempt to help the clinician determine if the patient had a firm grasp on the information. The CPG was also divided in many different forms including

charts and flow sheets to assist clinicians who respond to different learning techniques.

2. *Detailed Education Materials:* Michie and Johnston found that 67% of clinicians followed guidelines that were concise and well written compared to only 36% of clinicians who followed guidelines that were vague and open to interpretation.[69] In general, the more specific a guideline can be, the more likely it will be successful.[71] Very specific and non-ambiguous statements have been found to be the best understood and remembered.[72] The guidelines were re-written into specific statements in which the least amount of alternative interpretation was possible. Language used in the materials was specific to the intended user's level of education.
3. *Multi-Media Education:* Reliance on one method of education, especially only paper based, printed materials, has not been found to be successful.[73-76] A combination of methods including printed materials, web sites, multi-media (such as videos and pictures) and education by experts in the field has produced positive results. A web-site was developed that attempts to incorporate many learning styles and educational formats[77]. On the site, both clinician and patient educational materials are posted. The clinician has the option to print these materials to be used during his/her session or work with them on the website. Because the patient does not have access to the website, the clinicians are instructed to print the materials for the patients. A video displaying the proper way to perform a transfer and wheelchair propulsion was developed and is also posted on the website. In addition, these videos are burned on DVDs for the participants to take home. A quiz was developed to assess the amount of information the clinician has learned and is available on the website.

2.0 RELIABILITY AND VALIDITY ANALYSIS OF THE TRANSFER ASSESSMENT INSTRUMENT

2.1 ABSTRACT

Objectives: To describe the development and evaluate the reliability and validity of a newly created outcome measure, the Transfer Assessment Instrument (TAI), to assess the quality of transfers performed by full-time wheelchair users.

Design: Repeated Measures

Setting: 2009 National Veterans Wheelchair Games in Spokane Washington.

Participants: A convenient sample of 40 full-time wheelchair users who performed sitting pivot or standing pivot transfers.

Main Outcome Measures: Intraclass Correlation Coefficients (ICCs) for reliability and Spearman correlation coefficients for concurrent validity between the TAI and a global assessment scale (0-100 visual analog scale [VAS]).

Intervention: Not Applicable

Results: No adverse events occurred during testing. Intra-rater ICCs for 3 raters ranged between 0.35 to 0.89 and inter-rater ICC was 0.642. Correlations between the TAI and a global assessment VAS ranged between r = 0.19 (p=0.285) and 0.69(p>0.000). Item analyses of the

tool found a wide range of results, from weak to good reliability. Participants found the TAI to be safe and able to be completed in a short period of time.

Conclusion: The TAI is a safe, quick outcome measure that utilizes equipment typically found in a clinical setting and does not ask participants to perform new skills. Reliability and validity testing found the TAI to have acceptable inter-rater and a wide range of intra-rater reliability. Future work indicates the need for continued refinement including removal or modification of items found to have low reliability, improved education for clinicians and further reliability and validity analysis with a more diverse subject population. The TAI has the potential to fill a needed void in assessment of transfers.

KEYWORDS: Outcome Measures, Transfers, Reliability and Validity

LIST OF ABBREVIATIONS:

US = United States
SCI = Spinal Cord Injury
TAI = Transfer Assessment Instrument
CPG = Clinical Practice Guideline
MWC = Manual Wheelchair
NVWG = National Veterans Wheelchair Games
DGI = Dynamic Gait Index
ICC = Intraclass Correlation Coefficients
VAS = Visual Analog Scale
WST = Wheelchair Skills Test

McClure LA, Boninger ML, Ozawa H, Koontz A. Reliability and Validity Analysis of the Transfer Assessment Instrument *Arch Phys Med Rehabil*. (In Press).

2.2 BACKGROUND

People with mobility impairments who are full time wheelchairs users perform transfers frequently to complete basic activities of daily living (ADLs), such as getting in and out of bed, on and off a tub/shower seat, commode, and motor vehicle seat. Transfers, along with wheelchair propulsion, weight relief and overhead reaching have been identified as key activities leading to the development of shoulder pain and injury[27]. Pain and overuse injuries are significant, leading to increased healthcare expenses, limitation in activity, depression, decreased societal participation and a reduced quality of life [78]. In a survey of 130 individuals with SCI, 65% reported that pain interfered with their ability to transfer[27]. Transfer skills are also important to a wheelchair user's safety. Between 1973 and 1987, 8.1% of falls (reported to the U.S. Consumer Products Safety Commission) were related to transfers.[79] Research on wheelchair related accidents found that performing sideways transfers without a board was one of the factors associated with increased risk of accidents and falls.[80]

When an individual first requires full time use of a wheelchair he/she typically participates in some form of rehabilitation therapy, where education is provide on how to perform an appropriate, safe and efficient transfer. Obtaining independence with transfers is typically a top goal of both patients and therapists because transfers are needed to perform many critical functional activities. Even with such an emphasis placed on transfers, there is wide variation in the amount and type of training provided[81] and no uniform way to evaluate transfer quality. Observation by a therapist and qualitative assessment is the standard method of evaluating transfers. Research on clinical assessments have found that subjective evaluations are

less precise compared to objective measurement tools[82].Currently, there is no validated tool to assess the quality of transfers and to identify where improvements are needed.

The purpose of this study is to investigate the safety, feasibility, validity and the intra- and inter-rater reliability of the Transfer Assessment Instrument (TAI), a newly developed outcome measure to assess transfer quality.

2.3 METHODS

2.3.1 Description

The TAI was designed to be used by clinicians to evaluate transfer quality and a patient's adherence with 'best' transfer techniques. The current version of the TAI provided in Appendix C. The instrument assesses conservation of upper limb function, safety and how well a person can direct a caregiver to assist him/her with a transfer, if necessary. Initial items on TAI were based on CPG recommendations[29], review of current transfer literature[42, 83], and techniques that have been successfully used in the clinic. The tool is set up to evaluate independent, modified independent (transfers with the use of assistive devices, including transfer boards), human assisted transfers, and dependent transfers (using only human assistance or human assistance and a lift.) The TAI is made up of two parts. In part 1, a transfer is broken down from start to finish into small components and the individual is evaluated on each of these small components. Part 2 evaluates the individual's global performance on quality, conservation techniques, safety and, direction of care.

The tool is intended to be used by clinicians (typically Occupational and Physical Therapists) who instruct full time wheelchair users on transfer skills and have been trained to use the outcome measure.

2.3.2 Development

During a literature review of transfers to develop the clinical practice guidelines (CPG) for preservation of upper limb function following acute spinal cord injury [29], no measurement tool was found to objectively evaluate transfer skills and performance. Researchers concluded that an outcome measure was necessary to determine if wheelchair users were following the recommendations described in the CPG. The TAI was developed in a similar manner to the Wheelchair Skills Test (WST)[84-85] Berg balance test[86] and dynamic gait index (DGI)[87] which are all clinically useful and highly reliable outcome measures. Tool development and content validity was established via focus group meetings with an interdisciplinary, expert panel of rehab professionals with either experience in teaching transfers or personal experience due to disability. This team worked to reach consensus on the items and the domains considered essential for a 'global' measure of transfer construct: 1) preparing for the transfer (e.g., setup of the wheelchair with respect to the target surface), 2) use of conservation techniques (e.g., alternating leading/trailing arm, using handgrips when appropriate), and 3) quality of the transfer (e.g., smooth and controlled, avoiding impingement positions when weight-bearing). The results of the focus group were compiled and the two part scoring protocol was developed.

2.3.3 Scoring

The tool is divided into two portions. The first section has 17 items and scores participants on a categorical scale of yes/no/not applicable. An answer of "yes" equals one (1) point, "no" equals zero (0) points, and "not applicable" items are removed. All items are added together, multiplied by 10, and a score from 0-10 points is obtained. The second, 12- item portion, is scored on a Likert scale ranging from 0 (strongly disagree) to 4 (strongly agree). Similar to the first section, all applicable items are added together, multiplied by 2.5, and a score from 0-10 points is obtained. The two scores are averaged and one final score is reported (Range: 0-10).

Total score: Part 1 x 10 Total Score: Part 2 x 2.5

_____+_____= (Score /2) = Final Score

# of applicable items # of applicable items

The same scoring sheet is used for both manual and power wheelchair users.

2.3.4 Refinement

Initial reliability and validity was tested on one study participants as she performed 4 transfers. The reliability of each portion of the tool was evaluated separately; therefore a range of ICC's is reported. Results yielded weak to acceptable intra-rater reliability (ICC = 1.00-.369) and inter-rater reliability (of 4 raters) (0.601-0.271). From the initial reliability evaluation and feedback

from clinicians and researchers, refinements were made to improve the tool. Changes were integrated into the current version of the tool shown in Appendix C.

2.3.5 Subject Recruitment and Screening

Reliability testing of the TAI was performed at the 2009 National Veterans Wheelchair Games (NVWG). Individuals were approached at random by study investigators and asked to participate. Individuals who were willing to participate signed an informed consent document approved by the Veterans Association, Pittsburgh Health System IRB approval board. Each participant met the following inclusion criteria: 1) between 18-110 years of age; 2) used a wheelchair for >40 hours per week; 3) English speaking; 4) Free of open pressure sores. We included participants with all types of impairments that required full time wheelchair use.

2.3.6 Testing Protocol

General demographic information and the type of transfer the person performed were recorded. Participants either performed a standing pivot transfer, where the individual stands up, takes 1-2 small steps and sits on the target surface or a sitting pivot in which the individual remains in a sitting position, places one hand on the surface he/she is transferring to, and one hand on the surface that he/she is currently sitting on. The buttock is lifted and moved to the new surface. Study participants were then asked to transfer from their own wheelchair to a mat table.

Participants were told that if they needed assistance they could ask either their caregiver or one of the study raters (a licensed physical therapist) to help. Transfer devices were allowed, if needed. Participants performed up to 4 transfers, depending on activity tolerance. One transfer was considered moving in one direction either from a wheelchair to a height adjustable, soft mat table or from the mat table to the wheelchair. As the participant was performing the transfers, four physical therapists (with 6-12 years of experience) evaluated the transfer. Three of the therapists used TAI and one rated participants with a global rating scale. Study participants returned 4 to 72 hours later and perform the transfer portion of the protocol again.

2.4 DATA ANALYSIS

For each rater and individual item, descriptive statistics were calculated and the distribution of items was examined to evaluate potential floor/ceiling effects. Items with low/high means, small standard deviations and small variances, were considered to have a floor/ceiling effect. Interclass correlation coefficients (ICC) were calculated to determine intra-rater reliability of each rater and inter-rater reliability of all 3 raters in both sessions for each item. ICCs were also calculated for each part of TAI and the total score to determine the intra-rater reliability of each rater and inter-rater reliability of each session. A priori, based on previous studies evaluating reliability, we decided that ICC >0.8 indicate good reliability, 0.6-0.79 is acceptable, 0.40-0.59 is moderate and < 0.39 is weak.[87-88] Spearman's rank correlation coefficients were calculated to determine the correlation of each rater's total TAI scores with a global assessment of the transfers in session 1 (the global assessment was only completed in session1). The global

assessment evaluates the quality of the transfer on a single 100 mm visual analog scale (VAS) reflecting the global quality of each transfer (Appendix D). The VAS was anchored by 0 (poor transfer) and 100 mm (excellent transfer).

2.5 RESULTS

2.5.1 Participants

Fifty veterans at the 2009 NVWG participated in the study. Demographic characteristics of participants are listed in Table 1.

Variable	Units	n	Values
Age	Years (SD)	40	51.7 years (SD = 11.3)
	Range		27-74
Sex	Male	34	85.0%
	Female	6	15.0
Diagnostic Category	Spinal Cord Injury (SCI)	32	80.0%
	Multiple Sclerosis	4	10.0
	Brain Injury	1	2.5
	Amputation	2	5.0
	Guillan-Barre	1	2.5
Time Since SCI	Years (SD)	31	16.9 years (SD =10.7)
	Range		1-41
Method of Transfer	Sitting Pivot	30	75.0%
	Standing Pivot	10	25.0
Type of Wheelchair	Manual Wheelchair	28	71.8
	Power Wheelchair	11	28.2
Type of Transfer	Independent	33	82.5
	Human Assisted	7	17.5

Table 1. Demographic Characteristics

All participants completed the entire protocol. Of 50 participants, 40 performed either a standing pivot or a sitting pivot transfer, the focus of our initial evaluation. A total of 210 transfers were assessed with TAI. Rater 1 evaluated 80 transfers (40 in session 1, 40 in session 2), rater 2 = 64 transfers (39 in session 1, 25 in session 2), rater 3 = 66 transfers (39 in session 1, 27 in session

2). Raters 2 and 3 evaluated a limited number of participants in the 2nd session due to time constraints of the raters. The mean total score for all sessions (n = 210) was 7.77, SD = 1.03.

2.5.2 Face Validity

No adverse events, such as falls or injuries occurred. Time required to complete the outcome measure was primarily dependent on how long the study participant required to complete the transfers and if a rest period was needed. Evaluators were able to complete the form associated with the outcome measure in 2-3 minutes. No extra equipment was required to complete the exam. The therapists reported that they felt the tool could be easily integrated into a clinical setting. They also stated that that clarification of some subjective items and additional training would improve their confidence and make the tool easier to use. Study participants reported that the assessment was not difficult and they did not feel uncomfortable with any of the transfers the evaluators asked them to do.

2.5.3 Item Analysis

The distribution of each item was examined. Scores of all items ranged from 0-10 and except for item #17 in part 1, the mean score of each item was >0.50. The distribution of the Likert responses in Part 2 is shown in Table 2 and each item (Part 1 and 2) was examined for potential floor and ceiling affects (Table 3).

Table 2. Likert Scale Distribution

Likert Response *n(%)*	0	1	2	3	4
1	22(11.1)	10(5.0)	13(6.5)	50(25.1)	104(52.3)
2	2 (1.0)	16 (7.7)	15 (7.2)	62 (29.7)	144(54.5)
3	18(9.2)	85(43.4)	20(10.2)	7(3.6)	66(33.7)
4	4(1.9)	8(3.8)	12(5.8)	28(13.5)	156(75.0)
5	14(6.8)	36(17.5)	30(14.6)	69(33.5)	57(27.7)
6	21(10.9)	23(12.0)	2(1.0)	9(4.7)	137(71.4)
7	3(1.5)	3(1.5)	1(0.5)	2(1.0)	195(95.6)
8	3(1.4)	8(3.8)	14(6.7)	44(21.1)	140(67.0)
9	3(5.1)	1(1.7)	0(0)	22(37.3)	33(55.9)
10	6 (25.0)	4(16.7)	3(12.5)	4(16.7)	7(29.2)
11	2 (11.8)	1 (5.9)	4 (23.5)	4 (23.5)	6 (35.3)
12	3 (7.5)	0 (0)	1 (2.5)	18 (45.0)	18 (45.0)

Table 3. Item Analysis

				Intra-rater Reliability			Inter-rater Reliability	
	n	mean	standard deviation	Rater 1	Rater 2	Rater 3	Session 1 ICC	Session 2 ICC
Part 1				n = 40	n = 25	n = 27	n = 38	n = 20
1	210	8.64	3.41	0.748	0.304	0.278	0.550	0.570
2	209	6.12	4.86	0.554	0.243	0.664	0.819	0.739
3	173	9.09	2.80	0.910	-0.077	0.763	0.638	0.586
4	109	5.96	4.93	0.765	0.912	0.913	0.879	0.927
5	207	6.51	4.43	0.939	LV	-0.139	0.121	0.322
6	202	8.89	2.67	0.860	-0.060	0.465	0.556	0.160
7	209	7.86	3.84	0.405	0.687	0.892	0.538	0.535
8	207	7.36	4.10	0.640	LV	0.064	0.417	0.499
9	210	9.69	1.70	LV	-0.071	0.278	-0.054	0.655
10	210	5.17	3.632	0.474	0.669	0.696	0.817	0.851
11	210	5.66	5.00	0.336	0.554	0.756	0.805	0.832
12	210	9.52	1.98	-0.144	0.268	LV	0.333	0.335
13	158	5.52	4.86	0.684	0.248	0.571	0.024	0.438
14	201	8.11	3.62	0.812	0.383	LV	0.021	0.070
15	208	9.48	2.07	-0.072	-0.134	0.895	0.422	-0.171
16	210	9.49	2.09	0.585	-0.076	LV	0.353	-0.131
17	10	3.00	4.83	0.796	0.748	LV	0.754	LV
Part 2								
1	199	7.56	3.35	0.750	0.153	0.517	-0.122	-0.111
2	209	8.23	2.41	0.664	0.273	0.546	0.711	0.406
3	196	5.23	3.70	-0.352	0.581	-0.005	0.020	0.232
4	208	8.89	2.27	0.662	0.014	0.509	0.489	0.584
5	206	6.44	3.12	0.624	-0.088	0.233	0.219	-0.420
6	192	7.84	3.69	0.740	0.880	0.605	-0.273	-0.967
7	204	9.69	1.55	0.643	LV	0.629	0.592	-0.048
8	209	8.70	2.22	0.126	0.622	0.841	0.698	-0.048
9	59	8.43	2.45	0.480	0.287	0.299	0.406	0.939
10	24	5.21	4.03	1.00	0.603	LV	0.404	0.687
11	17	6.62	3.42	1.00	0.297	LV	0.256	0.819
12	40	8.00	2.66	0.890	0.683	LV	0.404	0.3381

LV = Unable to calculate due to low variance

Three items (items #9 and #15 in part 1 and item #7 in part 2) had a potential ceiling effect. Part 2 had a higher average (7.87, SD = 1.30) compared to part 1 (7.69, SD = 1.20). The "not applicable" response was included in the reliability analysis for the specific items. Items with a high frequency of a not applicable responses were found to be highly reliable and used correctly. Intra- and inter-rater reliability showed a wide range from very weak results (-.352) to very good reliability (1.00).

2.5.4 Scale Analysis

Inter- and intra-rater reliabilities of part 1, 2 and total scores are shown in table 4.

Table 4. Intra and Inter-rater Reliability

	Intra-rater n(ICC)			Inter-rater n(ICC)	
	Rater 1	Rater 2	Rater 3	Session 1	Session 2
Part 1	40(0.634)	24(0.34)	27(0.804)	38 (0.671)	23 (0.697)
Part 2	40(0.724)	24(0.35)	26(0.875)	38(0.516)	22 (0.511)
Total Score	40(0.741)	24(0.35)	26(0.893)	38(0.642)	22 (0.649)

Each portion of the tool was assessed individually to evaluate reliability in an effort to improve psychometrics. Related to intra-rater reliability, raters 1 and 3 achieved acceptable results ($\geq$0.634)[88] while the second rater's scores ranged from 0.34 to 0.35, indicating poor results. Rater 3 had the highest intra-rater reliability with all scores $\geq$0.804. Inter-rater reliability results of part 1 and the total score achieved acceptable scores (0.642-0.697), however; part 2 reliability was lower at 0.511-0.516.

2.5.5 Validity Testing

To establish concurrent validity, an independent therapist who had not seen TAI and was not involved with the development of the tool, rated the study participants on a global rating scale (Appendix D) to assess the overall quality of the transfer. This therapist has >10 years of experience working with wheelchair users and was knowledgeable of the clinical practice guidelines on transfers. [29]

Spearman's rank correlation coefficients were calculated for each rater to evaluate the correlation of TAI scores (total) with a global assessment of transfer skills. Correlations range from 0.192 (p = 0.285) to 0.690 (p>0.000) (Table 5).

Table 5. Correlation of Total Score with the Gold Standard (n=33), significance set at p=0.001

Rater	Correlations	p-value
Rater 1	0.279	0.116
Rater 2	0.192	0.285
Rater 3	0.690*	0.000
* indicates significance at p = 0.001		

2.6 DISCUSSION

The purpose of the study was to evaluate the practicality, safety, reliability and validity of the TAI as full time wheelchair users performed standing and sitting pivot transfers. Analysis has found that the instrument can be completed in a reasonable time period, uses equipment readily

available in a therapy clinic, is safe, and participants are not asked to perform an unfamiliar skill. Ease of use is an important factor to improve acceptance as clinicians are frequently resistant to outcome measures, particularly tools that are lengthy and require special equipment[89].

Initial reliability analysis found both intra and inter-rater reliability to be adequate. Intra-rater reliability scores were acceptable for 2 raters and poor for 1 rater. Inter-rater reliability was found to be acceptable for part 1 and total scores, while part 2 achieved moderate reliability. Results indicate a wide variability exists between raters. Rater 1 had past experience using TAI; however rater 2 and 3 used TAI for the first time at the NVWG. Raters 2 and 3 were educated at the same time and in the same manner. Education methods included handouts with an explanation of each item and a description of different scoring scenarios and a short practice session. The wide variability between raters 2 and 3 is significant and necessitates evaluation of a more in-depth education process.

Individual item analysis also found variability between specific items. Intra-rater reliability found 2 items to have poor reliability (<0.39) for all raters and inter-rater reliability analysis found 6 items to have poor reliability in both session 1 and 2. Of the 8 items with poor reliability, 4 were related to hand or shoulder placement. Depending on the position of the evaluator; the hands and shoulders can have limited visibility. Evaluators will be educated on better places to stand when observing the transfer. Also, due to the high frequency of items that evaluate hand and shoulder placement, the 4 questions will be condensed into one or two items. Two of the items were related to transfer surface height. At times the participant may change the height of the surface he/she is transferring toward, but still cannot perform a level or downhill transfer (due to wheelchair or table height limitations). Further education will be provided to evaluators that the participant should be graded on their attempt to change the surface height.

One item evaluates the quality of the transfer. This is a highly subjective item. Other outcome measures, such as the dynamic gait index, [87] have also found subjective items to have lower reliability. Reliability may be improved with a better definition of a smooth and controlled transfer. The final item with poor reliability was related to evaluating the participant's decision-making skills. Evaluators will be further educated on the decision making process (based on CPG recommendations). Several items were removed from the analysis due to zero variance. Additional education will be provided for these items to make sure the evaluators understand the question and are appropriately evaluating the participants.

Item analysis found 3 items to have a potential ceiling effect. Past analysis has indicated that individuals who participate at the NVWG have different subject characteristics compared to wheelchair users in the general population[90]. Potentially the group of subjects evaluated performed their transfers in such a manner that did warrant high scores.

At the current time, no other outcome measure exists to assess transfer quality; therefore comparison of TAI scores with a global assessment was completed to evaluate concurrent validity. Correlations with the global assessment displayed a wide range of variability from 0.19 to 0.69. While changes are necessary, if the scores correlated perfectly, there would be no need for TAI. Moderate correlations indicate that a specific scoring system is necessary to assess transfer skills. The wide range in reliability again highlights the need for a structured education program to improve consistency among raters.

2.6.1 Limitations and Future Work

Limitations to the study must be considered when evaluating the results. Future work will strive to correct present limitations and improve reliability and validity. Using a non-validated tool to evaluate concurrent validity is not preferred but cannot be avoided due to a lack of comparable gold standard. While not preferred[85], this method has been used in similar situations. Because only participants who performed sitting pivot or standing pivot transfers were evaluated, results cannot be generalized to all full time wheelchair users. Future work will focus on testing subjects with a variety of disabilities who perform different types of transfers. Finally, due to differences in subject characteristics of those who compete at the NVWG[90], potential floor effects may be present that were not seen. Additional testing of non-NVWG participants is necessary to determine if the tool is applicable for wheelchair users with different abilities and skills.

In the next version of the tool, the focus will be to improve intra-rater and inter-rater reliability by re-wording specific items found to have poor reliability. Therapists (the population targeted to most frequently use the tool) will be consulted to assist with re-wording specific items. An education program will be developed using current adult education methods and making use of multi-media options. The program will provide an overall description of TAI and explain each item of the tool. Videos will be incorporated so users can watch transfers and be instructed on how the item should be scored. At the end of the program, users will take a quiz to evaluate their overall knowledge of TAI.

2.7 CONCLUSION

Results indicate that TAI is a safe outcome measure that can be administered in a reasonable time period, uses equipment typically found in a clinical setting and does not ask participants to perform an unfamiliar skill. This pilot study establishes the initial reliability analysis of TAI and a basis for further refinement and development of an important outcome measure to assess transfer quality. Future work includes refinement to items with poor reliability, development of an instructional program for clinicians and the verification of validity of each item. After changes are made, additional psychometric testing will be conducted. Initial analysis finds the tool to have value and potential to be easily integrated into a clinic setting. While the tool is in need of further modification, TAI fills a substantial void in the area of outcome measures to evaluate transfer quality. There are no other instruments available to evaluate transfer quality. The TAI gives therapists the first objective measure to evaluate an important skill known to cause upper extremity pain and is necessary for many critical ADLs.

3.0 A RANDOMIZED CLINICAL TRIAL TO EVALUATE THE IMPACT OF THE CLINICAL PRACTICE GUIDELINE: PRESERVATION OF UPPER LIMB FUNCTION FOLLOWING SPINAL CORD INJURY ON TRANSFER SKILLS AND QUALITY

3.1 ABSTRACT

Objectives: To describe the development of a strict education protocol to implement the clinical practice guideline "Preservation of Upper Limb Function Following Spinal Cord Injury" and evaluate transfer quality and skills of individuals with new spinal cord injuries who have been strictly educated on the guideline compared to those who receive standard therapy.

Design: Randomized Clinical Trial

Setting: Acute Model Spinal Cord Injury Systems Rehabilitation Facility and community in Pittsburgh, PA

Participants: A volunteer sample of 52 full time wheelchair users with new spinal cord injuries randomized (1:1) to an intervention and standard of care group

Main Outcome Measures: Comparison of mean scores at three time points to determine if participants who were strictly educated on the guidelines performed higher quality transfers as measured by the Transfer Assessment Instrument.

Intervention: The intervention group was strictly educated on the clinical practice guideline "Preservation of Upper Limb Function Following Spinal Cord Injury" using current adult education techniques.

Results: A trend in the data ($p = 0.082$) found that individuals in the intervention group performed higher quality transfers compared to the standard of care group at discharge and six months after discharge. Manual wheelchair users in the intervention group ($n = 6$) were found to perform significantly better ($p = 0.03$) at six months post discharged compared to manual wheelchair users in the standard of care group ($n = 10$).

Conclusion: Results indicate that participants who were strictly educated on the CPG performed higher quality transfers. Due to the significant problems transfers can cause, improvement in quality may reduce the incidence of upper limb pain and preserve function in the long term.

KEYWORDS: Implementation of Guidelines, Transfers, Spinal Cord Injury

LIST OF ABBREVIATIONS:

SCI = Spinal Cord Injury
CPG = Clinical Practice Guideline
PVA = Paralyzed Veterans of America
TAI = Transfer Assessment Instrument
MWC = Manual Wheelchair
PWC = Power Wheelchair
IG = Intervention Group
SCG = Standard of Care Group
UPMC = University of Pittsburgh Medical Center
IRR = Institute for Rehabilitation and Research
PT = Physical Therapy
OT = Occupational Therapy
ADL = Activities of Daily living

3.2 BACKGROUND

Due to paralysis of the lower extremities, individuals with spinal cord injuries (SCI) need to complete transfers to perform activities of daily living (ADLs).[15, 25, 33] Activities include but are not limited to, getting out of bed, onto a shower bench and into a vehicle. Typically, manual wheelchair (MWC) users perform 14-18 transfer per day.[33-34] Transfers, along with wheelchair propulsion, weight relief and overhead activities largely contribute to the development of upper limb pain and injury [27]. Substantial moments at the shoulders are generated during transfers [37, 91]. A common shoulder pathology related to transfers is impingement of the rotator cuff tendon. Often when performing a transfer, a person places their upper limb in the classic position of impingement with the arm internally rotated, forward flexed and abducted[38]. In this position, the rotator cuff tendon insertions at the greater tuberosity of the humerus are in close proximity to the undersurface of the acromioclavicular joint. When the humerus is moved upward during the weight bearing portion of a transfer, the rotator cuff is compressed under the acromioclavicular joint, causing pain and dysfunction. [9] At the wrist, research has found that both the leading and trailing wrist exceed active physiological extension range of motion. Due to the combination of high forces and extremes of range of motion, transfers likely play a role in the development and exacerbation of carpal tunnel syndrome. [39, 41]

When an individual has difficulty transferring or has upper extremity pain, performance of necessary roles in society is limited. Amongst individuals experiencing upper limb pain, 26% reported they needed additional help with functional activities and 28% reported limitations of independence.[27] Experts have speculated that damage to the upper extremity may be functionally and economically equivalent to a SCI of a higher neurological level.[7] Upper limb pain was found

to be a prominent reason for functional decline in individuals with SCI.[28] In response to the impact of upper limb dysfunction, the clinical practice guideline (CPG): Preservation of Upper Limb Function Following Spinal Cord Injury[29] was developed by the Consortium for Spinal Cord Medicine and the Paralyzed Veterans of America (PVA). The CPG is intended to be used by healthcare professionals and provides recommendations on the correct methods of performing transfers, wheelchair propulsion and other Activities of Daily Living (ADLs) in a manner that is protective to the upper limb. The CPG was extensively researched, peer reviewed and published by the PVA in 2005 [29].

Preventing injury is important because treatment is often ineffective due to a wheelchair user's inability to rest their limbs. [23] The CPG makes several recommendations on transfer performance to prevent the development of pain.

Wheelchair users should be educated to transfer to a surface that is the same height, whenever possible. Gangon, et al, found that transferring to higher surfaces require additional upper limb work.[37] Shoulder and elbow joint angle displacements were greater, [39] and EMG analysis found that muscle activity in the biceps, deltoid and pectoralis major were greater.[40]

Another key factor highlighted in the CPG is that the individual should attempt to alternate which limb they lead with. Research has found that horizontal reaction forces were higher in the trailing limb, regardless of seat height.[37]

Finally, an individual should attempt to avoid a position of shoulder impingement during the weight bearing portion of the transfer. This concept has not been evaluated specifically in relation to transfers but has been extensively researched in ergonomic literature. When the shoulder is in a position of impingement (forward flexed, internally rotated and abducted) the

rotator cuff tendons are in close proximity to the acromioclavicular joint.[38] This can cause significant pain if the tendon is already inflamed.

Despite the importance of transfers, there is wide variation in the amount and quality of training provided in rehab [81]. The purpose of this paper is to describe the development of a structured education program to educate both clinicians and patients on best practices and perform a pilot analysis to investigate the impact of structured education and strict adherence to the CPG recommendations on transfer skills and quality. We hypothesize that due to the education provided; the IG will have superior transfer skills compared to the SCG.

3.3 METHODS

3.3.1 Study Design

A single blind, randomized clinical trial was conducted at the Institute for Rehabilitation and Research (IRR), part of the University of Pittsburgh. The SCI unit at IRR has been designated as a one of 14 model SCI systems (MSCIS) facilities across the United States, by the Department of Education, National Institute on Disability and Rehabilitation and Research[92]. Participants were recruited from patients admitted for acute inpatient rehabilitation following a new SCI between March 2007 and April 2010. To achieve 80% power, we intended to recruite 44 subjects (22 per group). Per approval by the University of Pittsburgh IRB, prior to signing the informed consent participants were screened to determine if they were: 1) between 16-110 years old, 2) first time wheelchair users, 3) had a non-progressive spinal cord injury (SCI) with residual neurological

deficits and 4) if the person's therapist anticipated he/she would be a full time wheelchair user. Participants also completed a modified Mini-Mental State Exam (MMSE) [93]. The exam was modified from its original version by removing any questions that required the participant to physically write. Participants who scored below a 17 out of a possible 25 points were not invited to participate because they may not be able to learn the required skills. If a participant met all inclusion criteria and was agreeable, an informed consent approved by the University of Pittsburgh IRB was signed. After enrollment, individuals were randomized to either the standard of care group (SCG) or intervention group (IG). Because both injury level and gender have been found to have an impact on pain, a stratified randomization scheme was used to ensure that an equal number of males and females and individuals with tetraplegia and paraplegia were assigned to each group. The individual performing the evaluations was blinded to the participant's group assignment. Participants in the SCG received standard therapy treatment. The IG received instruction from a PT and OT who were strictly educated on the CPG.

3.3.2 Development of the Education Protocol

A strict education protocol and original materials (Appendix A & B) were developed to instruct IG therapists on the transfer portion of the CPG[29]. The method of guideline implementation is an important factor in how well clinicians and patients learn and retain information. Factors to consider are identification of specific barriers hindering guideline implementation, and level of detail and format of the education materials.

Typical barriers to effective CPG use that clinicians face include time constraints, work overload and lack of financial backing.[70] The GPG [29] is 36 pages long and contains information

on a variety of topics. The transfer information is scattered through the document, making it difficult for a busy clinician to find the necessary information. To improve ease of use, education modules were created for specific topics, including transfers. All pertinent transfer information was consolidated and organized by the type of transfer being taught. Individual, sub-modules were created for independent, assisted and dependent transfers. All electronic materials were posted on a common share drive and physical materials were stored in a central location to streamline the process.

Research has found that clear and concise guidelines are followed 67% of the time while vague guidelines are only followed 36% of the time [69]. In general, the more specific a guideline can be, the more likely it will be successful.[71-72] Clinicians were consulted during module development to provide feedback on the clarity of the recommendations. The recommendations were re-written in a manner that clinicians felt were clear, concise, sufficiently detailed and easy to understand.

Single-strategy approaches (using only one form of instruction) has been found to be a poor method of instruction, [67] especially if it is not interactive[73-76]. In contrast, multi-faceted, interactive approaches of education were found to be effective. The education modules utilized a combination of education formats. The transfer module includes paper-based handouts that describe each recommendation in sufficient detail, pictures and videos. In addition, the therapists were educated on a variety of motor-learning theories, such as knowledge of results, use of intrinsic/extrinsic feedback, part to whole practice, and contextual variety. The therapists were given recommendations as to when and how to use these theories during the course of the education. Please see the introduction and appendix A and B for additional details.

Similar materials were developed for the patients, written in a manner appropriate for a typical patient's level of understanding. Patients were given the printed materials and a copy of the DVD to take home. Clinicians were able to choose which materials to give to patients and only provided information that is specific to the individual's needs. For example, patients who perform dependent transfers were not given materials on independent transfers. The intervention clinicians were educated on the CPG prior to the start of the study, over a period of several weeks and during the development of the education materials. Prior to the start of the study, IG clinicians took a quiz evaluating their knowledge of the education materials. Both scored 100% and reported that the materials were easy to understand and the method was unobtrusive on their treatment schedule.

Education was provided to IG participants over their entire length of stay. Average length of stay was 44.92 (SD = 16.17) days. There were no significant differences in length of stay between the IG and SCG or between MWC and PWC users.

3.3.3 Transfer Evaluation

Both power and manual wheelchair users were asked to complete up to four transfers, depending on the individual's level of fatigue, to and from either a mat table or a hospital bed. A transfer is considered moving in one direction. The height of either the mat table or hospital bed could be changed or adjusted, depending on the individual's preference. If participants needed assistance to transfer, their primary caregiver was asked to attend the study visit. If the caregiver was unable to attend, the evaluator assisted. Participants were able to use any assistive technology (AT), such as transfer boards or transfer lifts, they required or preferred. Participants performed

the transfer according to their preference. Transfer were classified as: 1) A sitting pivot where the individual remains in a sitting position, places one hand on the surface he/she is transferring to, and one hand on the surface that he/she is currently sitting on. The buttock is lifted and moved to the new surface. The user does not use any type of assistive technology (AT), such as a transfer board. The person may perform the transfer completely independent or ask for minimal to moderate assistance. 2) A sitting pivot transfer using AT. 3) A dependent transfer where the caregiver performs 100% of the physical work without the use of a transfer lift. Participants were instructed to direct his/her caregiver on how to perform the transfer. 4) A dependent transfer with the use of a transfer lift. 5) A standing pivot where the individual stands up, takes 1-2 small steps and sits on the target surface. As participants transferred, the primary blinded evaluator used the Transfer Assessment Instrument (TAI) [94], a newly developed outcome measure to assess transfer quality.

3.4 DATA ANALYSIS

General descriptive statistics were calculated for each study visit (discharge, 6 weeks post discharge and 6 months post discharge.) The time of each study visit was choosen to provide data on the participant's performance directly after the knowledge was aquired, and a short term and long term follow up. We did not evaluate the participant when they were first admitted to rehab because they had not yet learned the skills that we were evaluating. A Shapiro-Wilks test of normality was completed and the data was found to be normally distributed at all time periods except for the IG group at the six week visit. All other assumptions were met. A 2(group)x

3(study visits) mixed analysis of variance (ANOVA) was performed on transfer scores as a function of group assignment and visit time. Each study visit was also evaluated independently by performing independent samples t-tests. Subgroups of participants, based on level of injury, type of transfer performed, and type of wheelchair used were evaluated to determine if any differences existed between groups. A regression analysis was performed to determine if age, SCI level, gender or group is a significant predictor of TAI score at discharge, six weeks and six months after discharge. Significance was set *a priori* at $p = 0.05$. Due to the exploratory nature of the study, no corrections were made for multiple comparisons.

3.5 RESULTS

Seventy-one participants agreed and were eligible to participate. Of 71, 34 (47.9%) were randomized to the IG and 37 (52.1%) to the SCG. Distribution of participants is shown in Figure 1 and demographic characteristics in Table 6. At times, participants enrolled in the study were discharged from acute rehab and then returned. They were "re-screened" when re-admitted, but did not have to be re-enrolled in the study. Some participants had to be withdrawn because the IG group was saturated. The two IG clinicians could only treat a set number of patients at one time. If the clinicians already had a full case load, the participant could not be added. Those participants were withdrawn from the study.

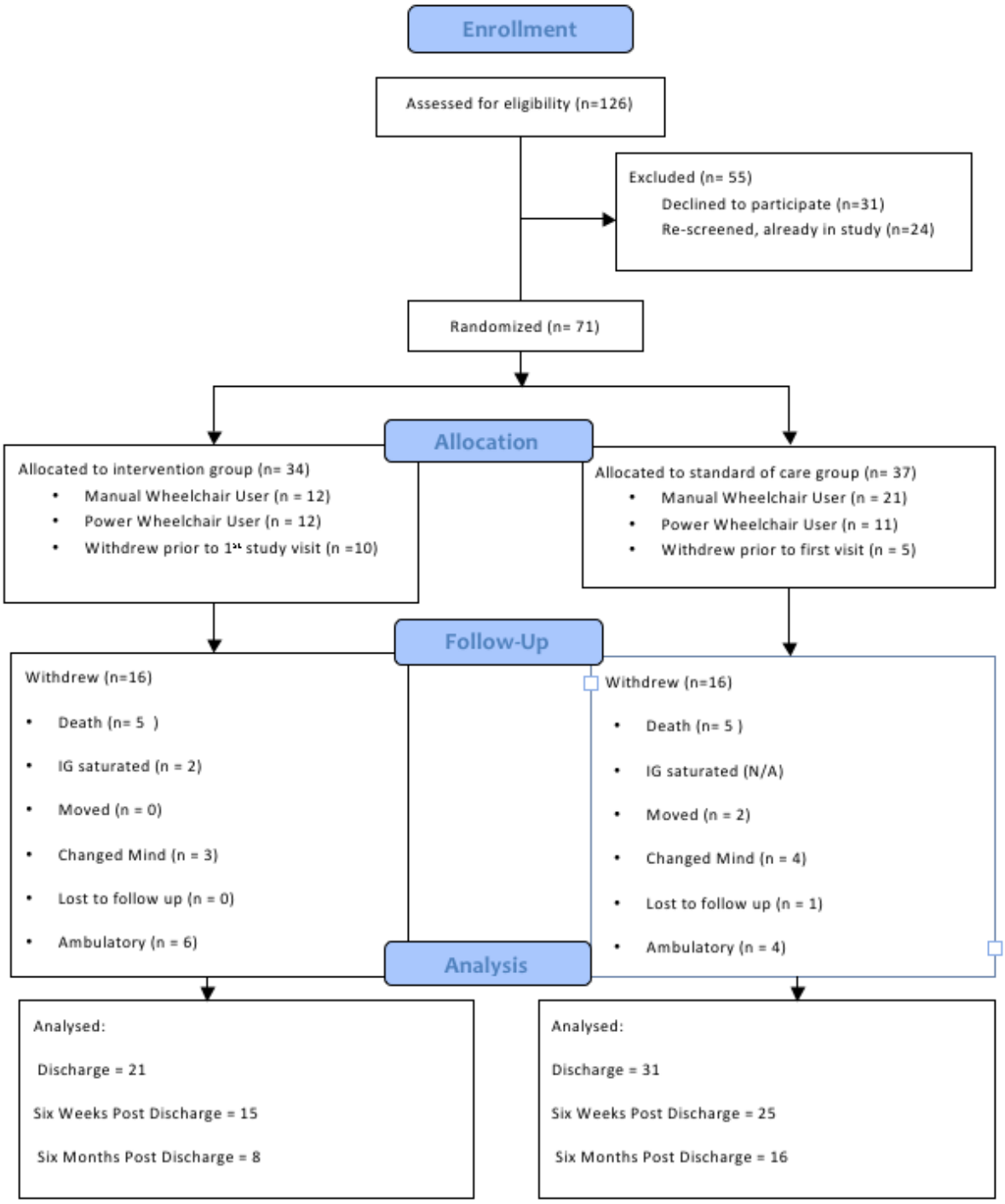


Figure 1. Randomized Clinical Trial Flow Chart

Table 6. Demographics

		IG	SCG	Total	Statistical Difference Between Groups
Age	Mean (SD)	50.83 (19.06)	50.94 (19.06)	50.88 (17.82)	p = 0.980
Gender	Male	23 (67.6)	26 (70.3)	49 (69.0)	p = 0.811
	Female	11 (32.4)	11 (29.7)	22 (31.0)	
Level of Injury	Paraplegia	19 (55.9)	22 (59.5)	41 (57.7)	p = 0.761
	Tetraplegia	15 (44.1)	15 (40.5)	30 (42.3)	
Status	Completed	12 (35.3)	16 (43.2)	28 (39.4)	P = 0.788
	Ongoing	5 (14.7)	5 (13.5)	10 (14.1)	
	Withdrew	17 (50.0)	16 (43.2)	33 (46.5)	
Reason for Withdraw	Cease to Breath	5 (14.7)	5 (13.5)	10 (31.3)	P = 0.490
	IG saturated	2 (5.9)	0 (0.0)	2 (6.3)	
	Moved	0 (0.0)	2 (5.4)	2 (6.3)	
	Changed mind	3 (8.8)	4 (10.8)	7 (21.9)	
	Lost to follow up	0 (0.0)	1 (2.7)	1 (3.1)	
	Ambulatory	6 (17.6)	4 (10.8)	10 (31.3)	
Randomization		34 (47.9)	37 (52.1)	71 (100.0)	

Twenty-eight participants (39.4%) completed the study, 33 (46.5%) withdrew and 10 (14.1%) are ongoing (enrolled in the study, but have not completed the entire protocol). The majority of participants were withdrawn from the study because they were no longer full time wheelchair users (31.3%) or as a result of death (31.3%). None of the participant's deaths were related to study interventions. No significant differences based on age, length of stay, gender, type of wheelchair used or level of injury was found between participants who withdrew and those who completed the study or between study groups. The type of transfer performed at each visit is shown in Table 7.

Table 7. Type of Transfer Performed

	Discharge		Six weeks post discharge		Six months post discharge	
	IG	SCG	IG	SCG	IG	SCG
Sitting pivot, no AT	7(30.4)	8 (25.0)	6 (33.3)	7 (25.9)	5 (45.5)	4 (25.0)
Sitting pivot, with AT	7(30.4)	11(34.4)	5 (27.8)	10 (37.0)	1 (9.1)	7 (43.8)
Dependent, no lift	3(13.0)	5 (15.6)	2 (11.1)	4 (14.8)	2 (18.2)	3 (18.8)
Dependent with lift	4(17.4)	7 (18.9)	2 (11.1)	4 (14.8)	0 (0.0)	2 (12.5)
Standing Pivot	2 (8.7)	1 (2.7)	3 (16.7)	2 (7.4)	3 (27.3)	0 (0.0)
						n(%)

Due to the low number of participants performing standing pivot transfers, those participants were not include not included in the data analysis. Also, an informal reliability evaluation of standing pivot transfers with the TAI was found to be poor. A mixed model ANOVA was performed with participants who completed all three visits. No significant between subject, within subject or interaction effects were found. When evaluating participants who completed all 3 visits, the IG had higher mean TAI scores (indicating a higher quality transfer), although not significantly different, at all time points. Independent samples t-tests were performed for each time point and evaluated all participants including those who did not complete all three visits. No significant differences were found between study groups at any time points, however a trend in the data ($p=0.087$) indicates that the IG had higher TAI scores at six months post discharge. The IG had higher mean TAI scores at discharge and six months and the SCG had a higher score at six weeks. (Figure 2)

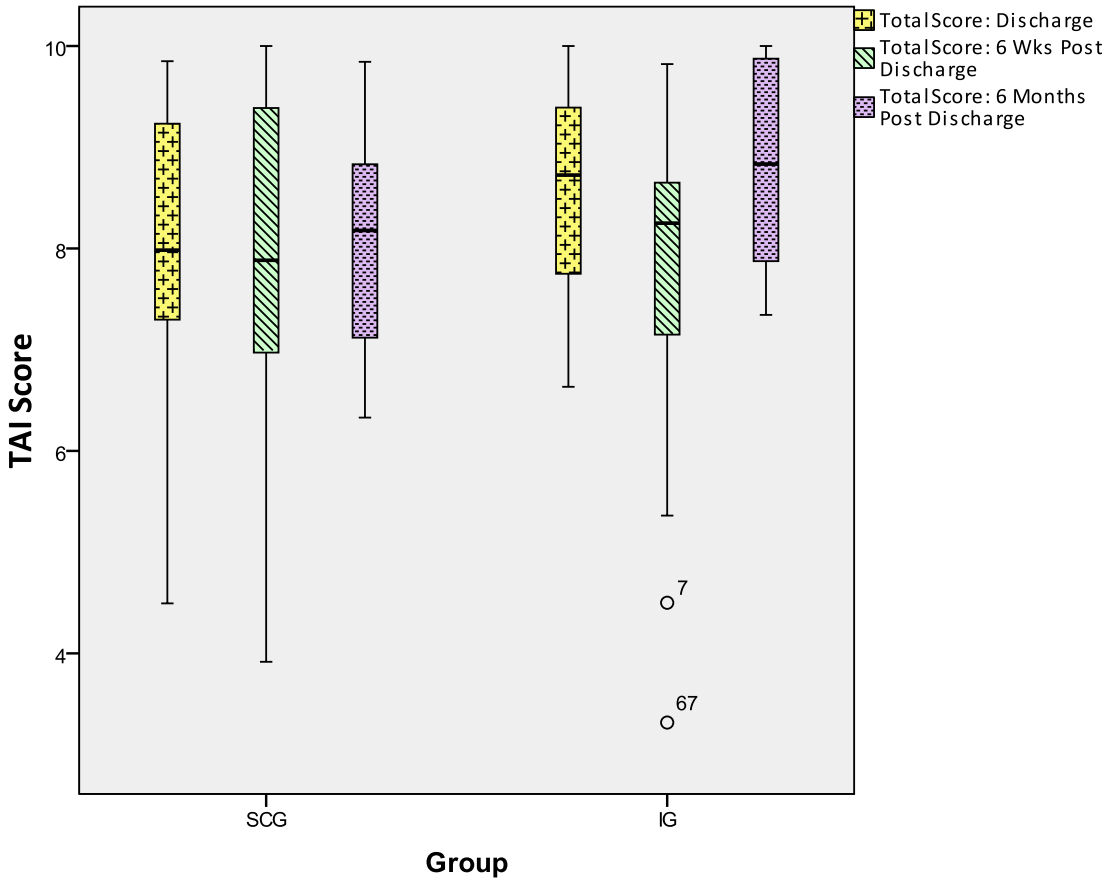


Figure 2. Comparison of TAI Scores at Each Time Point

Additional analysis was performed by looking at specific sub-groups of participants. Participants were divided by level of injury, type of transfer, and type of wheelchair (Table 8).

Table 8. Comparison of TAI Scores at Each Time Point, Split by Variables

		Discharge			6 weeks post discharge			6 months post discharge		
		IG	SCG	p	IG	SCG	p	IG	SCG	p
Level of Injury	Paraplegia	8.34(14)	7.93(18)	0.41	7.86(10)	7.83(16)	0.15	8.24(7)	7.74(9)	0.41
	Tetraplegia	8.85(7)	7.88(13)	0.15	6.74(6)	7.91(11)	0.40	9.26(2)	8.31(7)	0.38
Type of Transfer	Sitting Pivot, no AT	8.31(7)	8.12(8)	0.80	7.42(6)	7.62 (7)	0.76	8.40(5)	7.65(4)	0.30
	Sitting pivot, with AT	8.37(7)	8.28(11)	0.89	8.50(5)	7.70(10)	0.22	8.52(1)	8.06(7)	0.66
	Dependent, no lift	8.67(3)	7.79(5)	0.43	4.33(2)	7.20 (4)	0.26	n = 0 in IG		
	Dependent, with lift	8.98(4)	7.18(7)	0.11	9.77(2)	9.37 (4)	0.69	10.00(2)	9.33(2)	0.41
Type of Wheelchair	MWC	8.45(10)	7.98(19)	0.40	7.53(9)	7.48(17)	0.94	8.66(6)	7.41(10)	0.03*
	PWC	8.57(11)	7.80(12)	0.19	7.32(7)	8.57 (9)	0.22	9.26(2)	8.94(6)	0.57
*mean(n), * = significant difference*										

Individuals in the IG using a manual wheelchair at six months had significantly higher (p = 0.03) TAI score compared the SCG. No other significant differences were found. Although not significant, the IG had higher TAI scores at discharge and six months for all variables evaluated. At six weeks, individuals in the IG with paraplegia, those who performed sitting pivot transfers with AT and were manual wheelchair users had higher TAI scores compared to those in the SCG**.**

Analysis was performed for all participants, regardless of study group. No significant differences were found in TAI scores from discharge to six months. (p = 0.667). Scores followed the same pattern of the IG and SCG with the lowest score at six weeks post discharge and the highest at six months post discharge. (Figure 3).

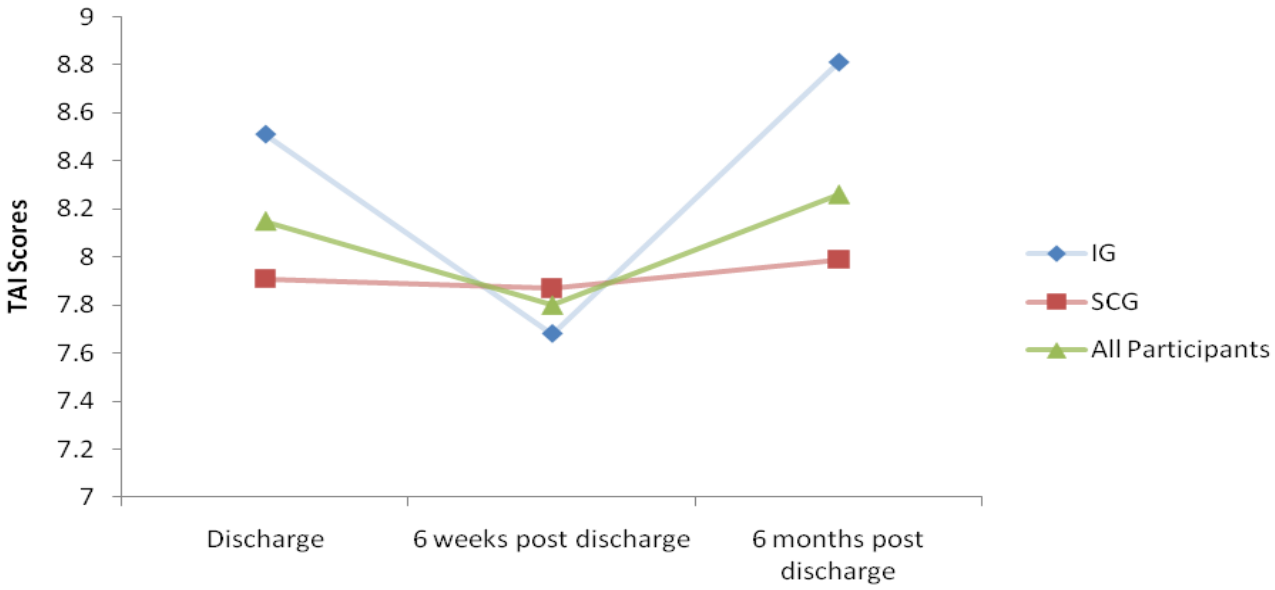


Figure 3. Comparison of TAI Scores at Each Study Visit

A significant change in scores was found (p = 0.016) between discharge to six months post discharge based on the participant's score at discharge. Participants who scored below 8 at their discharge visit (n = 8), increased their scores by 12.69% (SD = 22.55) while all participants (n=16) who scored above 8 decreased their scores by 5.69% (SD = 12.17).

Finally, the regression analysis did not find that age, SCI level, gender or group was a significant predictor for TAI score at discharge, six weeks and six months after discharge.

3.6 DISCUSSION

Results, although not significant, indicate that over the first six months after discharge the IG performed higher quality transfers compared to the SCG. As more people complete the study, the differences among groups may become significant.

Past research on guideline implementation has indicated that structured education programs are necessary to effectively use CPG [67, 95]. Many studies have found significant differences after a structured program was implemented, however the majority of past studies were a pre/post test design and had >100 participants. This is one of the first randomized trials to evaluate the impact of a CPG.

The data indicates that as time passes, greater differences are seen between groups. The divergence of the IG at six months is important and potentially indicates that participants are remembering the education provided to them longer and are integrating it into their daily life. The lack of significant differences, especially at discharge may due to study location and local influences. The study is being conducted at a MSCIS facility known for high quality of care. Also, a significant amount of research is being conducted at the University of Pittsburgh related to preservation of upper limb function. The SCG therapists may have had exposure to the CPG through local continuing education opportunities.

At six months post discharge, MWC users in the IG achieved significantly ($p=0.03$) higher TAI scores. Significant differences between groups may be seen in the MWC population due to a greater emphasis in the CPG on independent or assisted transfers (which MWC users are more likely to perform) compared to dependent transfers. Very little information in the CPG pertains to dependent transfers and few scientific studies have been conducted on this topic,

therefore the education materials were primarily based on clinician recommendations. Intervention group materials may therefore be very similar to the education the SCG received. Differences may not be seen based on type of transfer performed due to the low numbers of subjects in each group.

The data indicates that at six weeks after discharge, both groups have a decrease in TAI scores. The IG's groups TAI scores decreased by 5.60% (19.78) and the SCG's decreased by 2.80% (25.86). This is the only time point in which the SCG scores higher and there were no significant differences between groups (p=0.745). Six weeks post discharge can be very stressful and disturbing, [96] so it is not surprising that participants would have a lapse in quality of transfer skills when their focus and attention may be on bigger life obstacles such as getting adjusted to being home again. Fortunately, both groups improved their TAI scores by six months. The IG increased their scores by 10.77% (SD = 22.48) and the SCG by 7.34% (SD = 27.52).

When divided into sub-groups by level of injury, type of transfer and type of wheelchair, the IG achieved higher scores in all categories at discharge and six months post discharge. Higher TAI scores for all subgroups are important as it indicates that the strict adherence to the CPG can benefit a wide variety of wheelchair users.

Significant differences in change of scores from discharge to six months post discharge were found based on scores at discharge. This however, may be a limitation of the tool and indicates a ceiling affect. The majority of participants (67%) scored >8 at discharge and do not have much room to move on the assessment scale. Further refinement of the TAI is being conducted to correct this potential problem.

3.6.1 Limitations

There are several limitations to consider with this study. General limitations of the study design are presented in the conclusion. We were able to recruit 71 participants, however a large portion withdrew from the study due to factors outside of the researchers' control (such as no longer being a full time wheelchair user, moving to a new location and death). The power of the study at six months is 52.7%.

Due to changes in functional status and equipment and the presence of co-morbidities, participant's transfer techniques and skills may have changed throughout the course of the study. While TAI evaluates participants based on the functional abilities they have, participants may have had to re-learn how to perform a transfer and their skills and quality may not have been as it was in the past.

Because many participants did not have accessible transportation to return to IRR to complete the six week and six month study visits, the evaluations were at times completed in the participant's home. In their home, participants were transferring to different surfaces that may have been harder or easier to transfer to, compared to a mat table. At home, the majority of participants had hospital beds so differences were minimized, but may still have had an impact on the results.

Finally, the tool being used to evaluate transfer skills is newly developed. The tool has gone through its initial stages of reliability testing and refinement, however additional work is necessary. This factor could potentially account for some of the lack of significant findings. Further enrollment and testing is necessary to determine if structured implementation of the CPG significantly improves transfers skills and reduces upper extremity pain.

3.7 CONCLUSION

This randomized clinical trial evaluated the transfer skills of full time wheelchair users with new SCI over the first six months after injury. Results, although not significant, show that at six months after discharge, individuals who have been strictly educated on the CPG[29] (IG group) perform higher quality transfers compared to those who have received standard instruction (SCG group). Manual wheelchair users in the IG were found to perform transfer significantly better. Due to large forces placed on the upper limb during transfers and the substantial problems caused by upper limb dysfunction, improvement in transfer quality has the potential to reduce the development of upper limb impairments. Additional enrollment and testing of participants is necessary to determine if differences seen are significant and if participants can maintain their skills over a long period of time.

4.0 A RANDOMIZED TRIAL TO EVALUATE THE IMPACT OF THE CLINICAL PRACTICE GUIDELINE: PRESERVATION OF UPPER LIMB FUNCTION FOLLOWING SPINAL CORD INJURY ON WHEELCHAIR SET UP, SELECTION AND PROPULSION SKILLS

4.1 ABSTRACT

Objectives: To describe the development of a strict education protocol to implement the clinical practice guideline "Preservation of Upper Limb Function Following Spinal Cord Injury" and evaluate wheelchair set-up, selection, manual wheelchair propulsion and pain levels of individuals with new spinal cord injuries who have been strictly educated on the clinical practice guideline compared to those who received the standard of care.

Design: Randomized clinical trial following participants for six months

Setting: Acute Model Spinal Cord Injury Systems Rehabilitation Facility and community in Pittsburgh, PA

Participants: A volunteer sample of manual and power wheelchair users with new spinal cord injuries randomized (1:1) to an intervention or standard of care group

Main Outcome Measures: Comparison of wheelchair set-up, selection, manual wheelchair propulsion and pain at the time of discharge from acute rehabilitation and six months post discharge.

Intervention: The intervention group was strictly educated on the clinical practice guideline "Preservation of Upper Limb Function Following Spinal Cord Injury."

Results: No significant differences were found based on wheelchair set up and selection. Participants in the intervention group propelled on tile with significantly lower peak force ($p = 0.045$) at six months. Trends in the data indicate that, at discharge, participants in the intervention group are propelling with greater push length ($p = 0.101$) and lower push frequency ($p = 0.088$) on tile. At six months, the intervention group reported higher wheelchair user shoulder pain index scores ($p = 0.004$).

Conclusion: Our analysis found no differences between the intervention and standard of care group related to wheelchair set-up and selection; however the IG showed better skills on many key wheelchair propulsion biomechanics variables know to be related to upper limb health. The intervention group also reported significantly higher wheelchair users shoulder pain index scores at six months. Although contrary to our initial hypothesis, higher reports of pain may indicate that the intervention group is more aware of their pain. Increased pain awareness in combination with improved biomechanics may significantly improve the quality of life and independence of the IG in the long term.

KEYWORDS: Implementation of Guidelines, Spinal Cord Injury

LIST OF ABBREVIATIONS:

SCI = Spinal Cord Injury
ADL = Activities of Daily living
MWC = Manual Wheelchair
CPG = Clinical Practice Guideline
PVA = Paralyzed Veterans of America
PWC = Power Wheelchair
RCT = Randomized Clinical Trial
IG = Intervention Group

SCG = Standard of Care Group
UPMC = University of Pittsburgh Medical Center
IRR = Institute for Rehabilitation and Research
PT = Physical Therapy
OT = Occupational Therapy
NRS = Numeric Rating Scale
WUSPI = Wheelchair Users Shoulder Pain Index

4.2 BACKGROUND

Individuals with lower extremity paralysis due to spinal cord injuries (SCI) use wheeled mobility to perform necessary basic activities of daily living (ADLs) such as dressing, bathing and eating. Wheelchairs are also necessary to go to work, perform activities in the community and enjoy recreational events. Due to integral usage in daily life, the set up and selection of a wheelchair and propulsion skills can have an impact on an individual's ability to perform ADLs and the health of the upper limb[48].

Upper limb pain and dysfunction have been found to be related to decreased independence and quality of life and increased financial burden.[26] Wheelchair users with upper limb pain frequently report they need additional help with ADLs and their independence is limited.[27] Pain has been reported as one of the major reasons for functional decline.[28] Several experts suggest that damage to the upper limbs may be functionally and economically equivalent to a SCI of a higher neurological level.[7]

Upper limb pain and dysfunction are very common. Carpal tunnel syndrome (CTS) has been found to occur in 49% to 73% of manual wheelchair users [7, 18, 20-23] and shoulder pain present in 31% to 73% [2-3, 7, 21-22] of users. Treatment is difficult due to the inability to completely

rest the extremity.[23] Prevention of upper limb pain is the best method to preserve functional independence and quality of life.

Due the significant problems associated with upper limb pain and dysfunction, a set of clinical practice guidelines(CPG) on preservation of upper limb function[29] was developed and is described in Chapter 2. The CPG provides many important recommendations specifically related to wheelchair set-up, selection and manual wheelchair propulsion.

4.2.1 Wheelchair Set-Up

The CPG recommends that both manual and power wheelchairs should be as adjustable as possible (without a sacrifice in strength or addition of extra weight to manual wheelchairs) to put the user in the most biomechanically advantageous position.

For MWC users, the axle position, both horizontal and vertical should be adjustable. In the horizontal plane, moving the rear axle as far forward as the user can safely tolerate, has been found to reduce rolling resistance and forces during propulsion.[47-48] Specific biomechanic parameters known to correlate with median nerve injuries were found to be related to axle position relative to the shoulder[48]. An axle posterior to the acromion process will reduce the push angle a user can obtain.[48] A more forward position also decreases turning radius and downhill turning tendency when on a slanted surface.[47, 97]

In the vertical plane, the height of the rear axle should be placed so that when the user's hand is at the top dead-center of the wheel, the elbow angle is between 100-120 deg.[29] If the user's elbow angle is >120 degrees, a reduced amount of the pushrim can be contacted[49-50] and a higher stroke frequency must be used[50]. As elbow flexion angle was reduced, stroke frequency

also decreases[98]. If the elbow is <100 deg., the individual must place his/her arms in a position of greater abduction, increasing the risk of shoulder impingement syndrome.[48]

4.2.2 Wheelchair Selection

A MWC user should have the lightest possible wheelchair that can be adjusted to his/her specific needs.[44] The lightest possible chair is necessary to reduce rolling resistance, which in turn reduces the forces the individual must use during propulsion [45]. Also, ultra light wheelchairs allow for the needed adjustability to properly position the rear axle that standard and lightweight chairs do not provide.

For power wheelchair (PWC) users, the guidelines recommend that users with upper extremity function have power seat elevators[29]**.** A seat elevator decreases the amount of overhead activities the user must perform. Research has found that there is a relationship between overhead activity and the development of shoulder pain. [52] If the individual is trying to reach an item on a high shelf, he/she can rise up to the level of the item, instead of performing an overhead reach. In addition, the use of a seat elevator reduces the number of uneven transfers a person must perform.[53]

4.2.3 Manual Wheelchair Propulsion

A MWC user will push with their upper limb 2500 times per day[54] with a stroke cycle time of less than a second[55]. The shoulder is a joint designed for mobility, not load-bearing. During propulsion, a high amount of force is placed on the shoulder, most commonly in the posterior

direction.[55-56] The combination of a highly repetitive task performed at high frequency on a joint that was not designed to tolerate high forces, places the upper limb at substantial risk for overuse injuries. Components of a wheelchair propulsion stroke namely, cadence, magnitude of force and hand pattern during the non-propulsive portion of the stroke have been found to be related to injury. [44] Educating an individual how to properly propel a wheelchair is a realistic method to decrease upper limb injury. Boninger, et al stated in his 1999 study that "It may be that simple training to incorporate smooth, low impact strokes would reduce the chance of median nerve injury.[57]" The CPG states that individuals should use a long, smooth stroke to increase their contact angle (the amount of the push rim the user is contacting) and to prevent sharp increases in force and decrease cadence (the frequency of contacting the pushrim). These recommendations aim to decrease repetitive movements and the amount of force the wheelchair generates.

Components of wheelchair set-up, selection and propulsion must work together in combination to benefit the user. The correct combination of these factors will likely reduce the risk of injury[48].

4.2.4 Purpose

The purpose of this study is twofold: 1) develop a strict and structured educational protocol to implement the CPG: Preservation of Upper Limb Function into an acute rehabilitation facility and 2) conduct a randomized clinical trial (RCT) to determine if the strict protocol can affect the amount of information a patient learns and if that knowledge is translated into reduced pain. An intervention group (IG) of study participants will be educated by a Physical (PT) and

Occupational (OT) therapist who have been formally instructed on the CPG. A standard of care group (SCG) of participants will act as a gauge of the typical education provided. Participants will be evaluated on a series of items to determine if individuals in the IG have superior wheelchair set-up, selection, wheelchair propulsion skills and reduced upper limb pain compared to the SCG.

We hypothesize that after being strictly educated on the CPG, the IG's wheelchair set up, selection and propulsion skills will be superior to the SCG and the IG will report decreased pain at discharge and six months post discharge compared to the SCG.

4.3 METHODS

4.3.1 Study Design

A single blind, randomized clinical trial was conducted at the Institute for Rehabilitation and Research (IRR), an acute rehabilitation facility part of the University of Pittsburgh Medical Center. Participants were recruited from patients admitted to IRR between March 2007 and May 2010. These participants were also evaluated on transfer skills as described in Chapter 2. The study design has been described in Chapter 2. Power calculations are based primarily on data from literature[24, 99] on the primary outcome variables of numeric rating scale for upper limb pain and WUSPI for shoulder pain. Results indicate that 80 subjects (40 per group) are needed to achieve 80% power.

4.3.2 Development of the Education Protocol

A strict education protocol and original materials were developed to instruct IG clinicians on the wheelchair set up, selection and manual wheelchair propulsion portion of the CPG[29]. The development of the education protocol is described in detail in the introduction and in general terms in Chapter 2. Education materials include printed materials (with pictures and written text) describing wheelchair set up and selection for PWC and MWC users and MWC propulsion skills. A video was developed that instructs participants on MWC propulsion.

4.3.3 Wheelchair Set Up Evaluation

Each manual wheelchair user's horizontal axle position and elbow flexion angle was evaluated at six months post discharge. Axle position was assessed by measuring the horizontal distance between the participant's acromion process and rear axle position. Any distance in which the acromion process was posterior to the axle was recorded as a positive number; anterior to the axle was recorded as a negative number. (Figure 4)

Figure 4. Evaluation of Axle Position

To assess elbow flexion, the participant sat with his/her hand placed at the top, dead center of the pushrim. The angle of the elbow in this position was measured with a standard goniometer.

4.3.4 Wheelchair Selection Evaluation

For all wheelchair users, the type of wheelchair, model, manufacturer, status of the chair (own chair or a loaner chair) was recorded at discharge and six months post discharge. The manufacture and model of each wheelchair is shown in Appendix E. For PWC users, the presence of a seat elevator was noted. For MWC users, the weight of the chair (in kg) and the chair's Healthcare Common Procedure Coding System (HCPCS) "K" Code was noted. K-codes are the method in which the Centers for Medicare and Medicaid Services (CMS) categorize types of wheelchairs and base their reimbursement on. Many other insurance providers follow this categorization. Table 9 provides a listing of the categories.

Table 9. Selected HCPCS K Code Definitions

Code	Name	Description
K001	Depot Style	Non-adjustable, typically used to transport patients in facilities
K003	Lightweight	Minimal adjustability, short term use
K004	High Strength, Lightweight	Minimal adjustability, short term used
K005	Ultra lightweight	Fully adjustable and customizable. Ideal for active users, long-term use
K009	Other	"Other manual wheelchair bases" Often rigid, titanium chairs are classified with this code.
(Source: Centers for Medicare and Medicaid Services, www.cms.gov)		

Wheelchair selection was only evaluated at six months post discharge to allow participants sufficient time to order their own chair and modify their environment for the appropriate chair. New wheelchair users typically leave acute rehab with a loaner wheelchair provided by the wheelchair vendor until their own wheelchair is ordered and built.

4.3.5 Wheelchair Propulsion Evaluation

Manual wheelchair propulsion was evaluated at discharge and six months post discharge. Testing was performed by replacing the user's non-dominant side wheel with a Smart^{Wheel} . The Smart^{Wheel} is a modified wheelchair wheel, instrumented with strain gauges that measure 3-dimensional forces and moments applied to the wheelchair pushrim during propulsion[100]. The Smart^{Wheel} has been found to be a reliable method to assess wheelchair propulsion.[100] All testing occurred in the participant's own wheelchair, when possible. If a participant's chair did not have

quick release axles, testing was completed in a loaner, ultralight wheelchair. Chair substitution most frequently occurred at the discharge study visit. Only 1 substitution was needed at the six month study visit.

A "dummy" Smart^{Wheel} was attached to the dominant side. The "dummy" Smart^{Wheel} is a non-instrumented wheel that has similar rolling characteristics as the Smart^{Wheel}.[101] Participants were asked to start from a resting position (hands in lap and wheelchair stopped) and asked to push at a self-selected comfortable speed over three different surfaces: 1) 10 feet of level tile; 2) up a 5 degree ramp; and 3) over 10 feet of industrial grade carpet. Smart^{Wheel} data were collected during the entire time[102] and only steady-state data were analyzed. At times, due to environmental limitations, propulsion testing could not be performed on all surfaces. All available data were analyzed.

Primary manual wheelchair propulsion biomechanical variables of cadence (the number of times the wheelchair user contacts the pushrim, per second), push angle (the average length of the individual's push, measured in degrees), peak (the highest resultant forces recorded), average (resultant) force, peak/average force ratio (a ratio relating peak and average force to indicate "smoothness") and velocity. Propulsion forces were normalized, prior to data analysis, to the participant's weight and velocity by dividing the resultant force by the product of the participant's weight and velocity.:

Normalized Force = Resultant Force / (weight (kg)*m/s)

Prior research has found that weight and velocity are highly correlated with propulsion forces [57] and therefore these variables must be controlled for. These specific variables are mentioned in the guideline and are the primary focus of the wheelchair propulsion education.

4.3.6 Pain Assessment

Study participants were asked to rate their upper limb pain on a 0-10 Numeric Rating Scale (NRS) and using the Wheelchair Uses Shoulder Pain Index (WUSPI), after they completed all physical aspects of the research study (namely wheelchair propulsion and transfers.)

The NRS has been found to be a valid tool to assess pain levels.[103-105] In a review of pain rating scales for individuals with SCI by Bryce in 2007[106], the NRS was found to be the most appropriate scale to assess pain.[106] Participants are very familiar with the NRS because this tool is frequently used at IRR during the inpatient rehabilitation stay. The NRS, which is measured by verbal response, has been found to be superior to the Visual Analog Scale (VAS) because individuals with high levels of tetraplegia often do not have the hand function available to mark their pain levels on a line. Both tools are anchored by 0 which indicates no pain and 10 which indicates that worst possible pain. A combination of the two pain assessment tools was used. Participants were shown the VAS, and the researcher gave a describtion of 0/10 and 10/10 pain. Also, participants were told to describe his/her pain at the current time and only focus on upper limb pain. Participants were then asked to state their pain levels and the researcher marked the score.

The WUSPI is a validated and reliable tool (test-retest reliability of the total index score – 0.99 and Cronbach's alpha (internal consistency) – 0.98)[107] used to assess shoulder pain in wheelchair users while performing a variety of functional activities. The WUSPI consists of 15 items in which individuals self-report pain levels on a 10 cm VAS scale. A higher WUSPI score indicates higher pain. If a participant lacked the hand function to place a mark on the line, the evaluator assisted. An average score was calculated from applicable items.

4.3.7 Quality of Life Measures

Participants also completed the satisfaction with life scale[108] (SWLS) and Craig handicap assessment and reporting technique[109] (CHART) at six months post discharge. Both outcome measures have been validated and found to be reliable tools to evaluate satisfaction with life and participation of individuals with SCI. Hall, et al[110] recommended that each sub-section of CHART be reported separately, as the entire score may provide a misleading assessment. The cognitive portion was not analyzed, as there was not an applicable choice for many participants or the financial resources portion, as many participants were unable to recall their income or how much money was spent on medical equipment. The evaluator read the questions to the participants and wrote in the answers.

4.4 DATA ANALYSIS

General descriptive statistics were calculated for each study visit (discharge and 6 months post discharge.) Many variables were found to be non-normally distributed. Due to the low number of subjects (n) and non-normal data distribution, non-parametric analysis was performed. The differences between groups were compared by Mann-Whittney or Chi-square analysis when appropriate. Resultant forces in wheelchair propulsion biomechanics analysis were normalized to weight and velocity prior to analysis. Significance was set *a priori* at $p = 0.05$. Due to the exploratory nature of the study, no corrections were made for multiple comparisons. All analysis was performed using SPSS version 18.

4.5 RESULTS

Of 72 participants enrolled in the study, 35 were randomized to the IG and 37 to the SCG. Thirty-four participants were MWC and 23 PWC users at the time of their discharge from acute rehabilitation. Distribution of participants between groups is presented in Figure 5. Please see Chapter 2 for a further description of the distribution process.

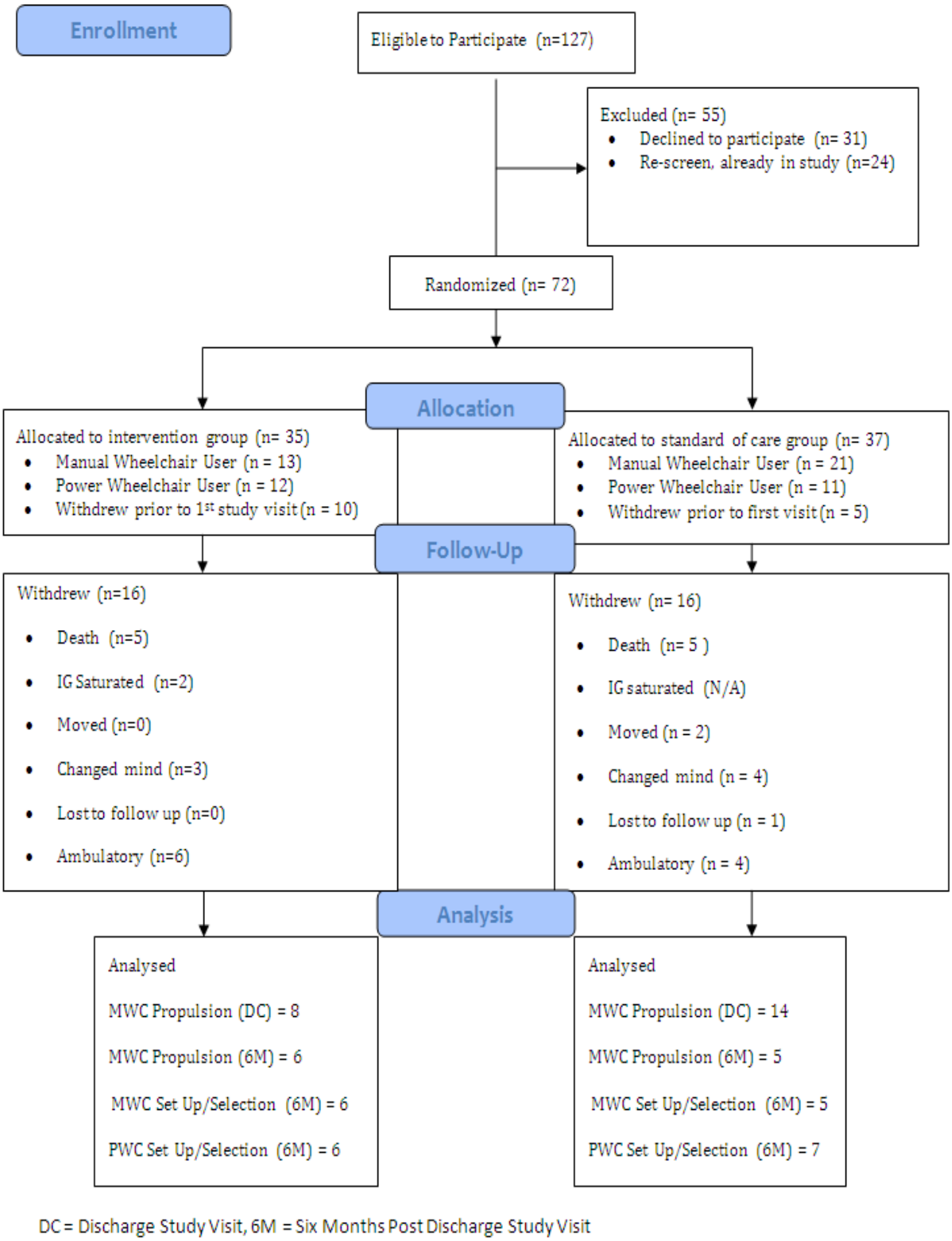


Figure 5. Randomized Clinical Trial Flow Chart

No significant differences were found between participants who withdrew or completed the study and study groups based on age, gender, level of injury, or type of chair used. Demographic characteristics of participants enrolled in the study are presented in Table 10.

Table 10. Demographics

		IG			SCG			Total
		MWC	PWC	Chair not defined	MWC	PWC	Chair not defined	
Age	Mean (SD)	36.4(18.0)	58.3 (8.2)	55.2 (23.2)	46.4 (15.5)	54.3 (17.6)	60.3 (18.9)	50.9(17.8)
Gender	Male n (%)	5 (45.5)	11(84.6)	7(70.0)	16 (80.0)	6 (50.0)	4 (80.0)	49 (69.0)
	Female	6 (54.5)	2 (15.4)	3 (30.0)	4 (20.0)	6 (50.0)	1 (20.0)	22 (31.0)
Level of Injury	Paraplegia	9 (81.8)	5 (38.5)	5 (50.0)	16 (80.0)	3 (25.0)	2 (40.0)	41 (57.7)
	Tetraplegia	2 (18.2)	8 (61.5)	5 (50.0)	4 (20.0)	9 (75.0)	3 (60.0)	30 (42.3)
Type of Chair	n (%)	13 (52.0)	12(48.0)	N/A	21 (65.6)	11 (34.4)	N/A	57 (100.0)
Status	Completed	6 (50.0)	6 (50.0)	0(0 .0)	9 (45.0)	7 (58.3)	0(0.0)	29 (40.3)
	Ongoing	3 (25.0)	3 (25.0)	0 (0.0)	4 (20.0)	1 (8.3)	0 (0.0)	11 (15.3)
	Withdrew	3 (25.0)	3 (25.0)	10 (100.0)	7 (35.0)	4 (33.3)	5 (100.0)	32 (44.4)
Reason for Withdraw	Death	1 (33.3)	2 (66.7)	2 (20.0)	2 (28.6)	2 (50.0)	1 (20.0)	10 (31.3)
	IG saturated	0 (0.00)	0 (0.0)	2 (20.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (6.3)
	Moved	0 (0.0)	0 (0.0)	0 (0.0)	1 (14.3)	1 (25.0)	0 (0.0)	2 (6.3)
	Changed mind	0 (0.0)	1 (33.3)	2 (20.0)	0 (0.0)	0 (0.0)	4 (80.0)	7 (21.9)
	Lost to follow up	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)	1 (3.1)
	Ambulatory	2 (66.7)	0 (0.0)	4 (40.0)	4 (57.1)	0 (0.0)	0 (0.0)	10 (31.3)
Randomization	n (%)	13 (16.7)	12 (18.1)	10 (13.9)	21 (27.8)	11 (16.7)	5 (7.0)	72 (100.0)

Due to the nature of the population, a large number of participants withdrew from the study. Fifteen participants were withdrawn from the study prior to the first evaluation. The most common reasons for withdraw were due to death (n=10, 13.89%) or becoming ambulatory (no longer being a full time wheelchair user) (n=10, 13.89%). None of the participant's deaths were

due to study interventions and the IRB was made aware of the deaths. A total of 33 participants (46.5%) withdrew.

4.5.1 Wheelchair Set Up

The MWC set up of participants who independently propelled (n= 11) were evaluated by Mann-Whitney tests at six months post discharge. No significant differences were found between groups. Both groups had average elbow flex angles within the guideline recommendation of 100-120 degrees. Axle position was found to be anterior to the acromion process for all participants with the exception of two participants in the SCG. (Figure 6)

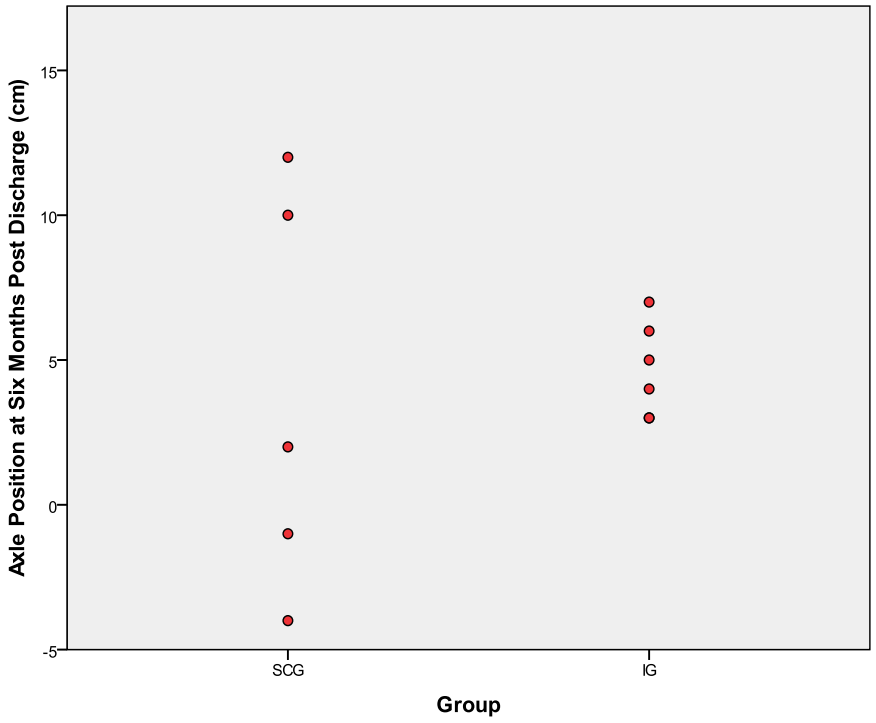


Figure 6. Axle position at Six Months Post Discharge

Although not significantly different, the IG had a more consistent axle position compared to the SCG. Levene's test for equality of variance was found to be significant (p=0.003) indicating that the variance of the two groups was different. No significant differences on wheelchair propulsion biomechanics at six months post discharge were found between participants based on axle position

4.5.2 Wheelchair Selection

Wheelchair selection of all participants was evaluated by chi-square tests except for chair weight, which was evaluated by Mann-Whitney tests at six months post discharge. Chair weight included all essential chair components such as wheels, brakes, cushions, etc. No significant differences were found between groups. (Table 11)

Table 11. Wheelchair Selection

		IG n(%)	SCG n(%)	p-value
Presence of a Seat Elevator on a PWC at six months post discharge	Yes	4 (66.7)	4 (57.1)	1.00
	No	2 (33.3)	3 (42.9)	
Type of chair used by active MWC users at six months post discharge	Depot	0 (0.0)	1 (20.0)	1.00
	Ultra light	5 (100.0)	4(80.0)	
Chair status of PWC and MWC users at six months post discharge	Own	11 (84.6)	11 (64.7)	0.407
	Loaner	2 (15.4)	6(35.3)	
MWC chair weight at discharge	(n) mean	(3) 15.97	(5) 18.25	0.456
MWC chair weight at six months post discharge	(n) mean	(4) 15.85	(3) 14.57	0.480
PWC = Power wheelchair, MWC = Manual wheelchair				

While not significant, (p=0.407), 84.6% (n = 11) of IG participants (both PWC and MWC users) at six months post discharge had their own chair (versus using a loaner chair), compared to 64.7% (n = 11) of SCG participants.

4.5.3 Manual Wheelchair Propulsion Components

At discharge, 22 manual wheelchair users (8 = IG, 14 = SCG) were evaluated on over ground wheelchair propulsion skills. Analysis was performed by Mann-Whitney tests. No significant differences were found between groups at discharge. Trends in the data indicate that on tile, individuals in the IG were using greater push length (p =0.101) (Figure 7), and were pushing with lower frequency (p = 0.088), (Figure 8).

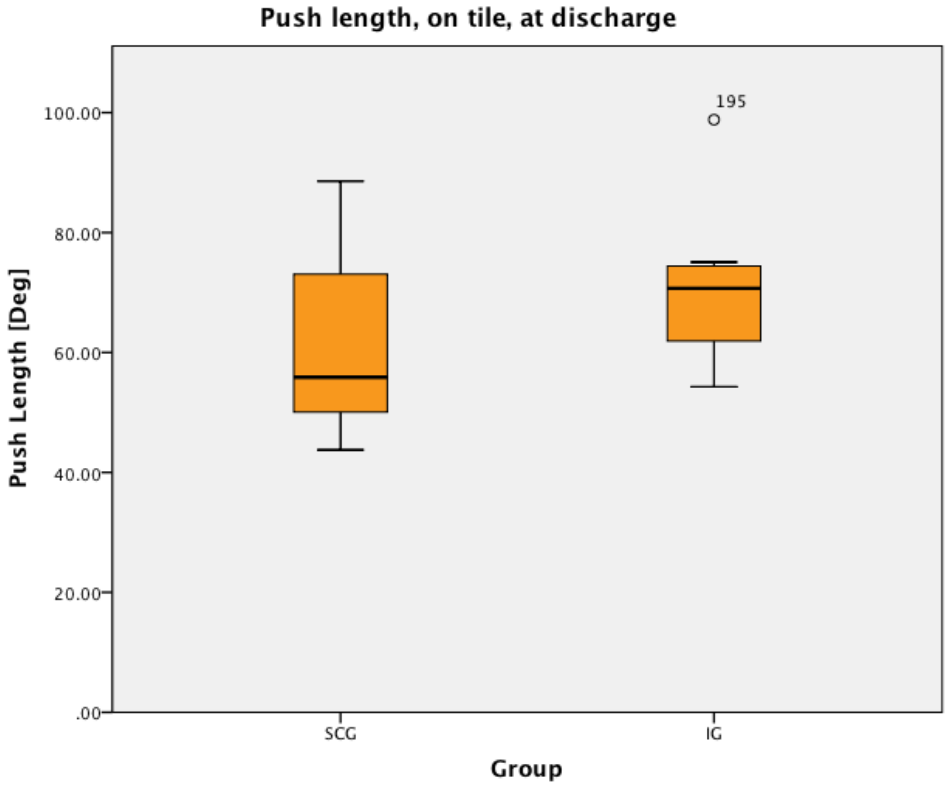


Figure 7. Difference in push length between groups on tile at discharge

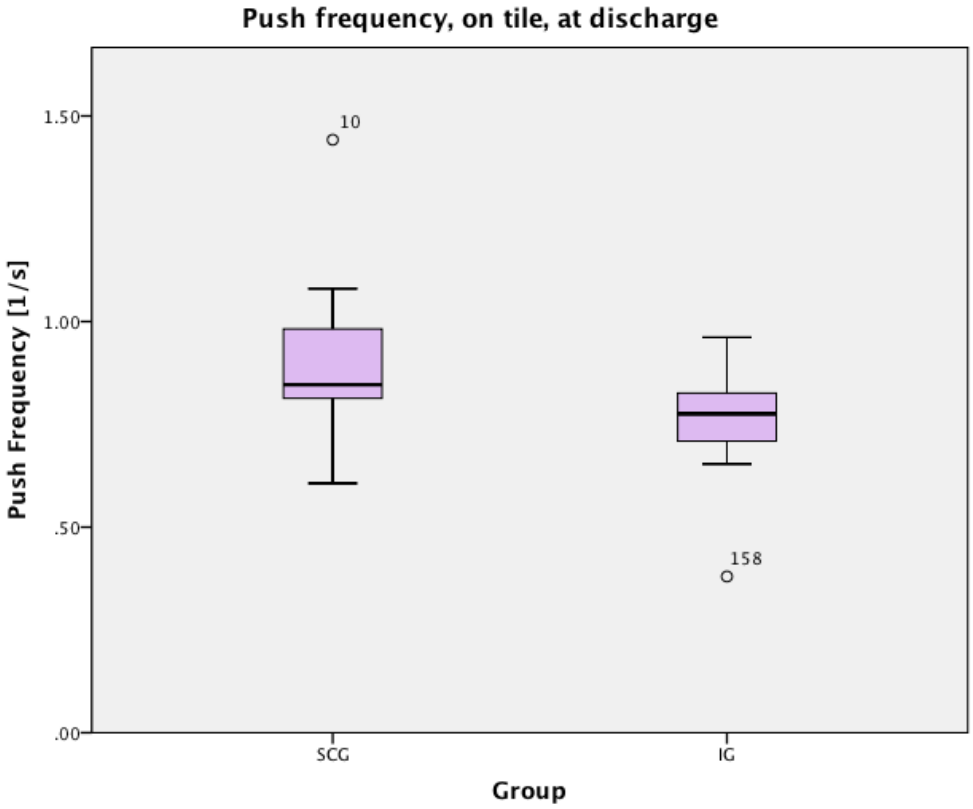


Figure 8. Difference in push frequency between groups on carpet at discharge

On carpet, participants in the IG were using greater push length (p = 0.122), (Figure 9).

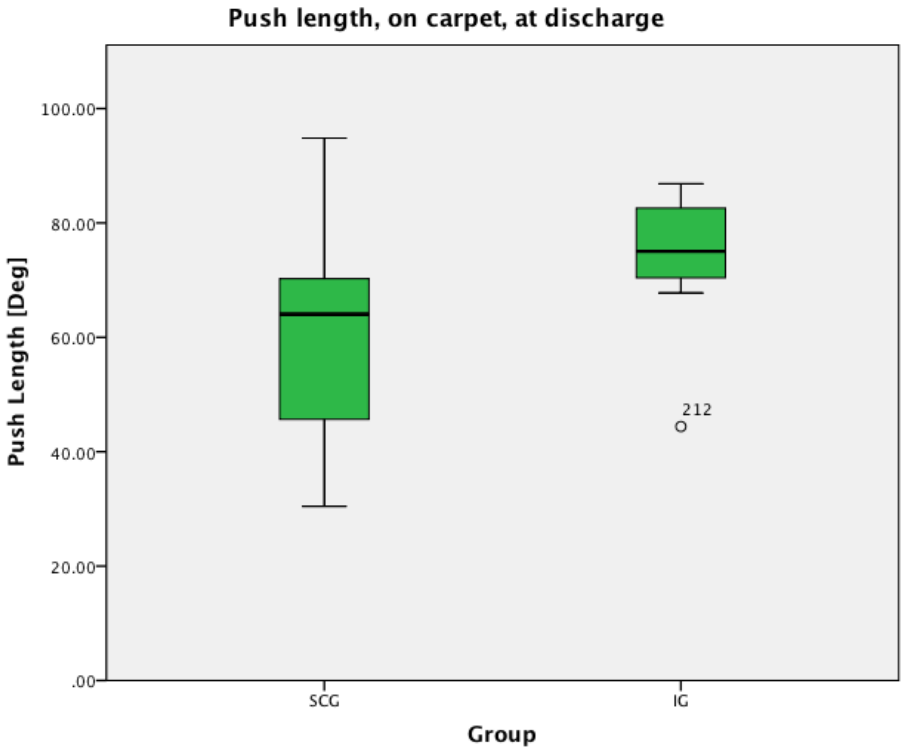


Figure 9. Difference in push length between groups on carpet at discharge

At six months post discharge, 11 manual wheelchair users (6 = IG and 5 = SCG) were evaluated. The most common reason that participants did not perform wheelchair propulsion at six months was due to study withdraw for no longer being a full time wheelchair user (Table 12).

Table 12. Reason for Withdraw

		DC		6M	
		IG n(%)	SCG n(%)	IG n(%)	SCG n(%)
# of Participants		13	21	13	21
# of Wheelchair Users Collected		8 (61.5)	14 (66.7)	6 (46.2)	5 (23.8)
Reason Wheelchair Propulsion Not Performed	Dependently Pushed	3 (23.1)	4 (19.0)	3 (23.1)	3 (14.3)
	Ambulatory	0 (0.0)	0 (0.0)	2 (15.4)	6 (28.6)
	Death	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.8)
	Unable to capture	2 (15.4)	3(14.3)	0 (0.0)	3 (14.3)
	Ongoing*	N/A	N/A	2 (15.4)	3 (14.3)
* Ongoing indicates the participant has not yet reached six months post discharge.					

At six months post discharge, participants in the IG propelled with significantly lower normalized peak total forces on tile. ($p = 0.045$) (Figure 10) and the IG propelled significantly faster on the carpet. ($p=0.028$) (Figure 11)

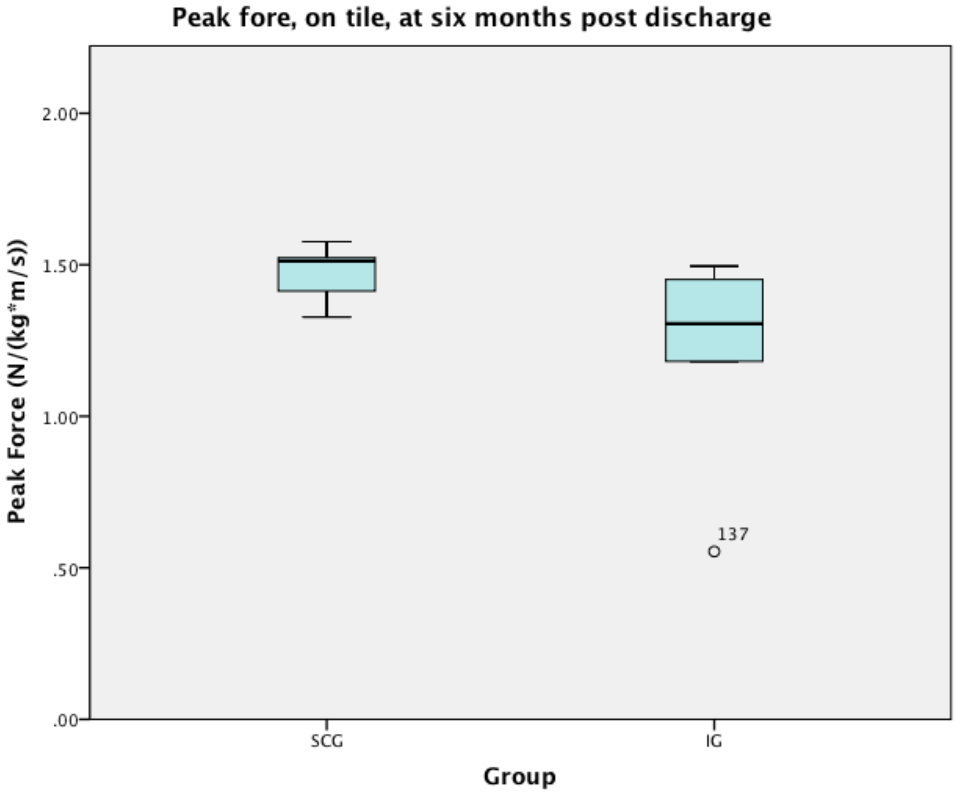


Figure 10. Difference in peak force between groups on tile at six months post discharge

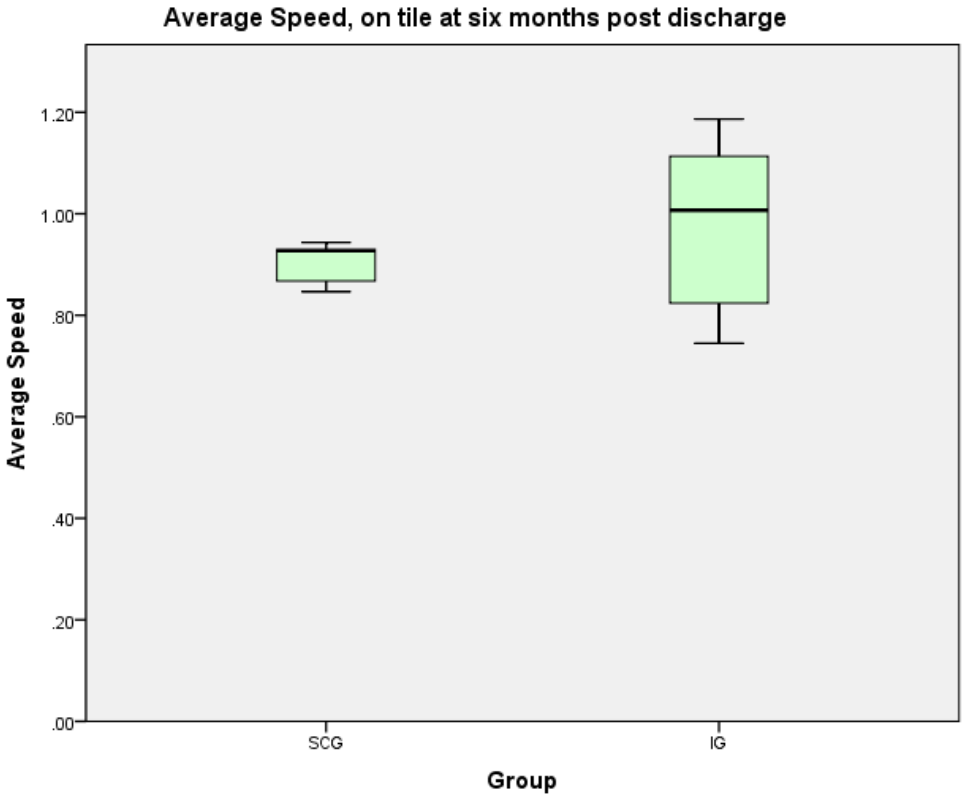


Figure 11. Difference in average speed between groups on carpet at six months post discharge

Also, a trend in the data indicates that individuals in the IG, have a lower peak/average force ratio on tile at six months (p=0.120). (Figure 12).

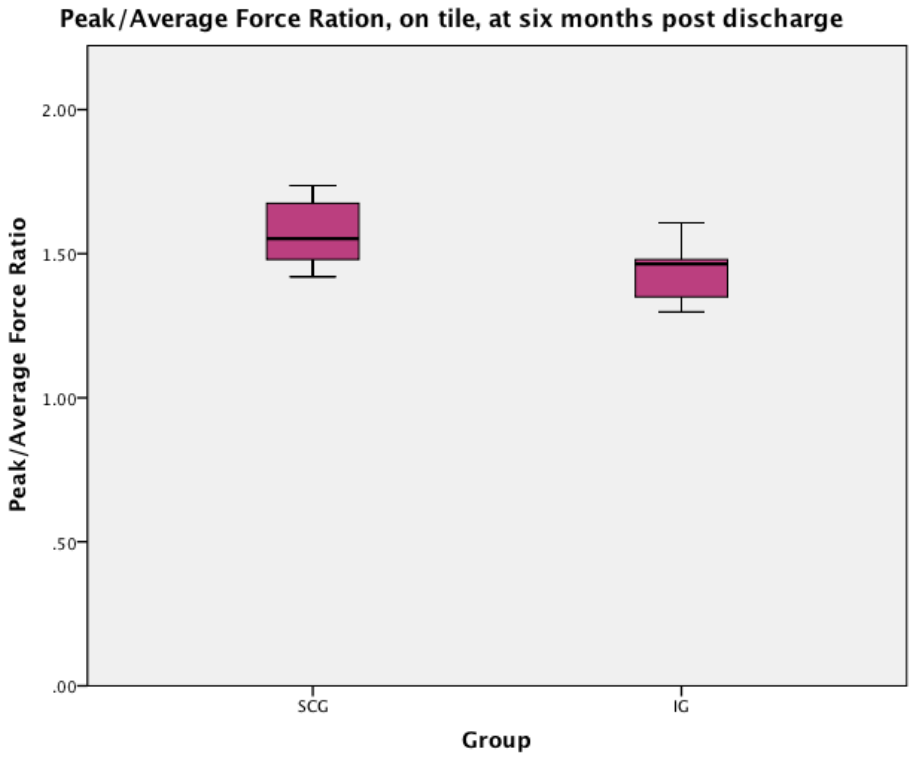


Figure 12. Difference in peak/average force ratio between groups on tile at six months post discharge.

Percent change in propulsion characteristics between discharge and six months were evaluated (Table 13).

Table 13. Percent Change Between Discharge and Six Months Post Discharge, Split by Group

		Tile				Carpet				Ramp			
Component	Group	n	Percent Change	SD	p-value	n	Percent Change	SD	p-value	n	Percent Change	SD	p-value
Peak Resultant Force (N(kg*m/s))	IG	6	+0.42	39.06	0.273	5	-24.37	22.23	0.624	5	-8.00	23.71	0.655
	SCG	5	+21.06	37.43		4	-2.86	53.00		3	+41.81	150.43	
Average Resultant Force(N(kg*m/s))	IG	6	+2.66	40.65	0.465	5	-21.92	24.62	0.624	5	-3.88	21.06	0.655
	SCG	5	+21.81	37.23		4	-5.61	45.32		3	+42.27	151.37	
Peak/Average Force Ratio	IG	6	-3.67	3.68	0.144	5	+1.32	2.62	0.624	5	+0.94	8.10	0.655
	SCG	5	+4.34	10.11		4	+4.63	7.25		3	+1.91	6.71	
Push Length (Deg.)	IG	6	-1.85	14.26	0.584	5	+7.86	37.22	0.624	5	-0.66	30.41	0.101
	SCG	5	+10.31	17.06		4	+17.64	32.61		3	+183.13	265.75	
Push Frequency (1/s)	IG	6	+23.33	78.69	0.715	5	+20.84	50.19	0.806	5	+9.43	46.38	0.101
	SCG	5	-9.20	23.05		4	+0.99	8.16		3	+97.71	48.21	
Velocity (m/s)	IG	6	0.56	17.74	0.144	5	42.56	53.73	0.462	5	2.27	11.72	0.180
	SCG	5	-13.48	13.48		4	10.89	27.84		3	73.07	107.34	

No significant differences were found. Trends in the data indicate that the IG lowered their peak/average force ratio on tile by 3.67% while the SCG increased by 4.34% (p=0.144) and the IG increased their velocity by 0.56 m/s while the SCG decreased by 13.48 m/s. On the ramp, the IG decreased their push length by 0.66% while the SCG increased by 183.13% (p = 0.101). The IG also increased push frequency by 9.43% while the SCG increased by 97.71% (p=0.101). Finally, the SCG increased their speed by 73.07% (p = 0.180).

The absolue values of each surface and variable are shown in Table 14.

Table 14. Absolue values of Wheelchair Biomechanics

		Tile		Carpet		Ramp	
Component	Group	Mean(DC)	Mean (6M)	Mean (DC)	Mean(6M)	Mean (DC)	Mean (6M)
Normalized Peak Force (N(kg*m/s))	IG	1.21	1.21	1.31	1.14	5.36	6.46
	SCG	1.29	1.47	1.75	1.28	5.61	5.58
Normalized Average Force (N(kg*m/s))	IG	0.83	0.98	0.89	0.79	3.68	4.72
	SCG	0.91	0.86	1.27	0.89	4.09	4.14
Peak/Average Force Ratio	IC	0.02	1.44	0.02	1.49	0.06	1.44
	SCG	0.02	1.57	0.03	1.53	0.06	1.40
Push Length (Deg)	IG	70.91	63.91	73.17	72.01	64.42	56.01
	SCG	61.06	68.85	61.19	70.47	43.26	45.97
Push Frequency (1/s)	IG	0.75	0.81	0.81	0.87	0.79	0.78
	SCG	0.91	0.80	0.91	0.87	0.81	1.15
Velocity (m/s)	IG	1.09	0.98	1.06	1.17	0.56	0.42
	SCG	1.04	0.90	0.88	0.96	0.41	0.29

Finally, percent change of all wheelchair users (regardless of group) between discharge and six months were evaluated (Table 15). No significant differences were found.

Table 15. Percent Change Between Discharge and Six Months Discharge

	Tile				Carpet				Ramp			
Component	n	% Change	SD	p-value	n	% Change	SD	p-value	n	% Change	SD	p-value
Peak Resultant Force (N(kg*m/s))	11	+9.80	37.94	0.790	9	-14.81	37.80	0.214	8	+10.69	86.33	0.327
Average Resultant Force (N(kg*m/s))	11	+11.36	38.47	0.929	9	-14.67	33.87	0.214	8	+13.42	85.85	0.484
Peak/Average Force Ratio	11	-0.03	8.08	0.790	9	+2.79	5.12	0.139	8	+1.30	7.11	0.674
Push Length (Deg)	11	+3.67	16.08	0.424	9	+12.21	33.44	0.678	8	+68.26	172.50	0.401
Push Frequency (1/s)	11	+8.55	59.98	0.424	9	+12.02	37.34	0.678	8	+42.54	63.29	0.401
Velocity (m/s)	11	-6.04	16.96	0.155	9	+28.48	44.86	0.110	8	+28.82	68.65	0.161

4.5.4 Pain

Pain levels of each group were examined at each study visit with Mann-Whitney tests.

No significant results were found on the NRS at the discharge or six months post discharge visit. Pain levels increased for both groups; however the change was not significant (Figure 13).

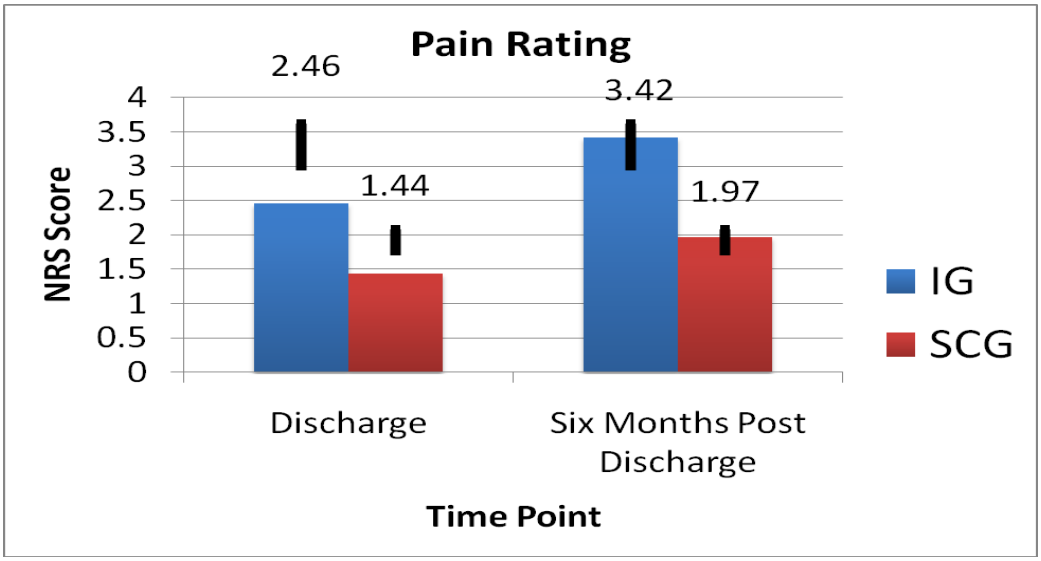


Figure 13. Comparison of pain at discharge and six months post discharge.

The IG had significantly higher WUSPI scores at six months (p = 0.004), as shown in Figure 14. Further analysis found that individuals with tetraplegia (p = 0.010) and power wheelchair users (p = 0.016) in the IG reported significantly higher WUSPI scores compared to the SCG. Trends in the data show that MWC users (p=0.153) and persons with paraplegia (p=0.194) in the IG reported higher WUSPI scores. The highest average NRS reported was 5.80 (participants with tetraplegia in the IG at six months) and the highest average WUSPI (4.63) score was reported by individuals with tetraplegia in the IG at six months.

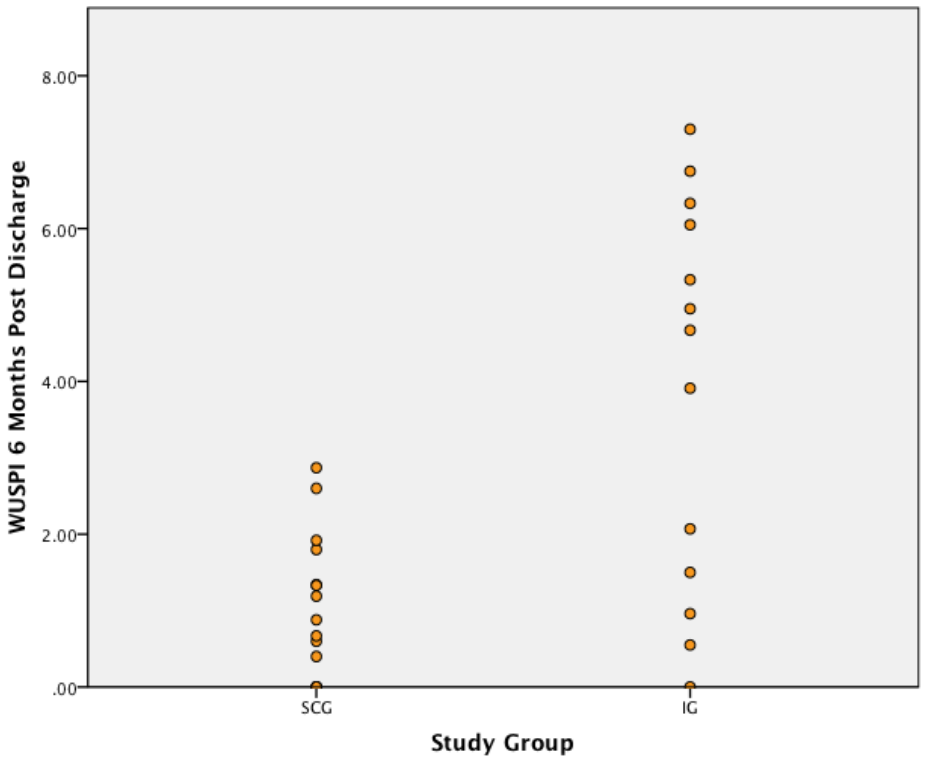


Figure 14. Comparison of wheelchair users shoulder pain index (WUSPI) six months post discharge.

4.5.5 Quality of Life Measurement

No significant differences were found between groups on either the SWLS or the physical independence, mobility, occupational or social integration portion of the CHART at six months post discharge. The IG scored higher on the SWLS and all portions of the CHART except for physical independence.

4.6 DISCUSSION

We hypothesized that after a strict and structured program, wheelchair users in the IG would display superior wheelchair set-up, selection and manual wheelchair users would propel their chair with decrease force, decreased frequency and increased push length. Results found that individuals in the IG group propelled with significantly lower peak forces at six months post discharge. Also, trends found the IG to use greater push length on tile and carpet, push with lower frequency at discharge and use a lower peak to average force ratio at six months post discharge. The IG however reported significantly higher WUSPI scores at six months post discharge.

Past studies evaluating implementation of CPG have found strong results indicating that structured implementation makes a significant difference in clinical results. These past studies have however only focused on one concept, such as bowel care[95] or preventing thromboembolism[67]. Preservation of upper limb function has many components involved, not only improving wheelchair set-up, selection and propulsion skills, but also transfer skills and positioning. Due to the complexity of the topic, initial results may not be as pronounced. Also, past studies have evaluated clinician behaviors, not patients. To our knowledge, this one of the first studies to evaluate guideline implementation success as measured by functional outcomes of patients.

4.6.1 Wheelchair Set Up

In general, the majority of manual wheelchair users in the study had acceptable elbow flexion and axle position. When looking at the distribution of the data however; the IG had a much more consistent axle position. Consistent results may indicate a more complete understanding of the recommendation and participants may be more likely in the future to continue to set up their wheelchairs in a similar manner. Maintaining a consistently anterior axle position is critical for the upper limb health of MWC users. In 2000, Boninger, et al found that individuals with axle positions anterior to the shoulder propelled with lower cadence and a decreased rate of rise[48]. Results are encouraging that the majority of participants, not just the IG, have a wheelchair set up consistent with the CPG recommendations.

4.6.2 Wheelchair Selection

Similar to wheelchair set up, the majority of MWC users who independently propel have the proper wheelchair for long term use. (Table 11) This finding is significant as ultra light chairs have many important characteristics. Cowan, et al found that peak resultant and tangential forces increased as chair weight and surface resistance increased and with a posterior axle position.[46] Wheelchair users frequently need to traverse rough terrain when in the community performing ADLs and may feel uncomfortable moving their axle anterior. A light chair however does not affect stability or prevent the user from performing necessary ADLs. In addition, depot style wheelchairs do not allow for adjustable axle positions. Therefore, even if education is provided on correct wheelchair set-up and wheelchair users have the necessary skills, adjustment will not

be possible. Ultra light wheelchairs can often be difficult to get funded, especially for CMS recipients. Due to the significant benefits the chairs can offer, clinicians must continue to fight to get these devices approved.

Seat elevators are also difficult to get funded. Although many participants have seat elevators (66.7% of the IG and 57.1% of the SCG), improvement is necessary. Seat elevators should be recommended for the majority of participants [29] and if denied, appealed. If the denial cannot be overturned, clinicians must help their clients seek out alternative funding sources, such as independent living centers or the office of vocational rehabilitation that can provide funding. Because some PWC users are weary of adding additional features to their chair, users should be educated on the benefits of the devices and educated that seat functions do not necessarily increase the number of wheelchair repairs[111].

When evaluating all wheelchair users, a higher percent of participants in the IG (84.6%) have their own wheelchair at six months post discharge, compared to 64.7% of people in the SCG. It is very important that both PWC and MWC user get their own, customized wheelchair as soon as possible. Often, especially for wheelchair users with higher-level injuries, loaner chairs do not provide the customization that is necessary to maximize effective movement, positioning and comfort. Differences may be due to the IG group's increased awareness of their wheelchair needs. Due to insurance regulations, the request for a wheelchair may not be submitted to insurance until the individual leaves inpatient rehabilitation. Once the patient leaves, it is more difficult for the inpatient clinician to track the wheelchair provision process and much of the responsibility falls to the patient. This can be difficult due to the variety of other challenges a new wheelchair faces when he/she first goes home. The education the IG received may make

the group more aware of the importance of a proper wheelchair and lead them to advocate for themselves and get the chair more quickly.

4.6.3 Wheelchair Propulsion

At six months post discharge, the IG was found to have significantly lower normalized peak forces (Figure 10). Past research has found peak force to be related to pain and injury, therefore; a decrease is important to the health of the upper limb [44, 62, 112-113]. A trend in the data at six months post discharge indicates that the IG was propelling with a lower peak/average force ratio compared to the SCG. Also, the IG decreased their peak/average ratio by 3.67% while the SCG increased by 4.34% between discharge and six months post discharge. Similar to peak force, past research has found that distributing propulsion forces over a longer period of time may decrease the risk of injury[114]. A combination of decreased peak force and improved smoothness from discharge are both positive findings associated with improved upper limb health.

A trend in the data found the SCG to have a greater change in push length and push frequency on the ramp compared to the IG from discharge to six months. The SCG increased push length by 183.13% and push frequency by 97.71% while the IG had very small changes. This analysis may be skewed by one participant in the SCG who had an orthopedic, upper limb injury at discharge, but was healed by six months post discharge. Differences may not have been as pronounced on surfaces that were easier to propel on (tile and carpet), but were seen on a more difficult surface. Analysis found forces and propulsion characteristics to be significant different on the ramp compared to the tile and the carpet. No differences were seen between the

tile and carpet. Despite the large changes, the IG had a larger push length and lower push frequency compared to the SCG at six months post discharge.

4.6.4 Pain

Contrary to our initial hypothesis, the IG as whole, individuals with tetraplegia and power wheelchair user report significantly higher WUSPI scores compared to the SCG. The greatest pain intensity reported was 4.63 by persons with tetraplegia in the IG.

Due to the subjective nature of reporting pain[115], intense education, knowledge of problems associated with upper limb impairments and increased awareness, may be leading the IG to report higher WUSPI scores, even though the group was consistent with many key CPG recommendations. The goal of the study was to reduce pain; however in the short term, increased reports may be beneficial. Increased awareness may cause the IG to be more careful in the short term and lead to less pain in the long term. A secondary analysis was performed on satisfaction with life and participant measures. No significant group differences were found on the SWLS or the physical independence, mobility, occupation and social integration portion of the CHART. Therefore, despite higher reports on the WUSPI, IG participants have similar levels of satisfaction with their lives and participation.

Level of injury may also play a role in the reports of pain. The CPG was developed to primarily target musculoskeletal, not the neuropathic pain that often causes significant problems for individuals with higher-level injuries. Greater differences between groups were seen when participants were divided by level of injury and type of wheelchair used. Persons with higher-level injuries may be reporting neuropathic pain, not musculoskeletal. While both groups would

be equally affected by neuropathic pain, increased education may cause the IG to be more aware of and report higher pain. It may be that in the early stages after injury, neuropathic pain has a greater impact on upper limb dysfunction, especially for individuals with higher level of injuries. It is very important for both therapists and physicans to be aware of the type of pain affecting their patients, as the two types are treated very differently. It is essential however that individuals are educated on methods to prevent musuloskeltal pain early after injury in order to develop good habits and prevent overuse injuries from occuring in the future.

Other activities in the individual's life pay a role in the development of pain, therefore wheelchair set-up, selection and manual wheelchair propulsion cannot be the only variables considered. Transfers also significantly impact pain development, as described in Chapter 2. Consistent with wheelchair propulsion, trends in the data found that participants in the IG were performing higher quality transfers ($p=0.087$) and MWC users in the IG were performing significantly ($p=0.03$) better transfers at six months post discharge. Transfers, wheelchair mobility and wheelchair characteristics have a large impact, but many other aspects of functional mobility may play a role in pain development. Clinicians must provide comprehensive education and encourage their clients to apply preservation techniques to all aspects of their life.

Additional investigation is necessary into the causes of upper limb pain that takes into account the variety of activities that wheelchair users perform. While overuse of the limb is a commonly accepted theory[1-2], other possibilities, such as range of motion used for various activities may also have a significant impact.

4.6.5 Limitations and Future Work

There are several limitations to consider with this study. General study design limitations are presented in the conclusion. We were able to recruit 72 participants; however 46.5% withdrew. Withdraw factors including no longer being a full time wheelchair user, moving to a new location and death. The low number of subjected evaluated may have reduced the presence of significant findings. The number of participants needed to achieve 80% power of selected variables is shown in table 16.

Table 16. Statistical power to detect differences between intervention group and control group after 6 months with two sided p=0.05

	Number of Participants Per Group (80% Power)	Number of Participants Per Group (85% Power)	Number of Participants Per Group (90% Power)	Current Power
Peak Force	16	18	21	33.4%
Push Angle	130	148	173	8.1%
Axle Position	214	245	286	8.6%
Pain	105	120	140	27.8%
All variables measured at six months post discharge				

After participants were discharged home, many did not have accessible transportation to return for follow up study visits. The investigator frequently went to the participant's home to complete the assessments; however evaluation of wheelchair propulsion and weighting the chair could not be conducted in these locations.

During the course of the study, participants frequently changed equipment, which could have an impact on the results found, particularly the changes seen in wheelchair propulsion between discharge and six months post discharge. In addition, when changes are made, it often takes the individual a period of time to get acquainted with the equipment. If a participant changed equipment just prior to a study visit, wheelchair propulsion variables may have been affected. In addition, changing equipment may increase pain levels in both MWC and PWC users. However, due to the acute nature of the participants, it would not be possible to use the same wheelchair for the duration of the study.

During the study, participants encountered many co-morbidities, such as the development of pressure sores and orthopedic injuries. Participants may have had to select a wheelchair that was not the best for long term use to accommodate these impairments.

Wheelchair vendors worked with clinicians and participants in both groups to select and develop the specifications of the wheelchairs. Vendors are also aware of the CPG recommendations. While it is the clinician's decision on which chair to select and how to set it up, the vendor's input is important and plays a role in the final wheelchair specifications. Their input may have diminished differences in chair selection between groups. In addition, because it was unsure if some participants would continue to be full time wheelchair users, rental wheelchairs were at times used for an extended period of time. Insurance companies will frequently refuse to purchase a permanent wheelchair for an individual who has a documented ability to functionally ambulate. Due to this uncertainty, type of wheelchair was not evaluated at discharge and may have an impact of the chair the participant used a six months post discharge.

Finally, as with any cross-sectional research study, participant's true performance during everyday life could not be evaluated. Using a tool that evaluates participant's performance in their daily lives may improve the researcher's ability to get an accurate representation of mobility skills at home.

Additional enrollment of participants and following participants for an extended period of time is necessary to determine if the trends currently being seen result in significant findings.

4.7 CONCLUSION

This single blind, randomized trial evaluated wheelchair set-up, selection and wheelchair propulsion skills of newly injured power and manual wheelchair users affected by SCI in the first six months of their injury. No significant differences between groups were found with respect to wheelchair set-up and selection; however the IG showed superior wheelchair biomechanics at both discharge and six months. Despite superior skills on key variables, the IG reported significantly higher WUSPI scores at six months post discharge. Increased reports of pain may turn out to be advantageous. Increased pain awareness in combination with improved biomechanics may significantly improve the quality of life and independence of the IG in the long term. Continued testing and a follow up period over several years is needed to determine if trends in the data are significant and if pain levels decrease in the long term.

5.0 CONCLUSION

5.1.1 Study Impact

It has been well documented that upper limb pain and dysfunction is a source of significant impairment for full time wheelchair users affected by spinal cord injury (SCI)[2, 7, 15-17, 23-28]. The onset is quick and may be a factor as soon as two to three months after injury[17]. Treatment is difficult due to the inability of the wheelchair user to rest the upper limb[23]. Consequently, clinicians need to focus on preventing pain instead of treating it, as soon after a SCI as possible. In response to the multiple problems caused by upper limb pain and dysfunction, the clinical practice guideline (CPG) " Preservation of Upper Limb Function Following Spinal Cord Injury[29]" was published in 2005. This document provides recommendations to clinicians on preservation methods.

To our knowledge, no previous studies have been conducted to determine if strict adherence to the CPG "Preservation of Upper Limb Function Following Spinal Cord Injury" significantly improves transfer skills, wheelchair set-up and selection, manual wheelchair propulsion skills and reduces upper limb pain. While many studies have evaluated guideline implementation[67, 95], few focus on patient performance or are conducted as randomized trials. This study is one of the first to compare strict adherence to a CPG against standard practice and evaluate how it impacts the day to day life of patients. Through the course of the study, the lack

of an objective method to evaluate transfer skills was highlighted. An original measure, the Transfer Assessment Instrument (TAI), was developed and used to evaluate transfer skills.

Initial results indicate that TAI is a safe outcome measure that can be administered in a reasonable time period, uses equipment typically found in a clinical setting and does not ask participants to perform an unfamiliar skill. Due to the wide range of reliability found, further refinement is needed.

An additional evaluation of the reliability and validity of the TAI was trialed by compressing the Likert Scale in Part 2 to only include 3 items; Disagree, Neutral and Agree. The three point Likert scale resulted in mixed results.

Item analysis (Table 17) reliability was found to improve for items 1-8 for atleast one of the raters or one of the sessions. More items however were unable to be calculated due to the low variance.

Table 17. Item analysis showing difference in scoring methods

	Intra-rater Reliability					Inter-rater Reliability				
	Rater 1		Rater 2	Rater 3		Session 1 ICC		Session 2 ICC		
Part 2	*0-4*	*0-2*	*0-4*	*0-2*	*0-4*	*0-2*	*0-4*	*0-2*	*0-4*	*0-2*
1	0.750	0.447	0.153	0.144	0.517	LV	-0.122	**0.002**	-0.111	**0.323**
2	0.664	**0.858**	0.273	**1.00**	0.546	0.309	0.711	0.606	0.406	
3	-0.352	**0.647**	0.581	0.212	-0.005	**0.419**	0.020	-0.035	0.232	-0.208
4	0.662	0.304	0.014	-0.095	0.509	**0.822**	0.489	0.238	0.584	0.323
5	0.624	**0.630**	-0.088	-0.118	0.233	**0.569**	0.219	-0.088	-0.420	-0.390
6	0.740	**0.953**	0.880	**0.928**	0.605	LV	-0.273	-0.323	-0.967	-0.536
7	0.643	LV	LV	LV	0.629	**0.940**	0.592	LV	-0.048	-0.105
8	0.126	**0.716**	0.622	0.547	0.841	-0.221	0.698	**0.833**	-0.048	0.304
9	0.480	LV	0.287	LV	0.299	LV	0.406	LV	0.939	LV
10	1.00	LV	0.603	LV	LV	LV	0.404	LV	0.687	LV
11	1.00	LV	0.297	LV	LV	LV	0.256	LV	0.819	LV
12	0.890	LV	0.683	LV	LV	LV	0.404	LV	0.3381	LV

LV = Unable to calculate due to low variance, **Bold** = improvement in reliability with using 0-2 scoring method

Intra and inter-rater reliability also found a variety in results (Table 18) Rater 1 and 2 improved their scores, while rater 3 got worse. The decrease in rater 3's scores may be due to low variance and the inability to allow all items on the tool to be analyzed.

Table 18. Intra and Inter-rater reliability showing differences in scoring methods

	Intra-rater n(ICC)						Inter-rater n(ICC)			
	Rater 1		Rater 2		Rater 3		Session 1		Session 2	
Scoring Method	*0-4*	*0-2*	*0-4*	*0-2*	*0-4*	*0-2*	*0-4*	*0-2*	*0-4*	*0-2*
Part 2	0.724	**0.773**	0.350	**0.557**	0.875	0.525	0.516	0.380	0.511	-0.147
Total Score	0.741	**0.747**	0.350	**0.463**	0.893	0.800	0.642	0.635	0.649	0.469

Bold = improved scores with 0-2 scoring method

Finally, concurrent validity was re-evaluated and shown in table 19. Only rater 1 improved correlations with the global rating scale.

Table 19. Correlation of Total Score with Gold Standard showing differences in scoring methods

Rater	Correlations (0-4)	p-value (0-4)	Correlations (0-2)	p-value (0-2)
Rater 1	0.279	0.116	**0.330**	**0.061**
Rater 2	0.192	0.285	0.085	0.638
Rater 3	0.690*	0.000	0.629*	0.000

* indicates significance at p = 0.001, **bold** indicates improvement in scores by 0-2 scoring method

Using the three point Likert scale has potential to improve the overall reliability and validity of TAI, however the tool needs to be tested with a more heterogenous sample to improve the variance in scores.

In addition to using the three point Likert scale, the next version of TAI will improve the clarity of specific items found to have low reliability and condense items that evaluate the same concept (such as hand placement). Also, a comprehensive program to instruct clinicians on proper use the tool is needed. Once changes have been made and the education program implemented, psychometric properties will be re-evaluated. Also, evaluation of psychometric properties will be completed with participants who have a variety of disabilities and perform different types of transfers. While further modification is necessary, TAI has been found to have value, potential to be easily integrated into a clinical setting and fills a substantial void in evaluation of transfer quality. Given that there are no other instruments available, the TAI gives therapists the first objective measure to evaluate an important skill known to cause upper extremity pain but needed for many critical activities of daily living.

The TAI was used to evaluate transfers skills of full time wheelchair users with new SCI. Although not significant, a trend in the data ($p=0.087$) found that at six months post discharge, the intervention group (IG) performed higher quality transfer skills. Further investigation found that manual wheelchair (MWC) users in the IG performed significantly ($p = 0.03$) better transfers compared to the standard of care group (SCG).

In addition to transfer skills, the same population was evaluated on wheelchair set up, selection and manual wheelchair propulsion skills. No significant differences between groups were found with respect to wheelchair set-up and selection. At six months post discharge, participants in the IG used significantly ($p=0.045$) lower peak forces during wheelchair propulsion on tile, a key variable related to the health of the upper limb. [62, 112-113]Trends in the data also found that the IG is performing other important biomechanical aspects of propulsion better than the SCG.

Greater differences were seen between groups both in transfer and wheelchair propulsion skills at six months post discharge. The divergence of groups at six months is important as it potentially indicates the IG is remembering the education provided and integrating it into their daily lifes.

Contrary to our initial hypothesis, the IG is reporting significantly higher wheelchair users shoulder pain index (WUSPI) scores at six month post discharge. The IG may however be reporting higher scores due to increased awareness of pain from the education they received. Past research has found reports of pain to be highly subjective[115] and the IG may have been influenced by the heavy emphasis on pain management in the education materials. The goal of the study was to reduce pain; however in the short term increased reports may be beneficial. A combination of increased awareness and good transfer and wheelchair propulsion skills may reduce musculoskeletal pain in the future. Although the IG reported higher pain levels, no significant differences were found on quality of life measures between groups. Therefore, although higher pain was reported, it does not appear to be affecting the group's quality of life. Overall, a high percent of participants reported no or very low levels of pain. In general, 48.3% participants reported 0/10 pain on the numeric rating scale at six months post discharge and 39.3% reported less than 1/10 pain on the WUSPI.

5.1.2 General Limitations

Several limitations must be considered when evaluating the results of this study. Participant drop out was a significant factor and may have impacted the results found. While a large number of participants were recruited, almost 50% dropped out. The most common reason for

withdraw was no longer being a full time wheelchair user (13.9%) or death (13.9%). Clearly, research personnel were unable to prevent these withdraws. A lower percent of participants in the current study were no longer full time wheelchair users at six months compared to the national average. Of 2,549 National Spinal Cord Injury Database (NSCID) participants, 30.4% (n = 899) reported they were not full time wheelchair users at one year post discharge. Data was not captured at six months so we are unable to make a direct comparison. Although the current study required participants to be full time wheelchair users at the time of their enrollment and the NSCID did not, these results indicate that it is common for a large percent of people with SCI to have enough neurological recovery to no longer require a wheelchair, especially in the first year after injury. Mortality rate in the current study was higher compared to the NSCID. A 4.52% mortality rate in the first year of injury was reported in the NSCID.[116] The mortality rate observed may be higher because older participants were involved in our study. The average age of participants is 50.88 years old, compared to the national average of 33.7 years old[116].

All participants are within the first six months of a new SCI. Research has found the period of time immediately after discharge from inpatient rehabilitation to be very stressful and disturbing,[96] which may affect study outcomes. While this variability is diminished by the randomized design, with a smaller number of subjects, these characteristics may have an impact on the data.

Another factor associated with testing newly injured individuals was the high frequency of co-morbidities encountered. Many participants were dealing with orthopedic limitations, developed pressures ulcers, infections or had additional surgeries that required them to be on bedrest for an extended period of time. All of these factors may have an impact on the variables collected.

As much as possible, the therapists of the IG and SCG treated participants in their respective groups, however due to weekend schedules, vacation coverage and other day to day occurrences that could not be avoided; cross contamination of study groups did occur. A "back up" clinician was indentified to work with individuals in the IG when the primarily therapists were not available however; there were times when this could not be accommodated.

Another factor that may be decreasing the differences seen between groups is that a significant amount of research is being conducted at the University of Pittsburgh on upper limb preservation. Although not strictly educated with the newly developed protocol, SCG clinicians are aware of the guidelines, more so perhaps then other locations. While other facilities may be aware of the CPG, they will not have the same local influences. Greater differences between groups may be seen when SCG clinicians have less prior knowledge of the CPG.

Another potential study limitation is the education materials themselves. The objective of the study was to determine if strict use of the CPG improved functional mobility skills and decreased pain, not the development of a new education protocol. Although the method of guideline implementation was thoroughly researched, evaluated by experts in the field of guideline implementation, and the knowledge of the clinicians assessed, other guideline implementation strategies were not tried or evaluated. It may be possible that a different protocol of guideline implementation or a variation on the current protocol may improve functional outcomes.

Finally, best efforts were made to blind the investigator performing follow up visits however, in a few instances group assignment was inadvertently divulged.

5.1.3 Impact on Clinical Practice

Current and past research results indicates that clinicians need to instruct patients on all aspects of upper limb prevention. This task is becoming harder as the time in rehab grows shorter. In the past 35 years, length of stay in rehab has decreased from 98 to 38 days.[116] The rapid decrease creates an even greater motivation to develop a structured education protocol to assure that wheelchair users are thoroughly educated on upper limb preservation. The education protocol developed for this dissertation is an important start to improve the efficiently of care in acute rehabilitation.

Our finding of higher pain levels in participants who perform transfers and have wheelchair skills and characteristics consistent with the CPG is important for clinicians to be aware of. A clinician may be concerned that his/her patients are reporting higher pain levels after being extensively instructed on pain management and change treatment strategies. The clinician must understand that due to increased awareness, participants may report higher pain. Clinicians do however need to closely monitor the patient's ability to participate in a variety of activities and their satisfaction with life. If pain is to too severe for a patient to participate appropriately and satisfaction with life decreases, changes should be made to the plan of care.

In addition to the development of a structured protocol, using the TAI may improve a clinician's ability to evaluate transfers and provide feedback. Several studies[117-118] have found that use of outcome measures improves the care provided. Also, the TAI may help to improve a clinician's ability to track a patient's performance throughout the course of rehab[118] and provide documentation to a third party payer that additional rehabilitation is warranted.

Evaluation of the limitations in the current study may not only help to improve future research but also inpatient rehabilitation clinical practices. Some of the major study limitations, such as the high frequencies of co-morbidities and the inability of participants to return for follow up visits due to transportation limitations all have an impact on rehabilitation.

Clinicians must be aware that their patients will be frequently affected by co-morbidities which will decrease the time for instruction on upper limb preservation and change equipment recommendations. Clinicians need to be efficient in their instructions and educate their patient's that when their co-morbidities (such as pressure sores or orthopedic limitations) are no longer a factor, their equipment should be re-evaluated to maximize efficacy and functional mobility.

Clinicians also must be aware that their patients may have difficulty traveling to outpatient therapy sessions once discharged home. Homecare therapy should be set up, but the patient must have a good understanding of the skills he/she needs to work on. Homecare therapists often have little exposure to SCI; therefore patients will need to direct their own care.

5.1.4 Impact on Future Work

Results and limitations of the current study may help to improve future research on an important population. Future researchers need to be aware that the dropout rate of the study may be higher than studies that evaluate participants at least a year post injury. Performance of studies at multiple sites and broad inclusion criteria may improve enrollment statistics and decrease cross contamination. At one site, all therapists could be educated on the CPG and treat IG participants. Even if participants were treated by another clinician, they would still be educated in the same manner. Another model systems facility could serve as the standard of care. More

participants could be enrolled and cross contamination would not occur. Expansion of the study to other locations would also help to increase dissemination of the CPG.
Also, because participants frequently have difficulties with transportation, a study that can be performed at a participant's home may decrease drop out and missing data.

Our initial intent was to evaluate a variety of aspects associated with upper limb preservation. Due to the variety of variables investigated (transfers, wheelchair propultion, etc) it became difficult to fully evaluate all aspects of the study. In the future, a study that is more focused may provide us with details results on a few items compared to very general results on many items.

Finally, the education materials that were developed for this study may also be beneficial to other wheelchair users, not just those with SCI. Increasing the study to include all wheelchair users may help to improve out knowledge of education techniques and a may benefit a wider group of individuals.

5.1.5 Summary

In summary, results found that wheelchair users who were strictly educated on the CPG showed better transfer and manual wheelchair propulsion skills. While results show that the IG has higher WUSPI scores, it may be due to increased awareness and encourage participants to preserve their upper limb function in the future. Clinicians should continue to provide intense education on prevention of pain and carefully monitor quality of life indicators of their patients. Additional enrollment of participants, possibly at different geographic locations, is necessary to

determine if the trends in the data are significant. Participants also need to be followed for several years to determine if increased awareness of pain translates into pain reduction.

APPENDIX A

CLINICIAN EDUCATION MATERIALS

Module 1a—General Patient Education

Timeframe: This module is to begin on day 1 of therapy. Patients should be given overall instructions on ways to prevent pain in their upper limbs. Information that is begun at the start of therapy will stick with the patient during rehab and when they return home. Most of the information will be an ongoing area of discussion during the patient's entire rehabilitation stay.

- **Talk to your patients early about the problems that upper extremity pain can cause in their daily lives.**
  - Some of these following study results may help to drive home the point that pain can significantly affect daily life:
    - Shoulder pain may be functionally and economically equivalent to higher lesion levels of SCI.[7]
    - Pain was the only factor correlated with lower quality-of-life scores.[119]
    - 26% of patients with upper limb pain needed additional help with functional activities and 28% reported limitation of independence.[120]
    - Unemployment was higher and full-time employment was lower in individuals with upper limb pain vs. those with no upper limb pain.[120]

▪ *Performance Criteria: Patient will display an understanding of the problems that upper extremity pain can cause in their daily lives by naming at least 3 problems pain can cause.*

- **Discuss ways to prevent development of upper extremity pain in daily life. The following are some important ideas that you might want to highlight initially.**
  - Decrease the number of non-level transfers performed per day.
  - Always use proper wheelchair propulsion techniques (even when not trying to go "fast")
  - Decrease the number of overhead activities performed per day.
    - Move frequently used items to a lower level that can be easily accessed.
    - Avoid floor to/from wheelchair transfers as much as possible.
    - If the patient does a lot of overhead activities and is using a power chair, discuss the possibilities of getting a seat elevator.
  - Perform a daily stretching and strengthening exercise program.

    - *<u>Performance Criteria</u>: Patients will be able to describe 3 general ways to preserve upper limb function and display proper techniques to prevent UE impairments.*

- During your demonstrations of transfers, wheelchair propulsion and other functional mobility activities, **mention ways that your patients can position themselves to prevent the development of upper extremity pain.**

- **Discuss the importance of keeping weight at a minimum (through diet and exercise) to prevent putting increased stress on the upper extremity.**

- **Discuss alternative methods to carrying or moving heavy loads.**

    - *<u>Performance Criteria</u>: Patient will describe their ideal weight, display correct biomechanics during weight bearing activities and decrease exposure to high loads during vocational and avocational activities.*

<u>Alternative Education Options for Patient/Therapist Discussions:</u>

1. Research has shown that when a **patient perceives a need to learn, they are much more compliant with education**.[121] Therefore, making sure the patient understands the problems that upper extremity pain/injury can cause significantly improves that patient's willingness to learn and become actively involved in the learning process.
2. **Actively involving** the patient in the discussion can provide significant results. To involve the patient, ask the patient to come up with their own ways to preserve their shoulder function and ask them to recall information you had presented to them.[121]
3. **The patient must be willing and ready to learn**.[121] If the patient is having a bad day, a difficult session or is unwilling to accept their injury, delaying the education session may be in the patient's best interest. If this becomes a persistent problem, please contact Dr. Barbara for further assistance.

Patient Education Materials:

- Prevention Methods of Upper Limb Pain Document (all patients)
- Common Causes of Upper Limb Pain Document (Give to patients who will be using a manual w/c and/or transferring mainly by themselves. (not applicable for dependent transfers))

1. Sie IH, Waters RL, Adkins RH, Gellman H. Upper extremity pain in the postrehabilitation spinal cord injured patient. Arch Phys Med Rehabil. 1992 Jan;73(1):44-8.
2. Lundqvist C, Siosteen A, Blomstrand C, Lind B, Sullivan M. Spinal cord injuries. Clinical, functional, and emotional status. Spine. 1991 Jan;16(1):78-83.
3. Dalyan M, Cardenas DD, Gerard B. Upper extremity pain after spinal cord injury. Spinal Cord. 1999 Mar;37(3):191-5.
4. May L, Day R, Warren S. Evaluation of patient education in spinal cord injury rehabilitation: knowledge, problem-solving and perceived importance. Disabil Rehabil. 2006 Apr 15;28(7):405-13.

Module 1b—Pressure Relief/Positioning in Your Chair

Timeframe: This module will begin on day 1 of therapy. Patients should be instructed on the importance of this module. Pictures should be posted in the patient's room and nursing aids should also be instructed to carefully follow these guidelines.

The purpose of this module is to instruct patients that when they are seated in a wheelchair or in bed, it **is very important that they protect their skin while not hurting their arms.**

When Patients are Sitting in a Wheelchair:

- Their arms should be supported by some type of arm rest if the patient is at risk for shoulder subluxation.

- Performing a wheelchair pushup puts a significant amount of stress on shoulders. The following are alternatives to wheelchair pushups that have been proven to provide sufficient pressure relief.

- Learn forward in the chair—(Possible explanation to patients: "Try to put your chest towards your knees.")

Figure 1—Anterior Lean Pressure Relief

- Lean to one side and then the other. (i.e. lift one side of your buttock up at a time) To increase the amount of pressure relief, hook one arm around the back of the chair and pull yourself further over to the side.

Figure 2—Lateral Lean Pressure Relief

- **If the patient cannot perform either of these two methods:**

- In a manual wheelchair your patient will need assistance from a caregiver. For the safety of the caregiver, the caregiver should be seated behind the patient in a sturdy chair. The caregiver should tilt the chair backwards for approximately 2 minutes.
- In a power w/c, **patients must have a tilt-in-space seating function** on their chair!

- *<u>Performance Criteria:</u> The patient will perform pressure relief techniques in a manner that reduces the stress on their upper extremity.*

SNF/Dependant Patients – If you anticipate that your patient is going to be d/c'ed to SNF, **the education portion of this module is very important.** With these patients, please make an effort to stress the need for these patients to speak up for themselves and not to let their caregivers pull on their arms when being transferred in and out of bed or being positioned. A poster has been created that the patient can take with him/her to the SNF. Please ask Karen Greenwald (greekk@upmc.com) for a poster when necessary.

Alternative Education Options:

"It is more important to know what sort of person this disease has than to know what sort of disease the person has." ~ W. Osler

It is essential that your patient has a good grasp of the issues associated with being transferred and positioned correctly. Airhibenbuwa, et al [122] found that effective communication is a pivotal point when promoting healthy lifestyle choices and creating good behaviors.

Keys to Effective Communication[123]:

1. **Paying close attention to the patient** (maintaining eye contact, sitting, not standing when talking with a patient, moving closer to the patient, leaning slightly forward when speaking)
2. Finds out the patient's **underlying concerns** about the situation.
3. Speak in a manner that alleviates fears (allows the patient and family members to focus on the education being provided)
4. Engages the patient in **interactive conversations** through:
    a. Open-ended questions
    b. Simple language
    c. Use of analogies
5. Determines what the patient's **immediate concerns** are about the situation and determine the patient's short term goals
6. Reviews the patient's long term plan for management
7. Help the patient to plan in advance for decision making about the condition.

In addition to effective communication, using these two other methods can help to improve your patient's compliance with the information presented in this module.

1. **Create a situation that will provide intrinsic feedback.** Position the patient (if appropriate) or have the patient get into these positions so they can feel what the proper position is.
2. **Role play with the patient**. For those patients who will need assistance with transfers and bed positioning, have the patient instruct you how to position them. Try to pull on their arms and do other things incorrectly so the patient has an

opportunity to correct you. The families/caregivers can be involved in the role playing as well.

Patient Education Materials:

- Managing Pressure in Your Wheelchair--(all patients)
- For patients going to SNF/Will be dependent for transfers, please notify Karen Greenwald (greekk@upmc.edu) that you need a bed positioning poster.

1. Airhihenbuwa CO, Obregon, R: A critical assessment of theories/models used in health communication for HIV/AIDS. Journal of Health Communication 2000; 5: 5-15.

2. Clark NM, Nothwehr F, Gong M, et al.: Physician-patient partnership in managing chronic illness. Acad Med 1995; 70(11): 957-9.

Module 1c—Wheelchair Education

- Discuss the pros and cons of using a power wheelchair with all patients, particularly with high risk patients.
  - **High Risk Patients:**
    - In the presence of weak bicep and tricep function
    - Prior injury to the upper limb
    - Obese
    - Elderly
    - Live in a challenging environment (i.e. hills, long distances that they would need to push their chair, etc.)
  - **Pros of power wheelchairs**:
    - Reduced propulsion-related repetitive strain
    - Conserved energy and therefore reduced fatigue
    - Increased speed
    - Increased ease of traversing uneven terrain and inclines
  - **Cons of power wheelchairs**:
    - Decreased transportability
    - Increased maintenance
    - Increased cost
    - Possible weight gain
    - Possible decreased fitness
- Discuss when power wheelchair use should be considered
- Discuss alternatives to manual mobility
  - Power wheelchairs

- Power-assist manual wheelchairs (with add on powered motors)
    - Supplements the force applied to the pushrim with additional rear-wheel torque
    - Requires considerably less energy expenditure
    - Mounted directly onto the manual wheelchair

> ▪ *<u>Performance Criteria:</u> Patients will display good knowledge of alternative mobility devices to preserve UE function.*

- Discuss important attributes of manual wheelchairs:
    - Is made of high-strength, lightweight materials (ex—Titanium)
    - Is customizable
    - Will be able to change with the patient
    - Fits the patient properly

- Discuss important attributes of power wheelchairs:
    - Seat elevator
    - Tilt-in-space
    - Recline
    - Elevating Leg rests

> ▪ *<u>Performance Criteria:</u> Patients will display good knowledge of all options available for high quality manual and power wheelchairs.*

<u>Alternative Education Options:</u>

1. **Involve your patients**! Don't let them listen passively to you when you discuss the pros/cons of manual and power wheelchairs. **When patients are more involved in their healthcare, they will be more proactive in their healthcare**. [124]
2. When quizzing, ask the patient several questions and wait until the end of the quiz to give the patient the results. **Help them to realize for themselves why their life situations and circumstance might be better fulfilled with one type of chair or another.**
3. If you have 2 or more patients who are both learning the guidelines, have small group discussions and (if appropriate) have quiz sessions with both patients together.

Patient education materials:

- Printed document of comparison of manual vs. power wheelchairs.(all patients)

1. Pollock N: Client-centered assessment. Am J Occup Ther 1993; 47(4): 298-301.

Module 2a-Transfer Education

Timeframe: This module will also begin when different transfer techniques are introduced. This module will be ongoing during the patient's rehab stay.

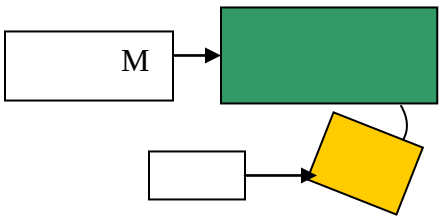
Instruct patient to:

SET UP PHASE:

- **Educate the patient to set up the transfer as "easy" as possible.**

  - Educate patients to set up their chair as close to the surface they are transferring to as possible. (The chair should be touching the surface)
    - This will decrease the amount of shoulder flexion/abduction that the patient must position their arm in to reach the surface.

  - Educate patients to position their chair on a 20-45 deg angle (between their chair and the surface they are transferring too.)
    - This position will help to:
      - put their shoulder in optimal alignment for the correct transfer position
      - decrease the distance and amount of time they have a significant amount of weight on their shoulder



- Educate the patient to position his/her chair in preparation for a transfer so her/she does not have to go over the rear wheel (i.e. transfer in front of the rear wheel)
  - This will decrease the height the patient must lift his/herself during the transfer.

- If necessary, educate the patient to remove their armrest or attempt to take it out of the way before they transfer.

- Educate the patient to place their feet in the most stable position (on the floor if possible) before they transfer.
  - Explain to the patient that their legs can support some of their body weight. This will decrease the amount of stress they put on their shoulders.
- Educate the patient to make sure that they are sitting on the front 2/3rds of their chair (or close to the edge of the surface they are transferring from)
    - This will decrease the amount of distance and thus work they have to do to move from one surface to another.
  - Hands are in a stable position prior to the start of the transfer
  - Push off hand is close to the body
  - Leading hand is close to where they will be landing

▪ *<u>Performance Criteria:</u> The patient will make every attempt possible to set themselves up for and execute a transfer that requires the least amount of skill and requires the least amount of strength to perform.*

- **Limit the number of transfers they perform with their shoulders in an internally rotated/abducted/flexed position.**
  - Educate patients to keep their leading arm abducted approximately 30-45 deg. when transferring. (Have the patient attempt to align the shaft of their humerus with their glenoid fossa.)

▪ *<u>Performance Criteria</u>: Patients will limit the number of transfers that require an IR/AB/Flex shoulder position. The patient will not fully weight bear on the arm that is in an IR/Flex/ABD position.*

Good!

Bad!

- **Avoid placing their hands on a flat surface when a handgrip is available**
  - Patients can use arm rest on wheelchairs, the edge of the mat table/bed, arm rests on chairs, the edge of a tub bench, or arm of bedside commode.
  - If no handgrip is available, patients should keep their hand flat.
  - **Be sure to educate patients that it is more important to maintain the proper shoulder position (keeping humerus in line with glenoid fossa), compared to reaching for an arm rest further away.**

▪ *<u>Performance Criteria</u>: Patients will avoid placing either hand on a flat surface when a handgrip is present during transfers.*

Avoid

Try to Avoid

Try to Best

<u>FLIGHT:</u>

- **Maintain forward trunk flexion during the transfer**

▪ *<u>Performance Criteria</u>: Patients will display a position of forward trunk flexion (trunk near parallel with the floor) during the weight bearing portion of their transfer.*

- Explain the concept of the head-hips relationship and how this will make the transfer easier and thus decrease the amount of stress they are placing on their shoulders.

  - Flight is smooth and well controlled.

END:

- Stress the importance of performing a well controlled transfer.
  - Hands are in contact with both surfaces at the end of transfer

GENERAL:

- **Perform level transfers whenever possible**.
  - Educate patients to look for alternative surfaces to transfer to, (not just the easiest place) or adjust the surface (if possible). ex. Adjust the height of their tub seat or bedside commode so they don't need to perform an uphill transfer.

▪ *<u>Performance Criteria:</u> Patient will make educated choices to perform level or downhill transfers whenever possible.*

- **Alternate leading/trailing arm** (i.e., don't always transfer with the right arm as the leading arm)

▪ *<u>Performance Criteria:</u> Patient will alternate right and left UE as their leading/trailing arm and display alternative types of transfers.*

- **Use transfer devices to decrease forces placed on the shoulder**
  - Patients should still be taught to do transfers (if appropriate) without transfer devices to improve their independence. However, the benefits of transfer devices should be

highlighted and **all patients should be taught to use transfer devices** when convenient (i.e., when they are at home and have to device readily available)

- *Performance Criteria: Patients will perform transfer with the use of transfer devices in the appropriate situation. Patients will also display good decision making skills of when to use the transfer devices and what situations are the best to use that device.*

Alternative Education Options:

Overall, several studies [125-127] have discussed the benefits of **contextual interference**. **Contextual interference involves performing practice sessions that includes many different concepts**. For example, in one treatment session, you could teach your patient a bed to chair transfer, a sit to/from supine transfer and wheelchair propulsion. **Research has shown this random practice schedule will lead to improved retention of skills in the future.[126] However, when using a random practice schedule, the time it will take the patient to learn the skill will be increased.** A possible explanation for this phenomenon is that the patient must actively reconstruct an action plan before performing that action. When performing blocked practiced, forming an action plan is often bypassed and the patient will not retain the information as well.[125]

If your patient is having a significant amount of trouble, Winstein, et al [128] has found these other methods to be beneficial.

1. Extrinsic/augmented feedback—Sensory information provided by an external force. (Give a lot more assistance then necessary during the transfer so the patient can feel what the motion should be/guide the patient through the motion)
2. Mental Practice – If the patient is having particular difficulty with a certain skill, have the patient visualize that part of the transfers (or whatever activity they are doing)
3. Part to Whole Practice – If the patient is having trouble with one particular part of a transfer, have the patient perform different parts of the transfer and then link those parts together.
4. Knowledge of Results Delay – After the patient has been doing a transfer for awhile and getting immediate feedback, decrease the amount of feedback you are giving the patient. (Instead telling the patient how they did after every transfer, reduce feedback to every other transfer, etc.)
5. Contextual Variety – Have the patient practice the transfers in areas (such as their room) where they are not necessarily focused on therapy.

Patient Education Materials:

- **Do's and Don'ts of transfers document**
- **Video/CD of Proper Transfer Techniques**

1. Immink MA, Wright DL: Motor programming during practice conditions high and low in contextual interference. J Exp Psychol Hum Percept Perform 2001; 27(2): 423-37.
2. Ste-Marie DM, Clark SE, Findlay LC, Latimer AE: High levels of contextual interference enhance handwriting skill acquisition. J Mot Behav 2004; 36(1): 115-26.
3. Magill RA: Motor learning: concepts and applications, 6th ed. Dubuque, IA: Brown & Benchmark, 2001.
4. Winstein CJ: Knowledge of results and motor learning--implications for physical therapy. Phys Ther 1991; 71(2): 140-9.

Module 2b—Transfer Ergonomics

Timeframe: This module will also begin when different transfer techniques are introduced. This module will be ongoing during the patient's rehab stay.

Instruct patient to:

- Avoid full wrist extension, when possible, during weight bearing portion of their transfers.
  - Emphasize the use of handgrips whenever possible. However, make sure that the patient understands that handgrips should only be used when:
    - The patient does not have to move their humerus out of alignment with the glenoid fossa.
    - The patient does not have to reach outside their base of support.

    - *Performance Criteria: Patients will display correct use of handgrips in the proper situation as defined above.*

- Avoid placing hand above shoulder when possible.
  - Limit number of floor to chair transfers
  - Position items in home below shoulder level

- *Performance Criteria: The patient will avoid positioning of the hand above their shoulder, when possible. Patients will display good knowledge of reasons for avoiding positioning of the hand above their shoulder.*

- Keep arm close to body during transfers
  - Minimize shoulder abduction/internal rotation/flexion
  - Position the leading arm in 30-45 deg. of abduction.

- *Performance Criteria: The patient will display a position in which both the leading arm is positioned in approximately 30-45 deg. of abduction, during the weight-bearing portion of the transfer. The patient will also avoid positions of shoulder internal rotation as well.*

Alternative Education Options:

Knowles [129] found that when educating adults with spinal cord injury, education was more effective if the patients had the following characteristics:

1. The patient perceived that the information was important
2. The patient was ready to learn
3. The patient took an active role in learning
4. The instructor had a good insight into the individuals past learning experiences
5. The individual was motivated to learn

1. Knowles M: The Adult Learner: A Neglected Species, 3rd ed. Houston, TX: Guld Publishing Company, 1984.

Module 2c -- Dependent Transfers

Teaching your patient to instruct their caregivers on the proper way to perform a dependent transfer is a very important area of education. Studies have shown that 78% of individuals with tetraplegia experienced shoulder pain.[130] One factor that has been associated with shoulder pain occurs when individuals are transferred incorrectly, particularly when caregivers are pulling on patients arms. Patients need to feel confident in their knowledge to instruct caregivers on the proper way to perform these transfers.

Your patient will experience many different types of transfers, and there is no way that you can go over every type of transfer they may encounter, however; the basic techniques of protection of the upper extremity during a dependent transfer should be mastered, and then applied to other situations.

In addition to educating individuals who will perform dependent transfers, it is important that all individuals with a spinal cord injury understand the basic concepts of a good dependent transfer. They may find themselves in a situation some day that requires a dependent transfer. It is important that they understand the proper way for someone to assist them without hurting their upper extremity.

Below, a dependent supine to sit and stand pivot transfer have been broken down into parts and key ideas listed for each stage of the transfer. Please educate your patient on how one and two people should be helping them with the transfer.

1. Supine to sitting transfer
    a. Preparing to move from supine to sidelying
        i. Upper arm must be supported when it is crossed over their body.
        ii. Raise the bed/table, if possible.

    b. Rolling
        i. Upper arm should be supported during rolling and lower arm should be slightly flexed to prevent impingement.

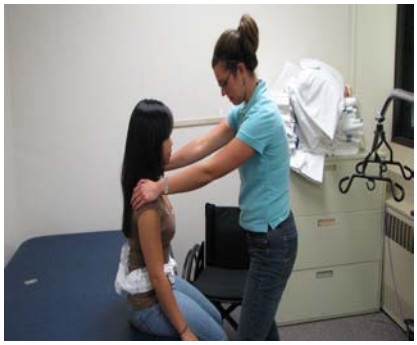
ii. Instruct patients to be aware of their caregiver's body mechanics and give them feedback.

c. Upper arm should be supported while the caregiver brings the patient's legs off of the bed.

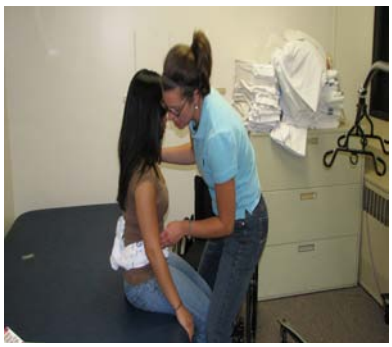
d. Moving from side lying to sitting.
    i. Let patients know that this will be a time that the caregiver will be very tempted to pull on his/her arm.
    ii.

e. Once sitting, the patient's arms should be supported by pillows or on the patient's lap.

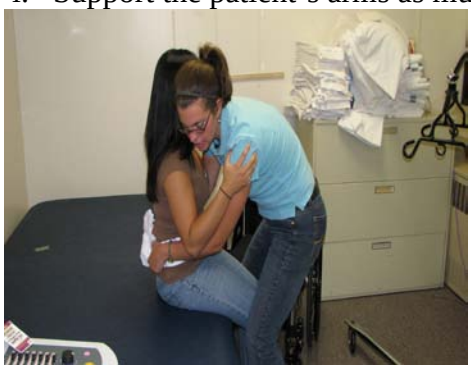
2. Stand pivot transfer
    a. Use a gait belt if possible
    b. Place the wheelchair as close to the bed as possible at a 20-45 deg. angle.



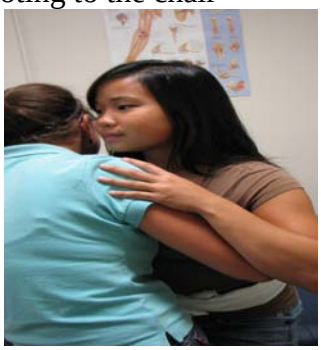
c. Try to make the chair lower than the bed.



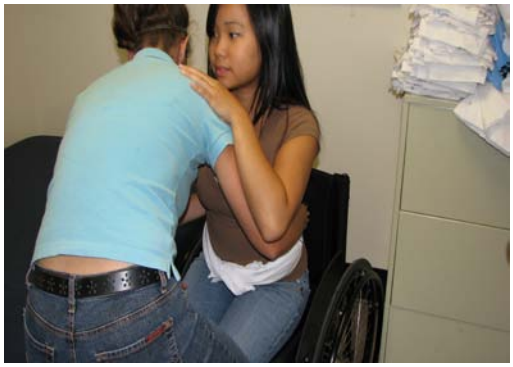
d. Encourage your patient's to again monitor their caregiver's body mechanics and give them feedback.
e. Preparing for the transfer
    i. Support the patient's arms as much as possible prior to the transfer.



f. Pivoting to the chair



g. Do not pivot more than 90 deg.



Having your patient practice these skills multiple times with different people will help to improve your patient's confidence. Prior to discharge, if possible, your patient's caregiver should come in to practice performing the transfers.

Performance Criteria: The patient will be able to independently explain to a caregiver the proper way to perform a dependent transfer.

Mechanical Lift Transfers:

If your patient is going to be using a mechanical lift device (e.g. Hoyer) to transfer from one surface to another, please educate the patient that they still must be aware of how to protect their upper extremity. Please educate your patient on the same steps for rolling to get positioned in the sling. **Once your patient has the sling around them, make sure that your patient's arms are crossed and not hanging out of the sling.**

Please make sure that your patient incorporates these points into their transfers—

- Your patients should have a clear understanding that they should never allow their caregiver to pull on their arms.
- Your patient should be able to instruct their caregiver set themselves up for theeasiest transfer possible
- Watch your arm position at all times to make sure it isn't being put into a position that causes pain.
- Don't "deal" with the pain during the transfer—even if a little damage is being done to your upper extremity, it can lead to a lot of damage in the future.
- Make sure your caregiver is always supporting your arms
- Make sure that your caregiver is protecting him/herself

If the patient is going to a SNF, it is extremely important that your patient understands that he/she will have to advocate for him/herself!

Here are some tips to give your patient on ways to advocate for his/herself:

- Become familiar with staff members who will be assisting you and their job responsibilities.
- Educate the person who is transferring you on the method of transfer you would prefer.
- Pay attention to how you are being transferred. Remember, don't "deal" with being transfer incorrectly—even a little bit of damage can end up being significant over time.
- Write down specific examples of problems. This way when confronting your caregiver, you can give specific examples of what is wrong.
- If you have concerns with your caregiver, talk to your caregiver first, if nothing changes, find out who their supervisor is and speak with that person. Make sure you go through the proper chain of command.
- Be assertive, persistent and respectful of the staff. Remember that you are the consumer in this situation.
- Set up a meeting to discuss the problems. Have your concerns ready and present them in an organized manner. This will show that you are serious about the situation.

<u>Performance Criteria:</u> The patient will be able to correctly direct his/her care in an assertive and polite manner.

Patient Education Materials:

- Dependent Transfers (Dependent Patients Only)

1. Silfverskiold J, Waters RL: Shoulder pain and functional disability in spinal cord injury patients. Clin Orthop Relat Res 1991(272): 141-5.

Module 3a—Wheelchair Propulsion Skills

Timeframe: Begin this module once the patient has an understanding that they will be using a wheelchair for the majority of their mobility. Initially, patients may be resistant to learning wheelchair propulsion techniques due to denial of the prospect of having to use a wheelchair for the majority of their mobility. However, this module needs to be started as early as possible in order to prevent bad techniques from developing.

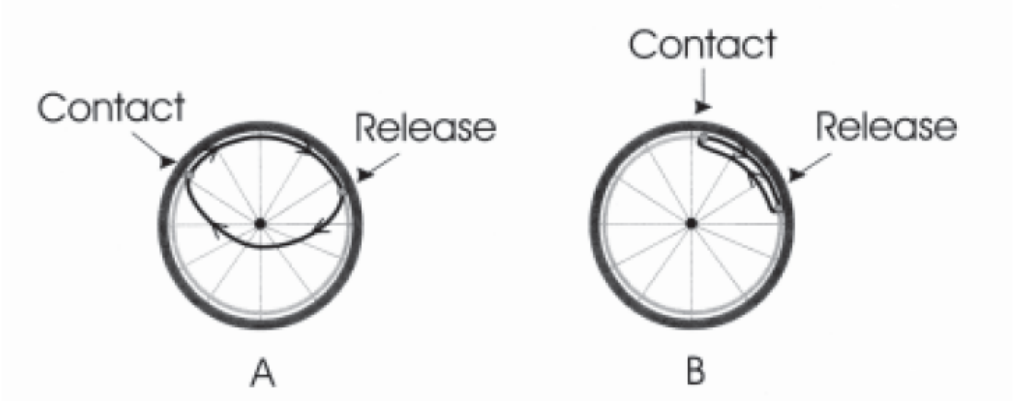
During wheelchair propulsion instruction, patients should be educated to:

- Use long strokes and encourage the patient to use as much of the pushrim as possible. (i.e., increase their contact angle)
- Use smooth strokes that limit the patient's impact on the pushrim. Educate patients that they should not be hitting into the pushrim when they initially contact the pushrim.

  - *<u>Performance Criteria</u>—Patient will display proper technique during w/c propulsion and display an understanding of reasons for long, smooth strokes.*

- Allow hand to drift down naturally, keeping hand below the pushrim (when not in contact with the wheelchair).

  - *<u>Performance Criteria</u>--Patient will display proper hand/arm techniques during w/c propulsion. Patient will also display an understanding of reasons to allow the hand to drift down naturally and keep the hand below the pushrim when not in contact with the rim.*



<u>Figure A</u> is the recommended, semicircular propulsion pattern. This pattern shows a long, smooth stroke.
<u>Figure B</u> is an example of a poor propulsion pattern. Notice how short the stroke is. The patient is using significantly less of the pushrim as compared to figure A.

To teach this skill, these alternative education techniques can be utilized:
***Extrinsic/augmented feedback**—Sensory information provided by an external force. (Move the patient's had through the wheelchair stroke so they can feel the correct way to propel)*[128]
***Knowledge of Results Delay** – After the patient has learned the proper wheelchair propulsion technique decrease the amount of feedback you are giving them.*[128]

- Wheelie

- Patients should be instructed how to safely perform a wheelie and understand the benefits of being able to correctly and safety perform a wheelie in a community setting.
    - Benefits:
        - Decreases stresses that are placed on the shoulders when ascending a curb.
        - Decreases the amount of stress placed on the shoulder when descending a ramp.

Potential Methods of Instruction

1. ***Demonstrate each phase*** *of the wheelie separately and verbally describe the phase.*[131]
2. ***Visualization*** *– Have your patient visualize performing the wheelie and balancing in the correct position.*[128]

- **Take off**:
    - "Roll slightly backward, then quickly forward to pop your front casters off the ground."
- **Balance**:
    - "Move the wheelchair in the same direction as the pitch was required."
    - Instruct patients to place their hands near the top center of the rear wheels.
    - Instruct patients to slightly flex their elbows during the balance phase of the wheelie.
- **Landing**:
    - "Gently return the front caster wheels to the ground."

- Competence Test:

A competence test was developed by Bonaparte, et al to determine if the patient was competent with wheelie performance. Please use the follow criteria to determine if your patient is "competent" performing a wheelie.

- Perform the take-off
- Maintain balance phase for 20 seconds
- Land safely
- Remain in a 1.5 meter diameter circle during the entire test.
- Perform 3 consistent trials.

- <u>*Performance Criteria:*</u> *The patient will perform a wheelie competently (per criteria proposed by Bonaparte, et al) and understand the benefits of a wheelie in relation to upper extremity function and pain reduction.*

Other methods of instruction:

Contextual Variety *–When you and the patient are going to another part of the facility, make sure to watch their w/c propulsion technique and comment on any problems you may see. This will encourage the patient think about their propulsion skills during daily activities, not just when they are in therapy.*[128]

Patient education materials:

- Printed document on wheelchair propulsion techniques. (Manual W/C users only)
- Printed document on wheelie skills (Manual W/C users only)
- CD or Video of proper wheelchair propulsion techniques. (Manual W/C users only)

1. Winstein CJ. Knowledge of results and motor learning--implications for physical therapy. Phys Ther. 1991 Feb;71(2):140-9.
2. Bonaparte JP, Kirby RL, Macleod DA. Learning to perform wheelchair wheelies: comparison of 2 training strategies. Arch Phys Med Rehabil. 2004 May;85(5):785-93.

Module 3b—Wheelchair Set-Up

Timeframe: This module will be used primarily when the patient is being fitted for their home wheelchair, however some of the thoughts (for example forward axle position = decreased rolling resistance) should be explained to the patient during their rehabilitation stay. The education component is an important part of this module.

- Adjust the rear axle as far forward as possible without compromising the stability of the user.
  - Forward axle position = decreased rolling resistance = increased propulsion efficiency
  - Forward axle position = increased contact angle
  - **Forward axle position = DECREASED rearward stability** (move the axle position forward incrementally!!)

    - *Performance Criteria: Patient will display good safety awareness during wheelchair mobility with the rear axle moved forward as patient safety will allow.*

- Position the rear axle so that when the hand is placed at the top dead-center position on the pushrim, the angle between the upper arm and forearm is between 100 and 120 deg.

    - *Performance Criteria: Patient will display a position in his/her wheelchair with elbow flexion between 100-120 degrees (when hand is placed dead-center on the pushrim) .*

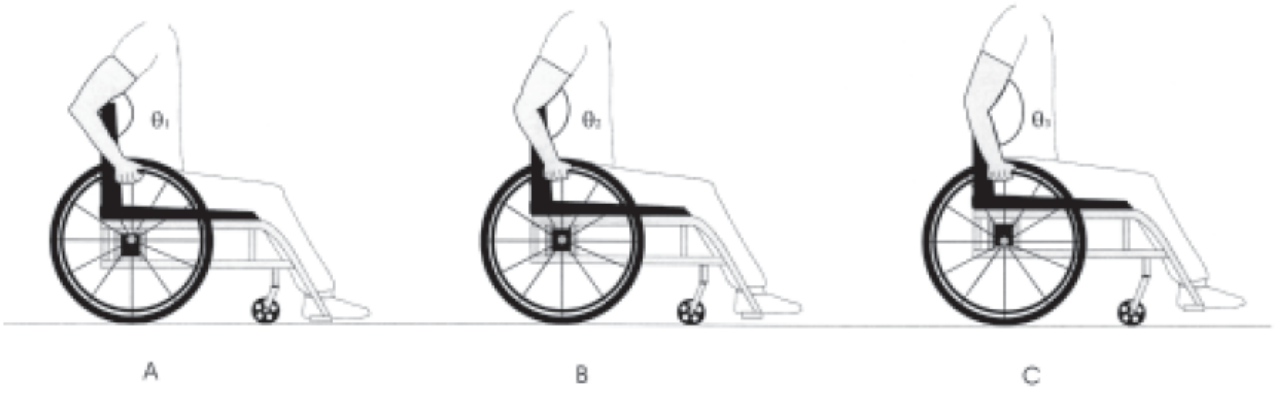


Figure 1: Difference in elbow flexion angle (Q). Diagram A = Angle is too small, Diagram B = Correct angle (100-120 deg.), Diagram C = Angle is too large. (Source: PVA CPG—Preservation of Upper Limb Function Following Spinal Cord Injury)

- Promote an appropriate seated posture and stabilization relative to balance and stability needs.
  - Stabilize the pelvis first, then the lower extremities and last, the trunk.
  - Use a cushion that provides postural support as well as pressure distribution.
  - Promote a neutral and midline position (if there are no fixed deformities).
  - Accommodate fixed postures of the pelvis, LE and trunk.
  - Place trunk support as high as the client needs to feel stable and comfortable. Apply lateral and anterior trunk supports if the client is unable to maintain a stable posture while performing activities of daily living and other functional skills.
  - Make special accommodations for patients who have a forward head posture that can lead to rounded shoulders. Use posterior stabilization of the pelvis in its most corrected posture (see figure A).
  - Accommodate a fixed kyphosis through shape and angle in space of the back support (see figure B).
  - For patient with C4 or higher neurological levels, provide full support of the upper limb.

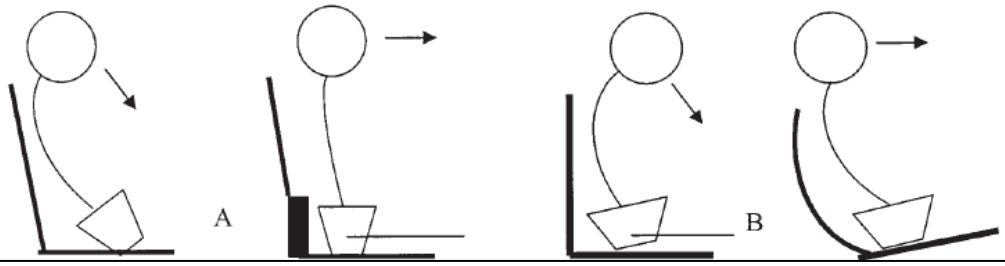


Figure 2: Diagram A—Provision of posterior pelvic support can prevent a kyphotic position of the trunk and anterior stability. Diagram B—A fixed kyphotic posture can be accommodated through seat tilt and a contoured backrest. (Source: PVA CPG—Preservation of Upper Limb Function Following Spinal Cord Injury)

- *<u>Performance Criteria:</u> Patient will display a stable base of support to provide a stable base for the upper extremities with assistance.*

<u>Alternative Education Options:</u>

4. Verbally quiz your patients on the guidelines
5. When quizzing:
    a. Ask the patient several questions and wait until the end of the quiz to give the patient the results.
    b. Structure your quizzes around how the patient is responding to the questions. This will allow the patient to think on his/her own and figure out what mistakes he/she is making.
6. If you have 2 or more patients who are both learning the guidelines, have small group discussions and (if appropriate) have quiz sessions with both patients together.

Patient education materials:

- Printed document: Wheelchair Set-Up. (Manual W/C users only)
- Printed document: Wheelchair Set-Up. (Power W/C users only)

<u>Module 4 -- Exercise</u>

The focus of this module is not only to prescribe an exercise program for your patient, but also to educate the patient on the importance of exercise and how it can help to preserve upper limb function.

Exercise is also a good way to maintain weight, which will decrease the forces placed on the shoulders during transfers and wheelchair propulsion. (Exercise is only **ONE** factor in weight control. Diet is another important factor which must be considered in weight control. Please make sure that your patient is seeing a nutrition counselor to make sure they are discussing weight control regarding diet.)

To develop an exercise program, either use your facilities' current program or the website: http://www.physiotherapyexercises.com/

Cardiovascular

Cardiovascular fitness is a very important component of the patient's overall health. Studies have shown that in general, cardiovascular exercise is related to a decrease in medical complications.

Educational method *– In a study performed by Lowther, et al,[132] results indicate that when interventions focused on increasing the use of behavioral processes (such as enhancing the subject's belief that exercise would benefit them), compliance to exercise improved. Therefore, educating patients that exercise will benefit them now and in the future, is a critical educational component to improve compliance to an exercise program.*

Please educate your patients on the following:

1. Individuals with SCI often have a more difficult time training (Decreased VO_2 Max) compared to able bodied individuals due to two major reasons
    a. The larger muscles are usually the ones that train the heart. Muscles of the arms often fatigue before a target heart rate can be achieved (an adequate volume load cannot be created to train the heart.)
    b. Loss of sympathetic neural regulation of the heart. (For injuries above T6)
2. Although central cardiovascular training changes may not occur, there are often other significant changes that can occur. They include:
    a. Increased exercise tolerance
    b. Improved muscular endurance due to muscle fiber growth in size (hypertrophy) and their improved ability to extract oxygen from the blood
    c. Strength gains that may allow increased cardiovascular endurance.
    d. Increase peripheral extraction of oxygen from the blood. (Lockette, pg. 93)

Your patients have a few options for cardiovascular training. They include:

1. Upper body ergometry.
2. Hand cycle
3. Functional Electronic Stimulation
4. Bodyweight Supported Treadmill
5. Pushing a wheelchair on a treadmill or rollers.
6. Swimming
7. Wheelchair sports (Basketball, Rugby, Soccer, etc.) Other resources for wheelchair sports include:

a. www.lifestylesport.com
b. www.planetmobility.com
c. http://heome.wi.rr.com/birzer

Education Method *– Lowther, et al [132] found that providing patients with point-of-decision prompts (such as a poster telling you to exercise), improved compliance with exercise programs. Therefore, providing patients with information about opportunities and encouraging patients to look at the websites on their own will help to make exercise a more common part of their daily lives.*

Performance Criteria: The patient will be able to explain the specific benefits of cardiovascular exercise and how it is related to preservation of shoulder function.

Strengthening

Exercise is a very important component of maintenance of healthy upper extremity. Individuals with spinal cord injury are very prone to muscle imbalances, which can lead to poor posture and increased upper extremity pain. A recent study performed by Nawoczenski, et al,[133] found that during an 8 week period individuals with SCI who participated in a specific strengthening program that targeted scapular musculature reported improved shoulder function and decreased shoulder pain.

- In addition to the home exercise program (HEP) that you would normally develop for your patient, please incorporate the following exercises that are recommended by the guideline. The guideline recommends a strong focus on strengthening the following muscles:
  - Infraspinatus
  - Subscapularis
  - Serratus Anterior
  - Latissimus Dorsi
  - Trapezius (Middle and Lower)
  - Rhomboids
- The guidelines recommend:
  - Perform one set of 8-10 exercises
  - 8-12 repetitions
  - 2-3 days/week
  - Goals for daily repetitions should systematically increase, starting low and gradually working up to target levels.

- Additional resistance can be added, through theraband, as your patient becomes stronger.

- **Don't increase both resistance and repetitions at the same time.**

- **Educate your patients on the importance of remembering the signs of autonomic dysreflexia during exercise! Please instruct your patient on the precautions suggested by Lockette:**

  - **Empty leg bag, etc.**
  - **Keep a cool cloth close by when exercising in the heat.**
  - **Monitor body temperature frequently**

  Please give your patients the PVA's consumer guide regarding the signs and symptoms of AD.

- **When possible, try to incorporate weight bearing activities into your patient's exercise program.**

  - **Weight bearing activities can help to reduce the problems associated with osteoporosis, which is a very common problem for individuals affected by SCI. (Lockette, pg.92-97)**

Education Method *--Show patients the specific muscles on an anatomic model or in a text book to improve their comprehension on the exercise*[133].

> *<u>Performance Criteria</u>: The patient will be able to explain the specific benefits of a strengthening program and how it is related to preservation of shoulder function.*

Stretching:

Stretching is another essential part of maintaining a healthy upper extremity. Many wheelchair users display a posture of protracted shoulders with shortened anterior and lengthened posterior musculature and a forward head position. Decreased range of motion can potentially lead to increased upper limb injury and pain. Stretching has been found to decrease pain intensity. [134] In addition, stretching allows the glenohumeral joint to move freely and decreases the possibility of shoulder impingement.

- In general, patients should be instructed in the importance of stretching the **anterior shoulder musculature**. The guidelines recommend a strong focus on stretching the following muscles:
  - Internal rotators of the humerus
  - Scapular protractors
  - Upward rotation of the scapula
  - Neck
  - Pectoralis Major/Minor
  - Long Head of the bicep

- The guideline recommends:
  - Perform stretching 2-3 times/week
  - Apply gentle, prolonged stretch in each direction of tightness.
  - Avoid internal rotation when completing overhead range of motion

- *Performance Criteria: Patient will be independent or be able to independently instruct a caregiver to assist with a ROM program.*

Performance Criteria: The patient will be able to explain the specific benefits of a stretching program and how it is related to preservation of shoulder function.

Please instruct your patients who have injuries above C6 or who cannot perform a comprehensive stretching program independently and their caregivers PROM techniques. Make sure to emphasize to the patient, the differences between a distractive force to mobilize the joint with a destructive force of someone pulling on their arm. Also, make sure that the patient's caregiver is able to correctly perform a distractive force to allow for optimal ROM, but not performing it incorrectly so that the patient will sustain damage to their shoulder.

Performance Criteria: The patient will be able to correctly instruct their caregiver how to correctly perform a comprehensive PROM program.

A checklist has been created, for your convenience, to make sure that you have incorporated all aspects of the exercise program into your patient's HEP. You can either use the checklist below or print out a separate sheet (The checklist is stored in the same folder, named HEP checklist.xls)

Did you include the following items in your HEP?

Strengthening

Humeral external rotation
Humeral internal rotation
Scapular Depression (Serratus Anterior and Lats)
Scapular Retraction (Mid/Lower Traps and Rhomboids)

Stretching

Internal humeral rotators
Anterior Chest musculature (Focus on pecs)
Upper Traps
Neck musculature
Shoulder flexors

Lying in Bed:

Please instruct your patients that when they are sleeping, they should position themselves so that they do not put increased pressure on their upper extremity and do not let their musculature get tight. In addition, please stress to your patients that the time spent sleeping can also be a good time to stretch the shoulder musculature.

These positions incorporate the following important principals:

- Avoid direct pressure on the shoulder
- Provide support to arms and shoulders at all points.
- When lying supine, sidelying or prone, instruct patients to bring their arm out to the side (approximately 75 degrees) and bend their elbow to 90 degrees.
- If the patient is sidelying, they should have their entire body, rotated approximately 30 deg off the mattress and supported by pillows.

- As always, patients should be instructed to NEVER let anyone pull on their shoulders.

- *Performance Criteria: The patient will be able to independently position him/herself or instruct a care giver to position him/her correctly to avoid a decrease in ROM and increased pain.*

- *Performance Criteria: The patient will be able to describe a comprehensive exercise program and how they plan to execute their exercise program after discharge.*

Patient Education Materials:

- Exercise Program

Education Methods--

Kerstin, et al [135] performed a study in which SCI patients were interviewed to determine what motivates them to exercise. Overall, the SCI patients who were interviewed reported the following to be some of the **factors that motivated them to exercise**:

1. Improving and maintaining their independence
2. Improving overall health
3. Improving physical appearance
4. Establishing a self image of being physically active
5. Becoming part of a social network.

Surprisingly, many patients also indicated that becoming a **role model** was an important motivating factor associated with exercise. Therefore, during rehab, patients should be encouraged to speak with other patients and become role models for each other.

Kerstin [135] also asked patients what **strategies they used to keep them exercising**. The following are some of the factors that SCI patients reported:

1. Finding a role model/group to exercise with.
2. Creating a routine
3. Setting goals and performing standardized tests to objectively measure their performance.
4. Learning about different exercise methods.

Finally, Kerstin [135] asked these individuals what types of **barriers** they experienced, that were specifically related to their spinal cord injury.

1. Trouble with outdoor climate/medical complications
2. Lack of accessible facilities and transportation to those facilities
3. Absence of a training partner
4. Low self confidence in their ability to exercise

Understanding what predicts patient behavior is important for a clinician. [136] If the clinician can see that a patient does not understand the concept, he/she can change their educational tactics.

When encouraging patients to maintain their exercise routine after they leave rehab, Blue, et al [137] found that the patient's **attitude towards exercise** was a very strong predictor of their future exercise adherence. Lowther's [132] research also indicated that when patients have self-liberation (**having the mindset that exercise will help to prevent future health complications**) frame of reference, this is a good indication of future adherence to a long-term exercise program.

1. Lowther M, Mutrie N, Scott EM: Identifying key processes of exercise behavior change associated with movement through the stages of exercise behavior change. J Health Psychol 2007; 12(2): 261-72.

2. Nawoczenski DA, Ritter-Soronen JM, Wilson CM, Howe BA, Ludewig PM: Clinical trial of exercise for shoulder pain in chronic spinal injury. Phys Ther 2006; 86(12): 1604-18.

3. Curtis KA, Tyner TM, Zachary L, et al.: Effect of a standard exercise protocol on shoulder pain in long-term wheelchair users. Spinal Cord 1999; 37(6): 421-9.

4. Kerstin W, Gabriele B, Richard L: What promotes physical activity after spinal cord injury? An interview study from a patient perspective. Disabil Rehabil 2006; 28(8): 481-8.

5. Ajzen I, Fishbein, M: Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentic-Hall, 1980.

6. Blue CL, Wilbur J, Marston-Scott M: Exercise among blue-collar workers: application of the theory of planned behavior. Res Nurs Health 2001; 24(6): 481-93.

APPENDIX B

PATIENT EDUCATION MATERIALS

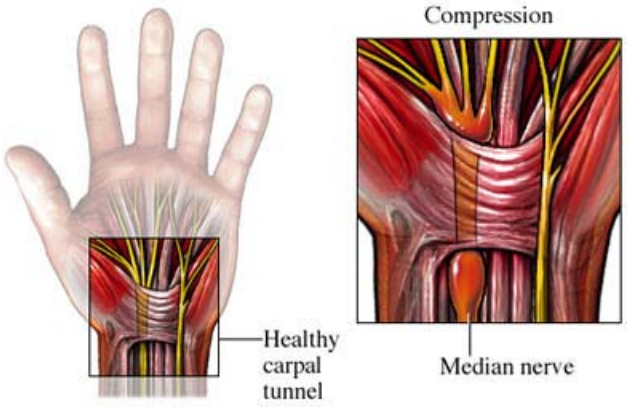
Causes of Upper Limb Pain

Many people develop pain in their wrist, elbows and shoulders after experiencing a spinal cord injury. This is caused by the increased amount of pressure that you place on your joints, muscles and nerves when using a wheelchair or transferring from one surface to another. Below is a list of common problems people have once they start using their wheelchair on a regular basis. We believe that many of these problems can be avoided if you follow the guidelines given to you by your therapist. However, **if you do notice some of these problems, please contact your doctor or therapist to discuss options to treat these problems.**

Wrist

Carpal tunnel syndrome:

The median nerve provides feeling to the thumb, index and middle fingers, and half of the ring finger. It also controls several muscles in the hand, the most important of which allows the thumb to touch the little finger. This nerve passes through a narrow passage in the wrist called the carpal tunnel along with several muscle tendons which enable you to curl your fingers and make a fist. When these tendons and other tissues in the carpal tunnel surrounding the nerve swell up or are inflamed, they put pressure on the nerve and cause it to malfunction. This pinching on the nerve, in turn, produces numbness, tingling, pain and weakness in the fingers, and eventually produce loss of grip strength.



Carpal tunnel syndrome is a repetitive strain injury, meaning the symptoms are caused by repeated movements and can get worse

with continued wrist and hand use and overuse. In persons with spinal cord injury, the most common cause of carpal tunnel syndrome is repeated use of your hands to to push your wheelchair or move from one surface to another. Symptoms of carpal tunnel syndrome can make it difficult for you to perform these tasks.

Ulnar Nerve Entrapment (Guyon's canal)

The ulnar nerve provides sensation to the ring finger, little finger, and the part of the palm of your hand connected to those fingers. It also controls most of the muscles in the hand. The nerve passes through Guyon's canal, which is located on the side of your palm near its border with the wrist. When the ulnar nerve is entrapped or compressed within this canal, you will have the same type of numbness, tingling and pain in your hand and fingers as in carpal tunnel syndrome, except that the location would be in the ring and little fingers. Later on there may also be weakness in the hand muscles. The pressure on the nerve is also caused by swelling and entrapment of the ulnar nerve within Guyon's canal. Again, this is a repetitive strain injury that occurs because the tissues in Guyon's canal swell up. This type of injury can also make it very difficult for you to push your wheelchair or move from one surface to another.

Elbow

Ulnar nerve entrapment at the elbow

Similar to the compression in the wrist, the ulnar nerve can also be compressed in the elbow when it passes through a small tunnel on the back side of your elbow called the cubital tunnel. You may get a feeling similar to when you have "hit your funny bone". Other symptoms can include:

- tenderness along the inside of the elbow
- tingling and numbness in little and ring fingers (especially at night)
- numbness in your hand when the elbow is bent, such as when you drive or hold a telephone
- difficulty with hand coordination
- decreased grip and pinch strength, muscle weakness
- pain along the inside border of the shoulder blade

This can be painful and make it difficult for you to push their wheelchairs and perform transfers that are necessary for your daily activities.

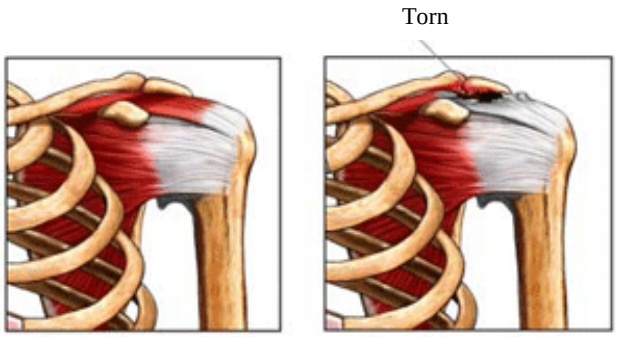
Shoulder

A group of four muscles called the rotator cuff surrounds the shoulder joint and helps to keep the joint stable. These muscles are important in tasks that involve lifting your arm, reaching for objects in front of you and overhead, reaching back, and propelling your wheelchair.

Impingement Syndrome:

Impingement occurs when the tendons of the rotator cuff muscles rub against the acromion (the top part of your shoulder blade) and become irritated in the process. Pain in the shoulder area, particularly on the front and side portions, is a symptom of impingement. This pain is made worse by activities when you hand is above your shoulder, and also may be worse at night. This can lead to serious problems affecting your ability to perform your daily activities, especially those which involve reaching.

Rotator Cuff Tear



Normal Rotator Cuff Torn Rotator Cuff

Impingement may lead to a more severe condition called a rotator cuff tear. Repeated and constant irritation of the tendons of the rotator cuff muscles can lead to more damage and eventually cause a tear. Treatment for this condition involves reducing your activities physical and occupational therapy, and in more severe cases, surgical repair. This would make it quite difficult for you to recover the full shoulder function needed to perform your daily activities such as transferring and pushing your wheelchair. If the damage is severe enough, you may need someone else's assistance for performing transfers, propelling your wheelchair and other activities of daily living while you recover.

All the information and images were obtained from www.upmc.com unless otherwise noted.

Welcome!!

This booklet is filled with different ways to help prevent pain in the shoulder, arm and hand (collectively called the "upper limb") when you are doing your everyday activities. Your therapist will go over all of these ideas with you in detail. Here is a short overview to get you started.

Preventing shoulder, arm and hand pain and preserving their function is a very, very important concept that spinal cord injury patients need to keep in mind.

Here is what some of the experts say about these issues:

- Shoulder pain may cause you to perform functional activities similar to and cost as much as an individual with a higher level lesion. (1)
- Pain was the only factor that caused individuals to report lower quality of life levels. (2)
- 26% of patients with upper limb pain needed additional help with functional activities and 28% reported limitation of independence because of shoulder pain. (3)
- Unemployment was higher and full-time employment was lower in individuals with upper arm/shoulder pain vs. those with no upper arm/shoulder pain. (3)

If you would like to see these articles, just ask your therapist! As you can see, upper limb pain can have a big effect on your daily life. A panel of expert physicians, occupational therapists, physical therapists and other specialists in the field of spinal cord injury have come together and studied the activities that people with spinal cord injuries do on a daily basis. This panel pinpointed about 20 activities that people often do wrong that lead to having shoulder, arm and hand pain. Next, with the aid of a lot of research, they came up with improved ways to continue doing these activities which put less stress on the person's upper limb. Their ideas have been taught to your therapist and are summarized in this book.

During your therapy sessions, your occupational and physical therapist will teach you how to take care of your upper limbs during:

- Transfers (moving from one surface to another)
- Pushing your wheelchair
- Exercise
- Daily activities

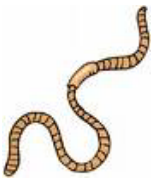
(1) Sie I, Waters R, Adkins R, Gellman H. Upper Extremity Pain in the Postrehabilitation Spinal Cord Injured Patient. *ArchPhys Med Rehabil* (1992) 73:44-8.
(2) Lundqvist et al, Spinal cord injuries: clinical, functional, and emotional status. *Spine.*16 (1991): 78-83.

(3) Dalyan, M., D.D. Cardenas, and B. Gerard. Upper extremity pain after spinal cord injury. *Spinal Cord* 37 (1999): 191-5.

Managing Pressure in Your Wheelchair

When you are in seated in a wheelchair or in bed, it is very important that you protect your skin while not hurting your arms.

Think about how much people move around daily. We seldom stay in one position for very long, and we are always adjusting and repositioning. Because you may not be able to feel pressure and pain on your skin after your spinal cord injury, it is important to take steps to make sure you are protecting your skin.



While Sitting in a Wheelchair:

- If you are unable to lift your arms above your head, it is important that when you are sitting in a wheelchair, you do not let your arms hang down to your side Always make sure that your arms are supported by some type of arm rest.
- Performing pressure relief is a very important aspect of your skin care but can also be hard on your shoulders if done the wrong way. Many people perform a "wheelchair pushup" (i.e. pushing up on the armrest of the wheelchair and lifting their buttocks off the seat) **Performing a wheelchair pushup puts a significant amount of stress on your shoulders**. In addition, recent research has shown that for pressure relief to really be effective, the area needs to be "unloaded" (significantly reducing the pressure on a specific area) for an extended period of time. Pushing up on the armrests of a wheelchair for an extended period of time would be difficult and uncomfortable. The following are different methods of pressure relief that decrease the stress put on your shoulders. These methods allow you to comfortably perform the pressure relief that is so important to your skin, for the necessary amount of time.

    - Learn forward in your chair—Try to put your chest towards your knees.

Figure1-- Leaning forward in chair pressure relief

- Lean to one side and then the other. (i.e. lift one side of your buttock up at a time) To increase the amount of pressure relief you can get from this method, hook your arm around the back of your chair and pull yourself further over to the side.

Figure2--Lean to one side and then the other pressure relief

- If you are unable to learn forward or to the side, leaning back in your chair 65 degrees is an effective method.
  - If you are sitting in a manual wheelchair you will need assistance from a caregiver. For the safety of your caregiver, they should be seated behind you in a sturdy chair. Your caregiver should tilt you back in the chair for approximately 2 minutes.
  - If you are sitting in a power wheelchair, you should request a chair that has a 'tilt-in-space' seating function. This seating function will tilt the seat and backrest of your chair back, but keep the angle between the backrest and seat of the chair the same.

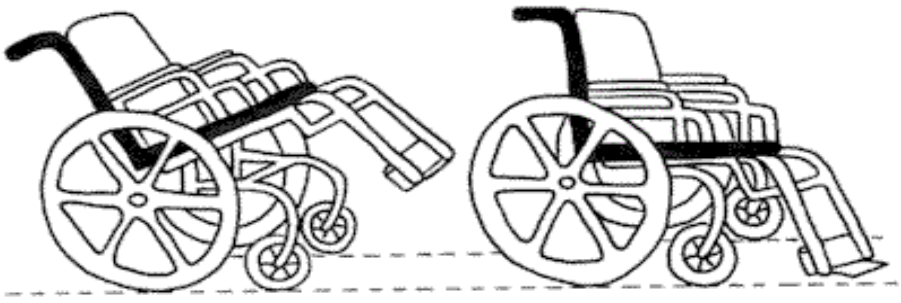


Figure 3--Tilt-in-space wheelchair

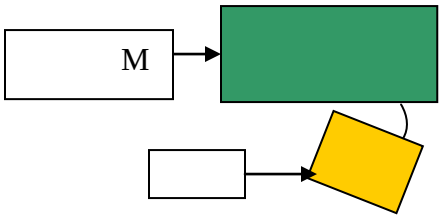
Transfer Education

SET UP PHASE:

- **Try to make the transfer as easy as possible.**

  - Your chair should be as close to the surface you are transferring to as possible. (Ideally, the chair should be touching the surface.)
    - This will decrease the amount that you need to bring your arm up and out to the side to safely reach the surface you want to get to.

  - Position your chair on a 20-45 deg angle (between your chair and the surface you are transferring too.)
    - This position will help to:
      - put your shoulder in the best alignment for the correct transfer position
      - Decrease the distance and amount of time you have a significant amount of weight on your shoulders.



2

  - Position your chair so that you do not have to go over the rear wheel (i.e. transfer in front of the rear wheel)
    - This will decrease the height you must lift yourself during the transfer.

  - If you have an armrest on your chair, take it out of the way before you transfer.

  - Place your feet in the most stable position (on the floor if possible) before you transfer.
    - Even if you do not have control of your legs, putting them in the proper alignment will provide a small amount of support and stability. Ultimately, this will decrease the amount of stress you put on your shoulders.

  - Sit on the front 2/3rds of your chair (or close to the edge of the surface you are transferring from)
    - This will decrease the amount of distance and work you have to do to move from one surface to another.

  - Place your hands in a stable position prior to the start of the transfer.
    - The hand that you will be pushing from is close to your body and holding onto a stable object.

- Your other hand should be positioned close to where you intend to land.

▪ *By this point you should feel that you have positioned yourself to perform a transfer that will be safe and easy. If you do not feel this way, discuss alterative ways to set your chair up with your therapist.*

- **During the transfer, limit the amount of time that your shoulder is in an internally rotated/abducted/flexed position.**
  - Your therapist will spend a significant amount of time teaching you the correct way to position your upper arm so that you do not damage your shoulder. Limit the amount of time that you spend during your transfer with either one of your arms lifted up and to the side along with being twisted inward. It is okay to position your arm in this manner, as long as you do not have a significant amount of weight on that arm.

▪ *By this point you should be able to describe the position of your arm that you want to avoid during transfers. In addition, you should ask your friends and family members to make sure that you are not placing your arm in this position when you transfer.*

Good!

Bad!

- **It is very important to have a good surface to push off of when performing a transfer. It is best for your wrist to use some type of a handgrip (if one is available).**
  - You can use the arm rest on your wheelchair, the edge of a mat table/bed; arm rests chairs, the edge of a tub bench, or arm of bedside commode.
  - If no handgrip is available, place your hand flat on the surface you are transferring from.
  - **It is very important to maintain the proper shoulder position, compared to reaching for an arm rest further away.**

- *By this point you should be able to make a good decision to either use a handgrip (if one is available in a good position) or place your hand flat on the surface you are transferring from.*



Try to Avoid Try to Avoid Best

FLIGHT:

- **Use the "head-hips" relationship.**
  - Your therapist will spend a significant amount of time teaching you about the "head-hips" relationship. You want to move your head in the opposite direction that you want your hips to move.

- *You should have a good understanding of the head-hips relationship (if this is a necessary skill for you) and should be utilizing the technique during most of your transfers.*

- Using the head-hips relationship will make the transfer easier and thus decrease the amount of stress you are placing on your shoulders.

  - Your flight should be smooth and well controlled.

END:

- When you reach finish your transfer, you should feel that it was very smooth and well controlled.

- Both of your hands should be in contact with both surfaces at the end of the transfer

GENERAL:

- **Perform level transfers whenever possible**.
  - Look for alternative surfaces to transfer to, (not just the easiest place) or adjust the surface (if possible). ex. Adjust the height of your tub seat or bedside commode so you do not need to perform an uphill transfer.

▪ *By this point, you should be able to make educated choices to perform level or downhill transfers whenever possible.*

- **Alternate which arm you use to push off with** (i.e., don't always transfer with the right arm as the arm to push off from the surface you are sitting on with)

▪ *By this time you should be making a conscious effort to alternate the direction you transfer. Ask your friends and family to remind you of this during your daily activities.*

- **Use a transfer devices to decrease forces placed on the shoulder**
  - Even if you are able to do a transfer independently, it is still a good idea to use a transfer device for transfers that may be more difficult for you. In addition, if you are in a place that you can conveniently use a transfer device, it is a good idea to use one to give your shoulders and upper arms a break.

▪ *By this point, you should be able to correctly decide when it is a good idea to use a transfer device to decrease the stress you put on your shoulders.*

Dependent Transfers

Learning how to tell someone how to transfer you is a very important part of preventing upper extremity pain. Even if you have a caregiver who has a good understanding of the proper way to perform a transfer or you can do most of the work yourself, you can still run into a situation where you need to be transferred by someone who does not know the proper techniques. You need to have the ability to easily explain to anyone how to transfer you in a manner that will protect you and the person who is transferring you.

Transfer techniques play a large role in the amount of upper extremity pain you experience. Studies have shown that 78% of individuals with tetraplegia experienced shoulder pain.[130] One factor that has been associated with shoulder pain is when individuals are transferred incorrectly, particularly when caregivers are pulling on the individual's arms.

There is no way that your therapist will be able to teach you how to transfer in every situation you will run into. However; once you are comfortable with the basic techniques, you can apply those techniques to other situations.

Below, a script has been prepared with key words you should say to your caregiver during transfers.

3. **Lying on back to sitting transfer**
    a. Raise the bed/table up as high as possible.
    b. To prepare to roll me onto my side, bend my legs up, cross my arm that is furthest from the edge over my body.

    c. Put one of your hands behind my knees and the other on my back (behind my shoulder). *Your caregiver should NOT be pulling on your arm*.

d. Roll me onto my side in one fluid motion.

e. If there are two people helping you, the 2nd person should be behind you with one hand on your back (near your shoulder) and one hand by your hip. He or she can do the majority of the work to help roll you, while the person in front can protect your shoulder.

f. *Tell your caregiver*--Please don't pull on my arm.

g. Scoot me over to the edge of bed as much as possible, without making me feel that I am going to fall off the bed. When scooting me over, please get as close to me as possible. *This position is best for your caregivers back.* When reaching towards me, make sure that you bend your knees instead of bending at your waist.

h. Your caregiver should move one section of your body at a time. (For example, move your shoulders, then move your hips and then your legs, then back to your shoulders, etc. He or she should just move each section a little bit at a time.

i. If two people are helping you, they should be working together to move each segment of your body.

j. Bend my legs up to my chest. My knees should be bent at a 90 deg. angle.

k. Place one hand under my shoulder and your other hand under my knees.

l. Move my knees so that the bottom part of my legs fall off of the side of the bed.

m. Move the hand that was under my knees to my hip bone.

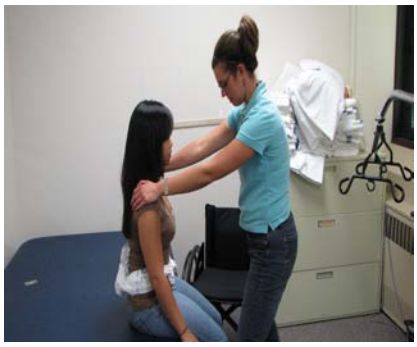
n. At the same time, pull my upper body (with your hand under my shoulder) up to a sitting position and push my hip into a sitting position. (Down and towards my feet) *This will be the point when your caregiver will be most tempted to pull on your arm, don't let them!*

o. *If two people are helping you, one person should be in-front of you and the other person behind you, working together (with the same technique stated above) to sit you up.*

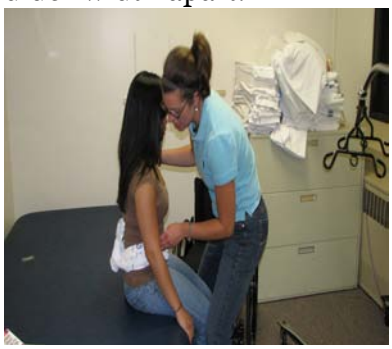
p. Once I am in a sitting position, make sure you hold onto me!
    i. Position my arms in my lap so that they are not hanging down at my side.
q. Move my legs into a stable position so that I can help as much as possible to remain sitting.

4. Moving from the bed to your wheelchair:

a. Please use a gait belt on me! If you do not have a gait belt, you can put a sheet under my buttock.
b. Place the wheelchair that you are transferring me to as close to the bed as possible at a 20-45 deg. angle to the bed.



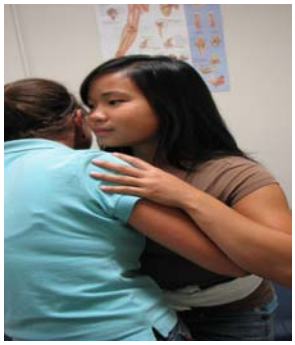
c. Try to make the chair lower then the bed.
d. Make sure that my feet are positioned on the floor, just slightly less then shoulder width apart.



e. Your feet should be on either side of my feet, about shoulder width apart.
f. You should be very close to me!
g. If possible, have me reach up and grasp the back of your arms. *Don't pull on your caregiver's neck.*
h. Reach around me, like you are giving me a bear hug, and grab the gait belt. If there is no gait belt, reach under my buttock. *Don't let your caregiver pull on your clothes!*

i. If two people are helping you, one person should be in-front of you and the other person will position themselves between the bed and the surface you are transferring to. They will either hold onto the gait belt or under your buttock.
j. Once you have a good hold, shift your weight backwards and lift me up.

k. Once my buttock is off the bed, pivot to the chair.
l. When two people are helping you, the person behind you will assist the person in front to lift you up and pivot you to the chair.



m. Do not pivot more than 90 deg.

Practice these skills multiple times with different people to improve your confidence. Before you leave, make sure that you have practiced this transfer with your primary caregiver (if know!)

Mechanical Lift Transfers:

If you are going to be using a mechanical lift device (e.g. Hoyer) to transfer from one surface to another, you and your therapist should go over the steps for the specific device you will be using at home. In relation to protection of your upper extremity, you should follow the same steps for rolling to allow your caregiver to position your sling. **Once you have the sling around you, you need to make sure that your arms are crossed and not hanging out of the sling.**

Summary:

- Don't let your caregiver pull on your arms
- Have your caregiver set you up for the easiest transfer possible
- Watch your arm position at all times to make sure it isn't being put into a position that causes pain.
- Don't "deal" with the pain during the transfer—even if a little damage is being done to your upper extremity, it can lead to a lot of damage in the future.
- Make sure your caregiver is always supporting your arms
- Make sure that your caregiver is protecting him/herself

By this point, you should be able to independently explain to a caregiver the proper way to transfer you.

You NEED to feel comfortable being able to advocate for yourself!

Here are some tip to effectively advocate for yourself[138]:

- Become familiar with staff members who will be assisting you and their job responsibilities.
- Educate the person who is transferring you on the method of transfer you would prefer.
- Pay attention to how you are being transferred. Remember, don't "deal" with being transfer incorrectly—even a little bit of damage can end up being significant over time.
- Write down specific examples of problems. This way when confronting your caregiver, you can give specific examples of what is wrong.
- If you have concerns with your caregiver, talk to your caregiver first, if nothing changes, find out who their supervisor is and speak with that person. Make sure you go through the proper chain of command.
- Be assertive, persistent and respectful of the staff. Remember that you are the consumer in this situation.
- Set up a meeting to discuss the problems. Have your concerns ready and present them in an organized manner. This will show that you are serious about the situation.

1. Silfverskiold J, Waters RL. Shoulder pain and functional disability in spinal cord injury patients. Clin Orthop Relat Res. 1991 Nov(272):141-5.
2. Benson WFH, Alice H. Advocacy Suggestions for Nursing Home Residents and their Families <http://www.nccnhr.org/public/50_152_430.CFM>. Accessed 2007 September 12.

Pushing Your Wheelchair

Here are some tips for you to make pushing your wheelchair as easy and efficient as possible. Pushing a wheelchair can be very hard on your arms. Because of this, you want to make each stroke count as much as possible. By following these simple suggestions we believe you can lead a more active lifestyle with less shoulder and arm pain.

❖ Use long and smooth strokes.

- When you are pushing your wheelchair, the best and most efficient way to push is to use **long and smooth strokes**. Think about swimming. When people do the doggy paddle with short and choppy strokes they do not go very far or very fast. If they do the freestyle or crawl stroke, they go much farther and faster with the same amount of energy. This is why Olympic swimmers use the crawl stroke and not the doggy paddle.

- When you take a stroke, reach back as far as you comfortably can then smoothly bring your hands as far forward as you can.
- Do not rush your stoke. Take your time moving the wheel forward and try to match the speed of the wheel.
- A slow, smooth stroke with more power will be much more efficient than taking short, fast and choppy strokes. Top wheelchair racers use a very long and smooth stroke to get the most from every stoke.

Start

Finish

- When you are finished with the stroke, let your hand gently relax and return to the back of the wheel. You should not do any excessive movements. Just let you hand drop down and reach as far back as you can comfortably.
    - As you reach back to start another stoke, the wheels will continue to glide smoothly forward.

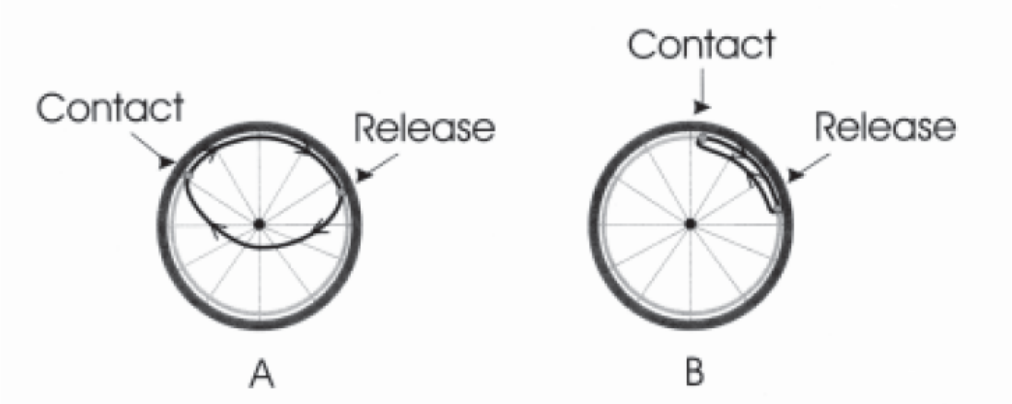


Figure A shows the wheelchair propulsion path of a person who pushes the wheel with a long, smooth stroke. The path starts when the person reaches as far back on the wheel as he comfortably can, and pushes forward with a long smooth stroke. The path also shows the person letting their hand relax between strokes and then reaching as far back as possible on the wheel to start their next stroke. Notice how they are using a lot of the wheel surface. **This is the most efficient way to push the chair.**

Figure B, shows the path of a person using short and choppy strokes. Notice how he is not using much of the wheel surface at all. **This is a bad way to push a wheelchair.**

- Do not hit your hand onto the pushrim of the wheelchair. You will waste a lot of energy this way. If you hit the rim, it will stop the wheel from gliding smoothly. Hitting your hand onto the pushrim will also cause damaging forces to the rest of your arm. Try to gently place your hand on the pushrim when you first make contact with the wheel. If you are pushing on a smooth surface, your wheel should continue to smoothly glide.

You can look at your DVD or video to see all the steps together.

Wheelchair Set-Up (Manual W/C)

Your therapist or wheelchair supplier will try to move the wheel axle (the part that holds the wheels of your wheelchair) as far forward as possible. By moving the wheel axle forward, your wheelchair will have less rolling resistance. By decreasing the rolling resistance, your chair will roll more smoothly. Also, the more forward the axle position is, the more you will be able to contact the wheel. This will help to make the most of your pushing efforts (i.e., improve efficiency). This increased efficiency has a trade off—**as the axle position is forward, the chair becomes more unsteady.**

- Your therapist will move the axle position forward slowly, giving you plenty of time to adjust.
- Do not place heavy backpacks or packages on the back of your chair. (this will make the chair even more unsteady)
- If you need to carry something, place it under your chair (but be careful that it is not too close to the ground and will get caught on things).

- Your therapist will also position the rear axle so that when your hand is placed at the top dead-center position on the pushrim, the angle between the upper arm and forearm is between 100 and 120 deg. You can test this out yourself by putting your arm straight down to your side. Your finger tips should reach just below the axle.
  - The will allow you to have optimal contact with the wheel and make your pushing efforts as efficient as possible.

Figure 1: Difference in elbow flexion angle (Q). Diagram A = Angle is too small, Diagram B = Correct angle (100-120 deg.), Diagram C = Angle is too large. (Source: PVA CPG—Preservation of Upper Limb Function Following Spinal Cord Injury)

Your therapist will also try to make your seat as comfortable as possible while trying to put you in the best posture.

- Your therapist will look for a cushion that:
  - Provides postural support as well as pressure distribution.
  - Promotes a neutral and midline position (if possible).

- Your therapist will give you as much trunk support as needed to make you feel comfortable.
- Make special accommodations if you have a forward head posture that can lead to rounded shoulders. (Diagram A)
- Accommodate a fixed kyphosis (forward bending) through shape and angle of the back support (Diagram B).

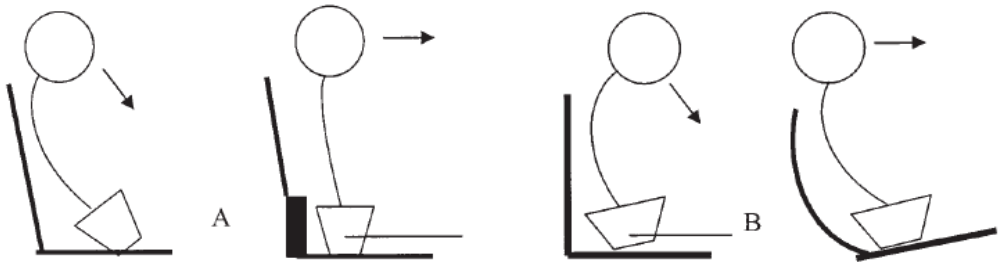


Figure 2: Diagram A—Provision of posterior pelvic support can prevent a kyphotic position of the trunk and anterior stability. Diagram B—A fixed kyphotic posture can be accommodated through seat tilt and a contoured backrest. (Source: PVA CPG—Preservation of Upper Limb Function Following Spinal Cord Injury)

Wheelie Skills

Performing a wheelie is an important wheelchair skill that you should be proficient with by the time you leave rehab. Not only can a wheelie help you to navigate your environment and overcome obstacles, but it will also help to decrease the stress you put on your shoulders during your daily activities.

Benefits:

- Decreases stress placed on shoulders when ascending a curb.
- Decreases the amount of stress placed on your shoulder when descending a ramp.

Important components of each phase: The steps of a wheelie have been broken down into 3 phases.

- **Take off Phase**:
  - This is the portion of the wheelie when you lift the front wheels off of the ground.

- This phase needs to be controlled enough that you do not push yourself back too far, but go back far enough so you can reach your balance point.
- "Roll slightly backward, then quickly forward to pop your front casters off the ground."

- **Balance Phase**:
  - This is the phase when you are balance on your rear tires.
  - "Move the wheelchair in the same direction as the pitch was required."

  - Make sure you place your hands near the top center of the rear wheels.
  - Slightly flex your elbows during the balance phase of the wheelie.
  - Relax! It does not take very much effort at all to maintain a wheelie. Once you have reached your balance point, allow your shoulders, arms and hands to relax.

- **Landing Phase:**
  - Gently return the front caster wheels to the ground by moving your hands backward (on the pushrim).

Practice makes perfect, but make sure that you have someone around to spot you when you are learning! The following are ways to instruct friends or family members to help you when practicing wheelies. Make sure that your therapist demonstrates these techniques to the person who is helping you before you try them on your own.

- If you are in a chair that has a pushbar on the back, put a sheet through the bar. Have your friend/family member hold onto both ends of the sheet. This way your friend/family member can easily catch you if you end up going back too far.
- You can practice performing wheelies on a thick mat. This will make it easier to obtain the balance position and also protect you if you fall backward. Make sure that you still have someone around (and possibly use the sheet method) to spot you.

Power Wheelchair Set-Up

When it is time for you to select a power chair, you and your therapist will work closely together to determine which chair will fit your specific needs and make you as comfortable as possible. The following are important components of a power wheelchair that you should discuss with your therapist when deciding which power wheelchair is best for you.

- Your therapist will try to make your seat as comfortable as possible while trying to put you in the best posture.
  - Your and your therapist should look for a cushion that:
    - Provides postural support as well as pressure distribution.
    - Promotes a neutral and midline position (if possible). You should be able to sit comfortably in the chair without feeling that you are leaning to one side or another.
  - If you are having trouble sitting upright in your chair, you and your therapist can discuss alternative trunk support methods, such as lateral supports or a molded back rest to make you feel as comfortable as possible.
  - Your therapist can make changes to your sitting position if you have a forward head posture. (This will prevent the development rounded shoulders. (Diagram A)
  - If you already have a posture that can not be changed by stretching and exercise, (for example-- a fixed kyphosis i.e. forward bending) you and your therapist can trial different back support systems to make you comfortable) by changing the shape and angle of the back support (Diagram B).

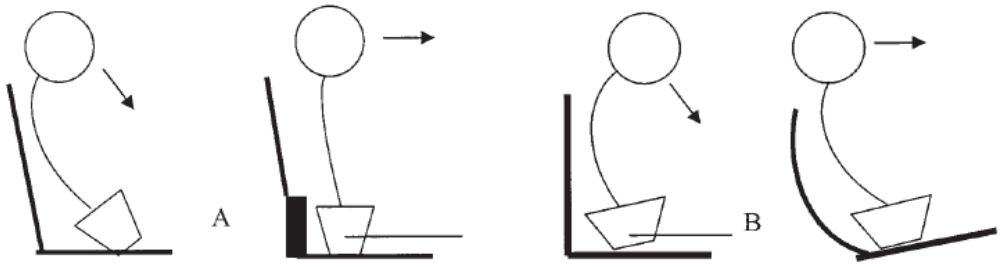


Figure 1: Diagram A—Provision of posterior pelvic support can prevent a kyphotic position of the trunk and anterior stability. Diagram B—A fixed kyphotic posture can be accommodated through seat tilt and a contoured backrest. (Source: PVA CPG—Preservation of Upper Limb Function Following Spinal Cord Injury)

- If you have difficulty lifting your arms above your head, your therapist will provide an arm rest that fully supports your forearms and hands to prevent dislocation of your shoulder.

- If you need to perform a lot of activities that require you to reach items above your head and you have good arm function, you and your therapist can discuss the pros and cons of having a seat elevator function on your chair.

  - Pros of a Seat Elevator
    - You will be sitting higher, so when you are speaking with others you will not strain your neck during conversation.

- Allows for eye to eye conversation with others.
- Easier to reach for items in cabinets at home, shelves in stores and bookcases at work.

- Cons of a Seat Elevator
  - Some seat elevators do not go low enough to allow your knees to fit under the tables or desks.
  - With any moveable device, there is a potential for it to break down.

- You and your therapist will discuss the specific activities you need to perform in your daily life to find the equipment that is best for you. **One size does not fit all!**

Exercise

Exercise is a very important component of your overall health and wellbeing.

Exercise is also a good way to maintain weight, which will decrease the forces placed on the shoulders during transfers and wheelchair propulsion. (Exercise is only **ONE** factor in weight control. Diet is another factor which is often more important than exercise, must be considered in weight control. Please make sure talk to your dietitian about weight control regarding diet.) Exercise will also make you stronger, thus making transfers and other functional mobility skills easier.

Cardiovascular

Cardiovascular fitness is an important component of your overall health. Research shows that in general, cardiovascular exercise is related to a decrease in medical complications after a spinal cord injury.

Here are some important facts about cardiovascular exercise after spinal cord injury:

You may have a more difficult time training compared to before your injury. This is because:

a. Before your injury, you used the large muscles in your legs to pump large amounts of blood to your heart. This gives the heart a good workout. Now you have to use the smaller muscles in your upper extremity to work out with. These muscles do not pump as much blood and often get tired before the heart can get a good workout.
b. If your injury is above T6, a disruption in the sympathetic and parasympathetic system exists, which changes your body's response to

exercise. This system prepares the body for stressful events and then returns it to normal after exercise.

Even though you may not be able to train as well as you did before, you will still benefit from exercise. These benefits include:

a. Increased exercise tolerance
b. Improved muscular endurance due to muscle fiber growth (in size)
c. Improved ability to extract oxygen from the blood.
d. Strength gains that may allow increased endurance.
e. Possible decrease in the risk of development of pain.

Some options for cardiovascular training include:

1. Upper body ergometry.
2. Pushing a wheelchair on a treadmill or rollers.
3. Functional Electronic Stimulation
4. Bodyweight Supported Treadmill
5. Swimming
6. Wheelchair sports (Basketball, Rugby, Soccer, etc)

If you would like more information about wheelchair sports, here are some good places to look.

a. www.lifestylesport.com
b. www.planetmobility.com
c. http://home.wi.rr.com/birzer

Your occupational and physical therapist will teach you which specific muscles need to be stretched and strengthened to protect the structures of your shoulders, provide stability and improve your transfer and wheelchair propulsion skills.

The muscles that your therapist will discuss primarily in relation to shoulder preservation are as follows:

Infraspinatus –

- This muscle is part of the rotator cuff. Its action is to roll your upper arm outward (external rotation)
- This muscle plays an important role in performance of transfers. It also helps to provide stability to your shoulder.

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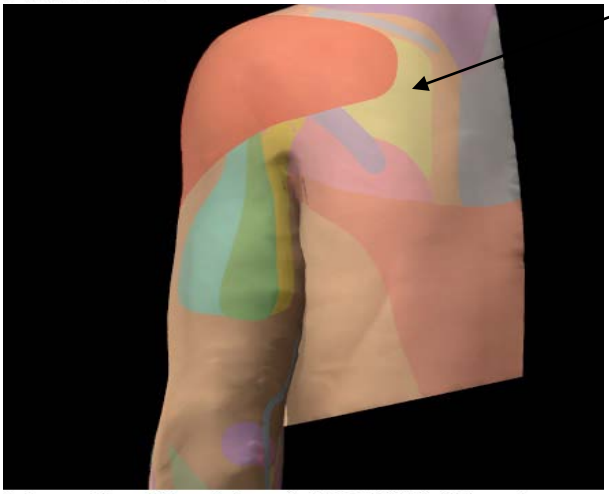
Infraspinatus



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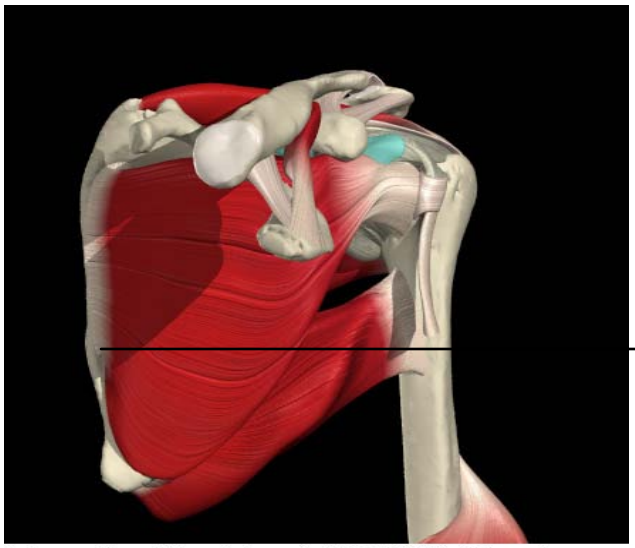
Subscapularis –

- This muscle is also part of the rotator cuff. It's action is to roll your upper arm inward (internal rotation.)
- This muscle also is an important muscle to improve transfer skills and provide stability to the shoulder.



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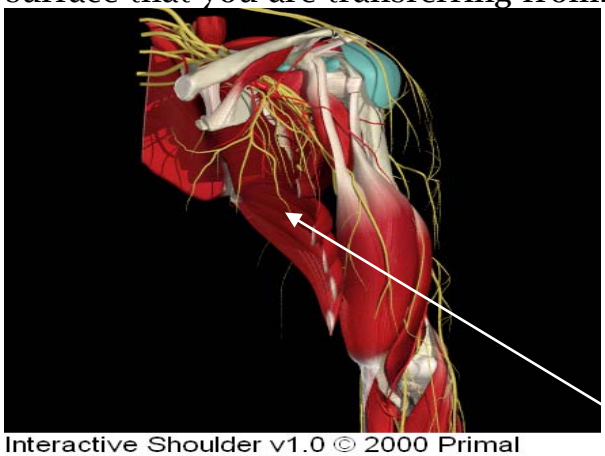
Serratus Anterior - -

- This muscle is used to move the shoulder blade (scapula) away (abduct) from your spine. In other words, it moves your scapula closer to your arm.
- Strengthening this muscle will help when lifting your buttocks up off the surface that you are transferring from.



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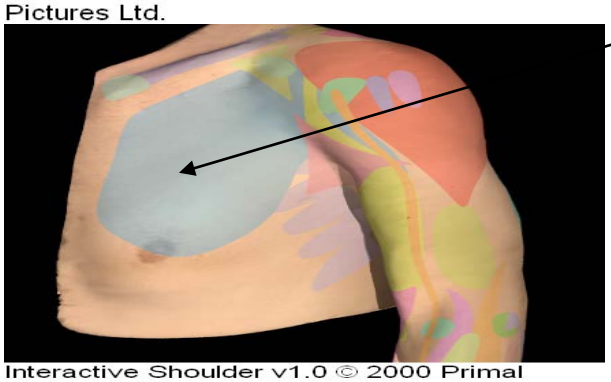

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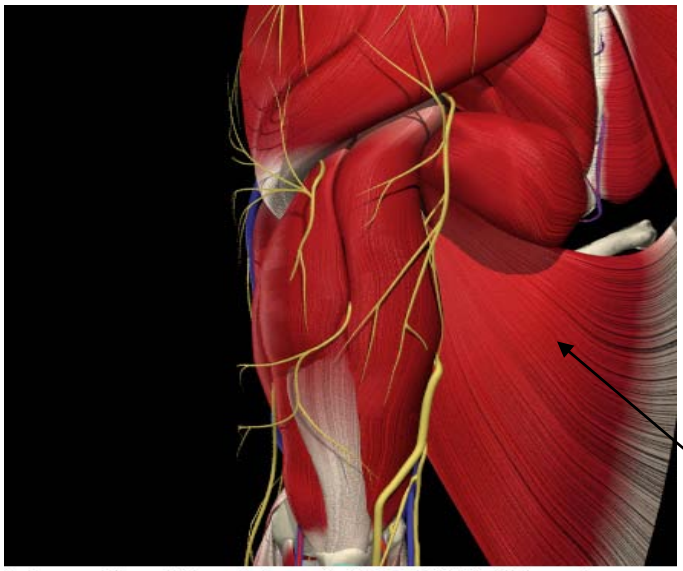
Serratus Anterior

Latissimus Dorsi –

- This muscle helps to extend (pull backward) your shoulder.
- This is one of the primary muscles used when lifting your buttock off a surface (when transferring.)
- You can also improve your posture by strengthening this muscle.



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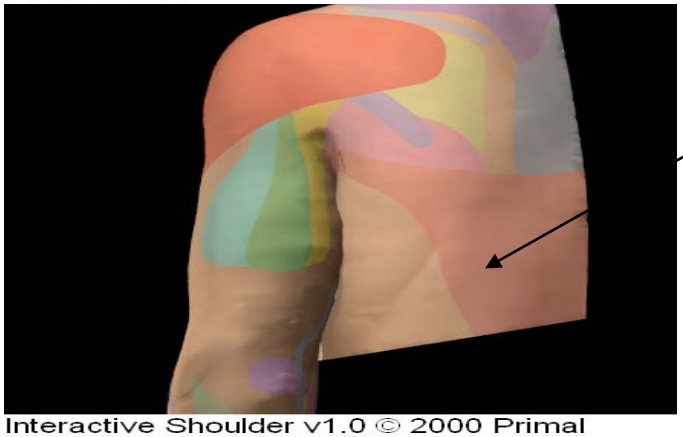

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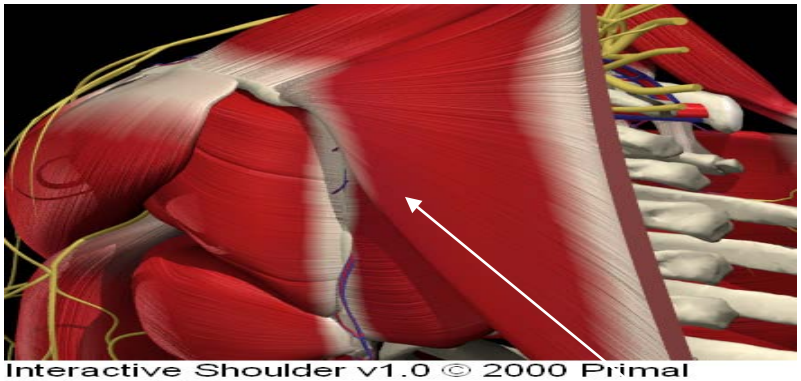
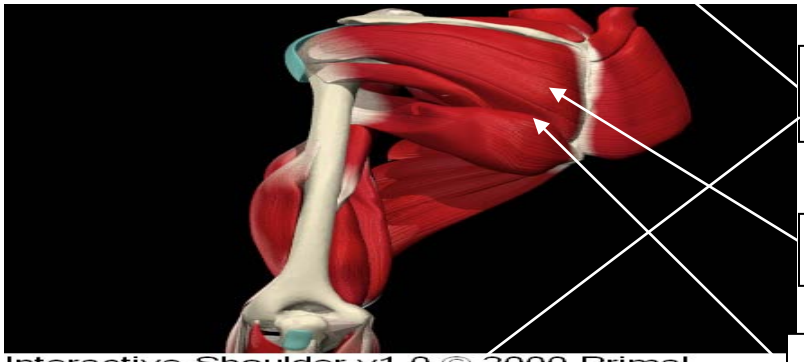
Latissimus Dorsi

Trapezius (Middle and Lower) and Rhomboids

- These muscles are used to retract (pull together) your shoulder blades (scapula).
- These are very important muscles to strengthen to improve posture and protect the structures of your back and shoulder. Often when these muscles are weak, nerve structures are compressed (pinched) in the back, which cause pain in the shoulder and arm.

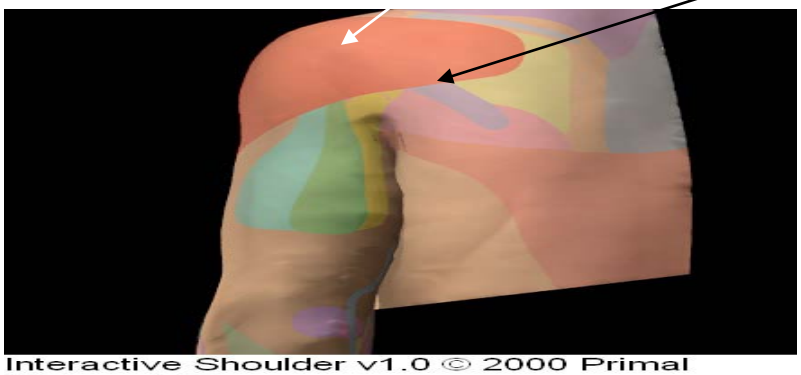




Trapezius

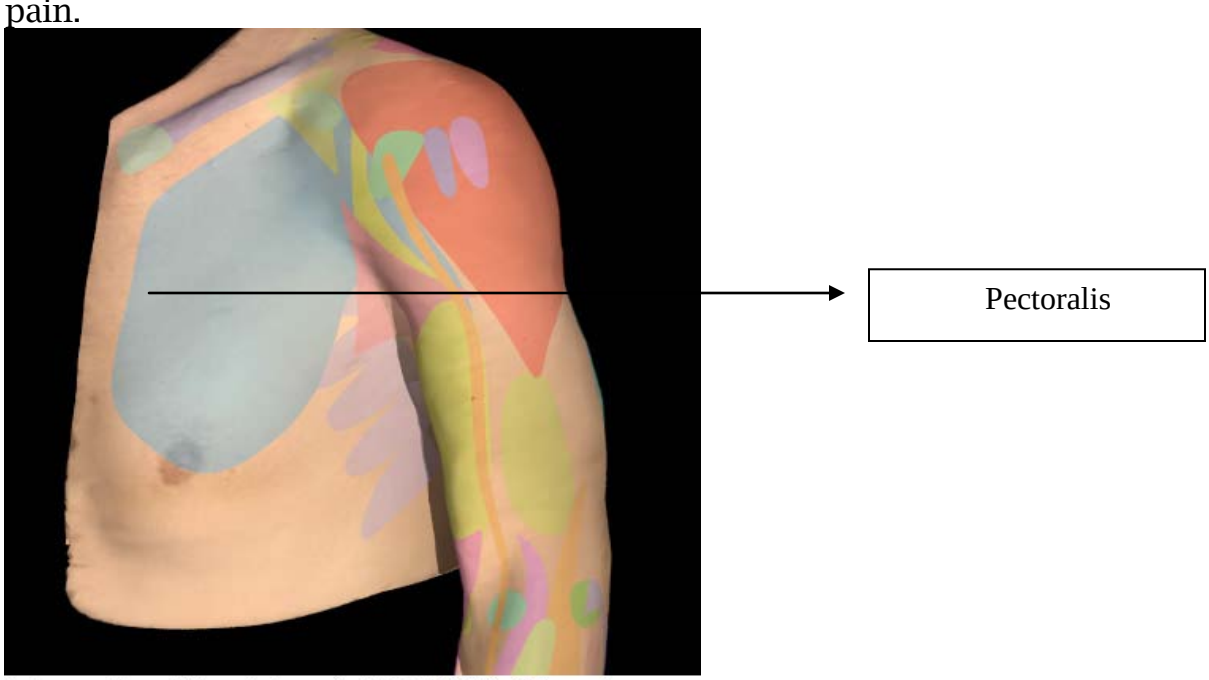
Rhomboid Minor

Rhomboid Major



Pectoralis Major/Minor –

- These muscles are used to adduct (pull inward) your upper arm.
- If these muscles get tight, they will cause a slumped posture and can potentially impinge (pinch) important nerves, which can lead to increased pain.



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Strengthening

Strengthening exercises are a very important component of your fitness routine and are a necessity to maintain a healthy upper extremity. Individuals with spinal cord injury are very prone to muscle imbalances, which can lead to poor posture and increased upper extremity pain. A recent study performed by Nawoczenski, et al,[133] found that during an 8 week period individuals with SCI who participated in a specific strengthening program that targeted specific shoulder and back muscles reported improved shoulder function and decreased shoulder pain.

Your occupational and physical therapist will design a specific home exercise program (HEP) for you that fits your specific needs. This program will focus on the muscles that:

- **Rotate your arm out to the side**. (Infraspinatus and Subscapularis)

- **Stabilize your shoulder blade**. (Rhomboids, Trapezius, Serratus Anterior and Latissimus Dorsi)

For all of these exercises:

- Perform 3 sets of 10 repetitions.
- If this is very easy for you, you can use a special elastic band, typically called a theraband (that your therapist can provide you) to make the exercise harder. Start light and gradually increase the resistance of the band.
- You can increase the number of repetitions you perform or increase the resistance of the band. (But only do one at a time)

Stretching

Stretching is a very important part of your daily exercise program and an essential part of maintaining a healthy upper extremity. Many wheelchair users display a posture of rounded shoulders and a forward head position. Decreased shoulder range of motion can potentially lead to increased upper limb injury and pain. Stretching has been found to decrease pain intensity. You shoulder perform your stretching exercises 2-3 days/week.[139]

Lying in Bed:

Sleeping time can be a good time to stretch out the muscles in your shoulders. You want to make sure that your shoulder muscles do not get tight as you spend eight hours or so asleep. Sleeping with your arms in the positions shown above will help keep the muscles from getting tight.

By using more than one of these positions, you can protect your skin and help your shoulders.

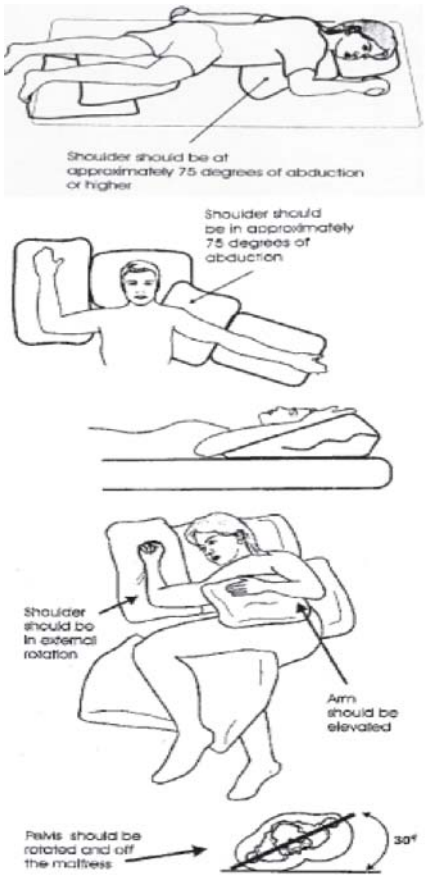


Figure 1—Recommended sleeping positions. (source: PVA CPG-Preservation of Upper Limb Function Following Spinal Cord Injury.

These positions incorporate the following important principals:

- Avoid direct pressure on the shoulder
- Provide support to your arms and shoulders at all points.
- When lying on your back, your side or your stomach bring you arm out to the side (approximately 75 degrees) and bend your elbow to 90 degrees.
- If you want to lie on your side, you should have someone help you roll your body 30 deg. off the mattress and place pillows under you so you stay in this position.
- If someone is helping you, don't let them pull on your arms!

Your therapist will provide you with a specific stretching program that is designed to fit your individual needs. In general, your therapist will instruct you to stretch the muscles on the front of your chest in the following manner:

- Perform stretching 2-3 times/week
- Apply a gentle, prolonged stretch in each direction of tightness.
- If someone is helping you stretch, do not let them pull on your arm in a manner that feels like they are pulling your arm "out of its socket." Your therapist will teach you that it is necessary to pull a little bit on your arm, close to the joint to get the most effective stretch possible, however; this should just feel like the person is "taking up the slack" in your arm, not a forceful pull.

Exercising with a Spinal Cord Injury Above T6

As stated above, after a spinal cord injury your body will react to exercise in a different way. There are some important precautions you should take and some symptoms to keep in mind while exercising to keep you safe.

MAKE SURE YOU TALK TO YOUR PHYSICAN AND YOUR THERAPIST ABOUT THESE PRECAUTIONS.

Precautions to take prior to exercise:

- **Empty leg bag, etc.**
- **Keep a cool cloth close by when exercising in the heat.**
- **Monitor body temperature frequently**

If you experience any of these symptoms, STOP exercising and seek medical treatment immediately! THESE ARE ONLY A FEW OF THE SYMPTOMS!

- **Elevated blood pressure**
- **Pounding headache**
- **Low heart rate**
- **Heart arrhythmias**
- **Blurred Vision**
- **Appearance of spots in the visual field**
- **Feelings of anxiety**

For additional information, please read the PVA's consumers guide on Autonomic Dysreflexia.

Now you know what to do….here is how to keep doing it!

Have an exercise plan!

Research[135] has shown that when a person has a set exercise time and a plan, they are much more likely to stick with exercise. To make a plan, find a time in your day to do your exercise program. Once you have established this time, stick with it. Make it a priority, just like you would make an important meeting.

Exercise with a friend!

Working out with someone has also been shown to improve a person's compliance with an exercise program.[135] In addition to working out with someone, research has also shown that if you become a role model for someone else, you are also more likely to stick with an exercise program.[135]

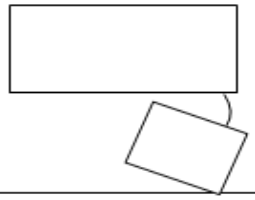
Most importantly, have fun with your exercise program. Find something that you like and are interested in and go for it!

Make sure you have a good understanding of what exercises you are doing and why you are doing them. Don't hesitate to ask your therapist for a further explanation of the importance of the exercise program.

APPENDIX C

TRANSFER ASSESSMENT INSTRUMENT (TAI)

Please evaluate the subject on each transfer separately. Encircle the appropriate response: Y = Yes, N = N, N/A = Not applicable

Part 1	1	2	3	4
1. The subject's wheelchair touches (or is very close to) the object to which he is transferring. • Distance between chair and object should be less than 3 inches	Y N N/A	Y N N/A	Y N N/A	Y N N/A
2. The angle between the subject's wheelchair and the surface to which he is transferring should be approximately 20-45 degrees 	Y N N/A	Y N N/A	Y N N/A	Y N N/A
3. Subject makes every attempt possible to position his chair to perform the transfer forward of the rear wheel (i.e., so he does not go over the rear wheel).	Y N N/A	Y N N/A	Y N N/A	Y N N/A
4. If possible, the subject should remove his armrest or attempt to take it out of the way. • If help is required, the subject asks the evaluator to remove the armrests in a clear and assertive manner.	Y N N/A	Y N N/A	Y N N/A	Y N N/A
5. The subject will perform a level or downhill transfer, whenever possible. • Seat cushion is at least level with the surface to which the subject is transferring.	Y N N/A	Y N N/A	Y N N/A	Y N N/A
6. The subject positions his leading arm in approximately 30-45 deg. of abduction. The humerus is grossly in line with the glenoid fossa.	Y N N/A	Y N N/A	Y N N/A	Y N N/A
7. Subject's feet are in the most stable position (on the floor if possible) before the transfer. • If help is required, the subject asks the evaluator to position his feet in a clear and assertive manner	Y N N/A	Y N N/A	Y N N/A	Y N N/A
8. Subject is scooted fully to the edge of the chair (i.e., sitting on the front 2/3rds of the seat). • If help if required, the subject asks the evaluator to scoot him to the front 2/3rds of the chair in a clear and assertive manner. (The subject specifically tells the evaluator what position on the chair he needs to be scooted too.)	Y N N/A	Y N N/A	Y N N/A	Y N N/A

Part 1, continued	1	2	3	4
9. Hands are in a stable position prior to the start of the transfer. • Push off hand is close to the body • Leading hand is close to where he will be landing.	Y N N/A	Y N N/A	Y N N/A	Y N N/A
10. A handgrip is utilized **in the correct manner** by the leading arm.	Y N N/A	Y N N/A	Y N N/A	Y N N/A
11. A handgrip is utilized **in the correct manner** by the trailing arm.	Y N N/A	Y N N/A	Y N N/A	Y N N/A
12. Flight is well controlled (smooth, coordinated movements with no flailing arms)	Y N N/A	Y N N/A	Y N N/A	Y N N/A
13. Head-hip relationship is used • Not applicable to participants who do not need to use the head/hip relationship for a safe transfer or are unable to perform.	Y N N/A	Y N N/A	Y N N/A	Y N N/A
14. The lead arm is correctly positioned (i.e. **NOT** in a position of IR/ABD/Flex when the subject is fully weight bearing on it.)	Y N N/A	Y N N/A	Y N N/A	Y N N/A
15. Hands should be in contact with both surfaces at the end of the transfer	Y N N/A	Y N N/A	Y N N/A	Y N N/A
16. Over all, the transfer is well controlled (i.e., hands are not flying off the support surface and the subject has transferred with smooth, coordinated movements)	Y N N/A	Y N N/A	Y N N/A	Y N N/A
17. If a caregiver is assisting, the caregiver supports the subject's arms during the transfer.	Y N N/A	Y N N/A	Y N N/A	Y N N/A

Summary of Transfers (Part 2)	0 = Strongly disagree	1= Disagree	2 = Neutral	3 =Agree	4 = Strongly agree	N/A
Position of the Weight Bearing Arm: 1. The lead arm is positioned correctly (i.e. *not* in a position of IR/ABD/Flex when the subject bears full weight on it.)	0	1	2	3	4	N/A
Set Up Phase:						
2. The subject sets himself up for a safe and easy transfer.	0	1	2	3	4	N/A
3. The subject attempts to change the height of the object he is transferring to/from to make the transfer level.	0	1	2	3	4	N/A
4. The subject gets close to the object that he is transferring on to.	0	1	2	3	4	N/A

Part 2, continued	0 = Strongly Disagree	1 = Disagree	2 = Neutral	3 = Agree	4 = Strongly Agree	N/A
5. The subject uses handgrips when necessary. • The subject does not attempt to reach outside his BOS to use a handgrip. • Humerus stays in line with the glenoid fossa as the subject makes his final preparations for the transfer.	0	1	2	3	4	N/A
Conservation:						
6. The subject uses a transfer device when necessary. • In the presence of weakness • Hoyer lift = Dependent Transfer	0	1	2	3	4	N/A
7. The subject attempts to alternate the leading/trailing arm over the course of the assessment.	0	1	2	3	4	N/A

Part 2, continued	0 = Strongly Disagree	1 = Disagree	2 = Neutral	3 = Agree	4 = Strongly Agree	N/A
Quality:						
8. The transfer is smooth and well controlled.	0	1	2	3	4	N/A
9. For any assistance the subject needs, he is able to clearly communicate his needs in an assertive and polite manner.	0	1	2	3	4	N/A
10. The subject does not allow the evaluator/caregiver to pull on his arms during a transfer.	0	1	2	3	4	N/A
11. The subject corrects the evaluator/caregiver if the evaluator/caregive attempts to perform the transfer in an unsafe manner. (i.e. pulling on arms, transferring uphill when a downhill transfer is possible)	0	1	2	3	4	N/A
12. The subject is able to correctly direct his care in an assertive and polite manner.	0	1	2	3	4	N/A

Performance Criteria:

Strongly Agree: The subject performs the task in a consistent manner throughout the entire session. **Performing the task appears to be the subject's natural movements. The subject does not appear to have to think deeply about the task.**

Agree: The subject performs the tasks on a fairly consistent basis (approximately 67-99% of the time), **but appears to require extra time to think about the task. The task is not a natural movement, but a forced activity.**

Neutral: The subject performs the task correctly approximately 34-66% of the time. **The subject does not perform the tasks smoothly and appears hesitant as to how the task should be performed.**

Disagree: The subject performs the task correctly 1-33% of the time. **The subject appears to only be putting minimal thought into the correct procedure, and performing the transfer with little regard for technique.**

Strongly Disagree: The subject performs the task incorrectly during the entire evaluation. **The subject displays no regard for the proper technique to be used and simply performs the transfer that is being asked. If the subject performs the task correctly, it is by coincidence only.**

APPENDIX D

TRANSFER QUALITY VISUAL ANALOG SCALE

Subject ID:_____

Transfer Quality Visual Analog Score

|_____|

Poor Fair Excellent

Scoring Procedure:

Please watch the study participant perform 1-4 transfers to and from his/her wheelchair. When the individual has finished all transfers, evaluate the quality of the transfers on the above scale, ranging from Poor (0) to Excellent (10). When evaluating the individual, please take into consideration his/her level of injury and strength. Please see below for further definition of a poor and excellent rating.

Poor Rating:

- The individual does not make use of equipment (transfer board or lift, etc), when the use of equipment would have been beneficial (in the presence of weakness, range of motion limitations).
- The individual does not attempt to make the transfer as easy as possible. (i.e. does not get close to the object he/she is transfer to, transfers uphill when a level or downhill transfer was possible)
- Performs the transfer in an unsafe manner.
- Does not place arms and feet in a biomechanical effective position. (i.e. the individual is reaching outside his/her base of support or placing the shoulder in a position of impingement)
- Does not make use of handgrips when appropriate.
- If human assistance is required, the individual does not direct his/her care in a polite and assertive manner.

Excellent Rating:

- Uses equipment when necessary. (If the individual can perform a transfer without equipment in a safe and efficient manner, they can receive an excellent rating.)
- Sets up the transfer to be as easy as possible.
- Performs the transfer in a safe and controlled manner.
- Places arms and feet in biomechanical advantageous positions. (i.e. the individual is not reaching out of his/her base of support or placing the shoulder in a position of impingement)
- Uses handgrips when appropriate.
- If human assistance is required, the individual is able to politely and effectively direct his/her own care.

APPENDIX E

MANUFACTURE AND MODEL OF WHEELCHAIRS AT SIX MONTHS POST DISCHARGE

Subject ID	Study Group	Type of Wheelchair	Manufacture	Model
AS200806	IG	PWC	Pride	Q6000Z
BR200913	IG	MWC	Pride	Jazzy 1121
BS200706	IG	MWC	Quckie	Ti
CK200810	IG	PWC	Pride	Q6000Z
EG200715	IG	PWC	Pride	Q6000Z
GK200916	IG	PWC	Permobil	C500
GO200808	IG	MWC	Invacare	Crossfire Titanium
JS200817	IG	MWC	Quckie	Ti
LP200805	IG	MWC	TiLite	ZRA
RB200713	IG	PWC	Invacare	TDX Storm
RB200824	IG	MWC	Invacare	9000
RF200901	IG	PWC	Invacare	Pronto
SW200717	IG	MWC	Invacare	A4
TM200902	IG	PWC	Pride	Jazzy Select 14
WH200822	IG	PWC	Pride	Q6000Z
BW200821	SCG	MWC	Invacare	9000
CM200815	SCG	PWC	Invacare	Arrow
DW200903	SCG	PWC	Invacare	TDX Storm
GH200825	SCG	PWC	Pride	Q6000Z
JC200704	SCG	PWC	Permobil	C300
JC200811	SCG	MWC	Invacare	A4
JS200904	SCG	MWC	Quckie	GTi
KS200710	SCG	MWC	Quckie	GT
LC200701	SCG	MWC	Invacare	9000
ML200808	SCG	PWC	Pride	Q6000Z
MP200802	SCG	MWC	Quckie	GTX
NM200719	SCG	MWC	Invacare	9000
PL200909	SCG	MWC	Invacare	9000
RM200804	SCG	PWC	Permobil	C500
RT200711	SCG	MWC	Invacare	9000
SC200826	SCG	MWC	Medline	Excel

BIBLIOGRAPHY

1. Bayley JC, Cochran TP, Sledge CB. The weight-bearing shoulder. The impingement syndrome in paraplegics. *J Bone Joint Surg Am.* Jun 1987;69(5):676-678.

2. Pentland WE, Twomey LT. The weight-bearing upper extremity in women with long term paraplegia. *PARAPLEGIA.* 1991;29:521-530.

3. Gellman H, Sie I, Waters RL. Late complications of the weight-bearing upper extremity in the paraplegic patient. *Clin Orthop Relat Res.* Aug 1988(233):132-135.

4. Gironda RJ, Clark ME, Neugaard B, Nelson A. Upper limb pain in a national sample of veterans with paraplegia. *Journal of Spinal Cord Medicine.* 2004;27(2):120-127.

5. Alm M, Saraste H, Norrbrink C. Shoulder pain in persons with thoracic spinal cord injury: prevalence and characteristics. *J Rehabil Med.* Apr 2008;40(4):277-283.

6. Roehrig S, Like G. Factors affecting shoulder pain in adolescents and young adults with spina bifida. *Pediatr Phys Ther.* Fall 2008;20(3):224-232.

7. Sie IH, Waters RL, Adkins RH, Gellman H. Upper extremity pain in the postrehabilitation spinal cord injured patient. *Arch Phys Med Rehabil.* Jan 1992;73(1):44-48.

8. Escobedo EM, Hunter JC, Hollister MC, Patten RM, Goldstein B. MR imaging of rotator cuff tears in individuals with paraplegia. *AJR Am J Roentgenol.* Apr 1997;168(4):919-923.

9. Reyes ML, Gronley JK, Newsam CJ, Mulroy SJ, Perry J. Electromyographic analysis of shoulder muscles of men with low-level paraplegia during a weight relief raise. *Archives of Physical Medicine and Rehabilitation.* 05 1995;76(5):433-439.

10. Boninger ML, Cooper RA, Shimada SD, Rudy TE. Shoulder and elbow motion during two speeds of wheelchair propulsion: a description using a local coordinate system. *Spinal Cord.* 06 1998;36(6):418-426.

11. Boninger ML, Dicianno BE, Cooper RA, Towers JD, Koontz AM, Souza AL. Shoulder MRI Abnormalities, Wheelchair Propulsion, and Gender *Archives of Physical Medicine and Rehabilitation.* 11 2003;84 (11):1615-1620.

12. Nichols PJ, Norman PA, Ennis JR. Wheelchair user's shoulder? Shoulder pain in patients with spinal cord lesions. *Scandinavian Journal of Rehabilitation Medicine.* 1979;11:29-32.

13. Subbarao JV, Klopfstein J, Turpin R. Prevalence and impact of wrist and shoulder pain in patients with spinal cord injury. *Journal of Spinal Cord Medicine.* 1994;18(1):9-13.

14. Werner R, Armstrong TJ. Carpal tunnel syndrome: ergonomic risk factors and intra carpal canal pressure, carpal tunnel syndrome. *Phys Med Rehabil Clin N Am.* 1997;8(3):555-569.
15. Silfverskiold J, Waters RL. Shoulder pain and functional disability in spinal cord injury patients. *Clinical Orthopaedics & Related Research.* 11 1991(272):141-145.
16. Waring WP, Maynard FM. Shoulder pain in acute traumatic quadriplegia. *Paraplegia.* Jan 1991;29(1):37-42.
17. van Drongelen S, de Groot S, Veeger HE, et al. Upper extremity musculoskeletal pain during and after rehabilitation in wheelchair-using persons with a spinal cord injury. *Spinal Cord.* 03 2006;44(3):152-159.
18. Gellman H, Chandler DR, Petrasek J, Sie I, Adkins R, Waters RL. Carpal tunnel syndrome in paraplegic patients. *J Bone Joint Surg Am.* Apr 1988;70(4):517-519.
19. Wylie EJ, Chakera TM. Degenerative joint abnormalities in patients with paraplegia of duration greater than 20 years. *Paraplegia.* Apr 1988;26(2):101-106.
20. Aljure J, Eltorai I, Bradley WE, Lin JE, Johnson B. Carpal tunnel syndrome in paraplegic patients. *Paraplegia.* Jun 1985;23(3):182-186.
21. Tun CG, Upton J. The paraplegic hand: electrodiagnostic studies and clinical findings. *J Hand Surg [Am]*. Sep 1988;13(5):716-719.
22. Davidoff G, Werner R, Waring W. Compressive mononeuropathies of the upper extremity in chronic paraplegia. *Paraplegia.* Jan 1991;29(1):17-24.
23. Burnham RS, Steadward RD. Upper extremity peripheral nerve entrapments among wheelchair athletes: prevalence, location, and risk factors. *Arch Phys Med Rehabil.* May 1994;75(5):519-524.
24. Curtis KA, Drysdale GA, Lanza RD, Kolber M, Vitolo RS, West R. Shoulder Pain in Wheelchair Users With Tetraplegia and Paraplegia. *Archives of Physical Medicine and Rehabilitation.* 04 1999;80:453-457.
25. Curtis KA, Roach KE, Applegate EB, et al. Development of the Wheelchair User's Shoulder Pain Index (WUSPI). *Paraplegia.* May 1995;33(5):290-293.
26. Salisbury SK, Choy NL, Nitz J. Shoulder pain, range of motion, and functional motor skills after acute tetraplegia. *Archives of Physical Medicine and Rehabilitation.* 10 2003;84(10):1480-1485.
27. Dalyan M, Cardenas DD, Gerard B. Upper extremity pain after spinal cord injury. *Spinal Cord.* 03 1999;37(3):191-195.
28. Gerhart KA, Bergstrom E, Charlifue SW, Menter RR, Whiteneck GG. Long-term spinal cord injury: functional changes over time. *Archives of Physical Medicine & Rehabilitation.* 10 1993;74(10):1030-1034.
29. Boninger ML, Waters RL, Chase T, et al. Preservation of upper limb function following spinal cord injury: a clinical practice guideline for healthcare professionals. Washington DC: Consortium for Spinal Cord Medicine; 2005.
30. A Guide to the Development, Implementation and Evaluation of Clinical Practice Guidelines. Canberra: National Health and Medical Research Council; 1999.
31. Milstein A, Galvin RS, Delbanco SF, Salber P, Buck CR, Jr. Improving the safety of health care: the leapfrog initiative. *Eff Clin Pract.* Nov-Dec 2000;3(6):313-316.
32. Kirshblum S. New rehabilitation interventions in spinal cord injury. *J Spinal Cord Med.* 2004;27(4):342-350.

33. Pentland WE, Twomey LT. Upper limb function in persons with long term paraplegia and implications for independence: Part II. *Paraplegia.* Apr 1994;32(4):219-224.
34. Finley MA, McQuade KJ, Rodgers MM. Scapular kinematics during transfers in manual wheelchair users with and without shoulder impingement. *Clin Biomech (Bristol, Avon).* Jan 2005;20(1):32-40.
35. Bromley I. *Tetraplegia and paraplegia: a guide for physiotherapists*. Edinburgh, UK: Churchill Livingstone; 1998.
36. Gagnon D, Nadeau S, Gravel D, Noreau L, Lariviere C, Gagnon D. Biomechanical analysis of a posterior transfer maneuver on a level surface in individuals with high and low-level spinal cord injuries. *Clinical Biomechanics.* 05 2003;18(4):319-331.
37. Gagnon D, Nadeau S, Noreau L, Dehail P, Gravel D. Quantification of reaction forces during sitting pivot transfers performed by individuals with spinal cord injury. *J Rehabil Med.* Jun 2008;40(6):468-476.
38. Neer CS, II. Impingement lesions. *Clinical Orthopaedics & Related Research.* 1983;173:70-77.
39. Gagnon D, Nadeau S, Noreau L, Eng JJ, Gravel D. Trunk and upper extremity kinematics during sitting pivot transfers performed by individuals with spinal cord injury. *Clin Biomech (Bristol, Avon).* Mar 2008;23(3):279-290.
40. Gagnon D, Nadeau S, Noreau L, Eng JJ, Gravel D. Electromyographic patterns of upper extremity muscles during sitting pivot transfers performed by individuals with spinal cord injury. *J Electromyogr Kinesiol.* Feb 9 2008.
41. Yarnall M, Koontz A, Yang Y, Price R, Boninger M. Wrist range of motion during lateral transfers among persons with paraplegia. *28th Annual RESNA Conference*. Atlanta, GA2005.
42. Minkel J, Hastings J, McClure L, Bjerkefors A. Transfer Training for Transfering in the Home and Beyond. Paper presented at: Posture and Mobility Group; June 7-9, 2010; Glasgow, Scotland.
43. Campbell CC, Koris MJ. Etiologies of shoulder pain in cervical spinal cord injury. *Clinical Orthopaedics & Related Research.* Jan 1996(322):140-145.
44. Boninger ML, Koontz AM, Sisto SA, et al. Pushrim Biomechanics and Injury Prevention in Spinal Cord Injury: Recommendations Based on CULP-SCI Investigations. *Journal of Rehabilitation Research and Development.* 2005;42(3, Supp. 1):9-20.
45. Beekman CE, Miller-Porter L, Schoneberger M. Energy cost of propulsion in standard and ultralight wheelchairs in people with spinal cord injuries. *Phys.Ther.* 02 1999;79(2):146-158.
46. Cowan RE, Nash MS, Collinger JL, Koontz AM, Boninger ML. Impact of surface type, wheelchair weight, and axle position on wheelchair propulsion by novice older adults. *Arch Phys Med Rehabil.* Jul 2009;90(7):1076-1083.
47. Brubaker CE. Wheelchair prescription: An analysis of factors that affect mobility and performance. *Journal of Rehabilitation Research & Development.* 1986;23:19-26.
48. Boninger ML, Baldwin MA, Cooper RA, Koontz AM, Chan L. Manual Wheelchair Pushrim Biomechanics and Axle Position. *Archives of Physical Medicine & Rehabilitation.* 01/05/ 2000;81(5):608-613.

49. Hughes CJ, Weimar WH, Sheth PN, Brubaker CE. Biomechanics of wheelchair propulsion as a function of seat position and user-to-chair interface. *Archives of Physical Medicine & Rehabilitation.* 1992;73:263-269.

50. van der Woude LHV, Veeger DJ, Rozendal RH, Sargeant TJ. Seat height in handrim wheelchair propulsion. *Journal of Rehabilitation Research & Development.* 1989;26:31-50.

51. Coggrave M, LS Rose. A specialist seating assessment clinic: changing pressure relief practic. *Spinal Cord.* Feb. 1 2003;41:692-695.

52. Herberts P, Kadefors R, Hogfors C, Sigholm G. Shoulder pain and heavy manual labor. *Clinical Orthopaedics & Related Research.* 1984:166-178.

53. Arva JMS, ATP,, Schmeler M, M.S., OTR/L, ATP, Lange MO, ABDA, ATP, Lipka DME, OTR/L, ATS. RESNA Position on the Application of Seat-Elevating Devices for Wheelchair Users. *Rehabilitation Engineering & Assistive Technology Society of North America.* 2005.

54. Boninger ML, Cooper RA, Robertson RN, Rudy TE. Wrist Biomechanics During Two Speeds of Wheelchair Propulsion: An Analysis Using a Local Coordinate System. *Archives of Physical Medicine & Rehabilitation.* 1997;78(4):364-372.

55. Cooper RA, Boninger ML, Shimada SD, Lawrence BM. Glenohumeral joint kinematics and kinetics for three coordinate system representations during wheelchair propulsion. *American Journal of Physical Medicine & Rehabilitation.* 09 1999;78(5):435-446.

56. Kulig K, Rao SS, Mulroy SJ, et al. Shoulder Joint Kinetics during the Push Phase of Wheelchair Propulsion. *Clinical Orthopaedics and Related Research.* 09 1998;354:132-143.

57. Boninger ML, Cooper RA, Baldwin MA, Shimada SD, Koontz A. Wheelchair pushrim kinetics: body weight and median nerve function. *Archives of Physical Medicine and Rehabilitation.* 08 1999;80(8):910-915.

58. Werner RA, Franzblau A, Albers JW, Armstrong TJ. MEDIAN MONONEUROPATHY AMONG ACTIVE WORKERS - ARE THERE DIFFERENCES BETWEEN SYMPTOMATIC AND ASYMPTOMATIC WORKERS. *American Journal of Industrial Medicine.* 04 1998;33(4):374-378.

59. Silverstein BA, Fine LJ, Armstrong TJ. Occupational factors and carpal tunnel syndrome. *American Journal of Industrial Medicine.* 1987;11:343-358.

60. Loslever P, Ranaivosoa A. Biomechanical and epidemiological investigation of carpal tunnel syndrome at workplaces with high risk factors. *Ergonomics.* 1993;36:537-555.

61. Roquelaure Y, Mechali S, Dano C, et al. Occupational and personal risk factors for carpal tunnel syndrome in industrial workers. *Scandinavian Journal of Work, Environment & Health.* 10 1997;23(5):364-369.

62. Fredriksson K, Alfredsson L, Thorbjornsson CB, et al. Risk factors for neck and shoulder disorders: a nested case-control study covering a 24-year period. *Am.J.Ind.Med.* 11 2000;38(5):516-528.

63. Cohen RB, Williams GR. Impingement syndrome and rotator cuff disease as repetitive motion disorders. *Clin.Orthop.* 06 1998(351):95-101.

64. Frost P, Bonde JP, Mikkelsen S, et al. Risk of shoulder tendinitis in relation to shoulder loads in monotonous repetitive work. *Am.J.Ind.Med.* 01 2002;41(1):11-18.

65. Andersen JH, Kaergaard A, Frost P, et al. Physical, psychosocial, and individual risk factors for neck/shoulder pain with pressure tenderness in the muscles among workers performing monotonous, repetitive work. *Spine.* 03/15/ 2002;27(6):660-667.

66. Freemantle N, Harvey EL, Wolf F, et al. Printed educational materials: effects on professional practice and health care outcomes. [Review] [11 refs]. *Cochrane Database of Systematic Reviews.* 2000(2):CD000172.

67. Burns SP, Nelson AL, Bosshart HT, et al. Implementation of clinical practice guidelines for prevention of thromboembolism in spinal cord injury. *J Spinal Cord Med.* 2005;28(1):33-42.

68. Goetz LL, Nelson AL, Guihan M, et al. Provider Adherence to Implementation of Clinical Practice Guidelines for Neurogenic Bowel in Adults with Spinal Cord Injury. *Journal of Spinal Cord Medicine.* 2005;28 (5):394-406.

69. Michie S, Johnston M. Changing clinical behaviour by making guidelines specific. *Bmj.* Feb 7 2004;328(7435):343-345.

70. Shuval K, Berkovits E, Netzer D, et al. Evaluating the impact of an evidence-based medicine educational intervention on primary care doctors' attitudes, knowledge and clinical behaviour: a controlled trial and before and after study. *J Eval Clin Pract.* Aug 2007;13(4):581-598.

71. Davis DA, Thomson MA, Oxman AD, Haynes RB. Changing physician performance. A systematic review of the effect of continuing medical education strategies. *Jama.* Sep 6 1995;274(9):700-705.

72. Ley P. *Communicating with patients*. London: Chapman and Hall; 1988.

73. Oxman AD, Thomson MA, Davis DA, Haynes RB. No magic bullets: a systematic review of 102 trials of interventions to improve professional practice. *Cmaj.* Nov 15 1995;153(10):1423-1431.

74. Wensing M, Grol R. Single and combined strategies for implementing changes in primary care: a literature review. *Int J Qual Health Care.* Jun 1994;6(2):115-132.

75. Avorn J, Soumerai SB. Improving drug-therapy decisions through educational outreach. A randomized controlled trial of academically based "detailing". *N Engl J Med.* Jun 16 1983;308(24):1457-1463.

76. Evans CE, Haynes RB, Birkett NJ, et al. Does a mailed continuing education program improve physician performance? Results of a randomized trial in antihypertensive care. *Jama.* Jan 24-31 1986;255(4):501-504.

77. Heiner C, McClure LA, Talmadge Z, Boninger ML. A Prototype Web Site for Clinical Education: Implementation of Guidelines for Preventing Upper Limb Pain in People with Spinal Cord Injury *Rehabilitation Engineering and Assistive Technology Society of North America*. New Orleans, LA2009.

78. Rintala DH, Loubser PG, Castro J, Hart KA, Fuhrer MJ. Chronic pain in a community-based sample of men with spinal cord injury: prevalence, severity, and relationship with impairment, disability, handicap, and subjective well-being. *Arch.Phys Med Rehabil.* 06 1998;79(6):604-614.

79. Calder CJ, Kirby RL. Fatal wheelchair-related accidents in the United States. *Am.J.Phys.Med.Rehabil.* 08 1990;69(4):184-190.

80. Kirby RL, Ackroyd-Stolarz SA, Brown MG, Kirkland SA, MacLeod DA. Wheelchair-related accidents caused by tips and falls among noninstitutionalized users of manually

propelled wheelchairs in Nova Scotia. *American Journal of Physical Medicine & Rehabilitation.* Sep-Oct 1994;73(5):319-330.

81. Fliess-Douer O, van der Woude LHV, Vanlandewijck Y. The most essential wheeled mobility skills for daily life--an international survey among elite wheelchair athletes with SCI. Paper presented at: 4th International State-of-the-Art Congress Rehabilitation: Mobility, Exercise & Sports; April 7-9, 2009; Amsterdam, The Netherlands.

82. Newton AM, Kirby RL, MacPhee AH, Dupuis DJ, MacLeod DA. Evaluation of manual wheelchair skills: is objective testing necessary or would subjective estimates suffice? *Archives of Physical Medicine and Rehabilitation.* 09 2002;83(9):1295-1299.

83. Gagnon D, Koontz A, S M, et al. Biomechanics of Sitting Pivot Transfers Among Individuals with a Spinal Cord Injury: A Review of the Current Knowledge *Topics in Spinal Cord Injury Rehabilitation.* 2009.

84. Kirby RL, Dupuis DJ, Macphee AH, et al. The wheelchair skills test (version 2.4): measurement properties. *Arch Phys Med Rehabil.* May 2004;85(5):794-804.

85. Kirby RL, Swuste J, Dupuis DJ, MacLeod DA, Monroe R. The Wheelchair Skills Test: a pilot study of a new outcome measure. *Archives of Physical Medicine and Rehabilitation.* 01 2002;83(1):10-18.

86. Berg KO, Wood-Dauphinee SL, Williams JI, Maki B. Measuring balance in the elderly: validation of an instrument. *Can J Public Health.* Jul-Aug 1992;83 Suppl 2:S7-11.

87. Jonsdottir J, Cattaneo D. Reliability and validity of the dynamic gait index in persons with chronic stroke. *Arch Phys Med Rehabil.* Nov 2007;88(11):1410-1415.

88. Srebnik DS, Uehara E, Smukler M, Russo JE, Comtois KA, Snowden M. Psychometric properties and utility of the problem severity summary for adults with serious mental illness. *Psychiatr Serv.* Aug 2002;53(8):1010-1017.

89. Jette DU, Halbert J, Iverson C, Miceli E, Shah P. Use of standardized outcome measures in physical therapist practice: perceptions and applications. *Phys Ther.* Feb 2009;89(2):125-135.

90. Cooper R, Thorman, T, Cooper, R, Dvorznak, Michael, Fitzgerald, SG, Ammer, W, Song-Feng, G; Boninger, M. Driving Characteristics of Electric-Powered Wheelchair Users: How Far, Fast, and Often Do People Drive? *Arch Phys Med Rehabil.* 2002;83.

91. Gagnon D, Nadeau S, Noreau L, Dehail P, Piotte F. Comparison of peak shoulder and elbow mechanical loads during weight-relief lifts and sitting pivot transfers among manual wheelchair users with spinal cord injury. *J Rehabil Res Dev.* 2008;45(6):863-873.

92. Lammertse DP, Jackson AB, Sipski ML. Research from the Model Spinal Cord Injury Systems: findings from the current 5-year grant cycle. *Arch Phys Med Rehabil.* Nov 2004;85(11):1737-1739.

93. Folstein MF, Folstein SE, McHugh PR, Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research.* 11 1975;12(3):189-198.

94. McClure LA, Boninger ML, Ozawa H, Koontz A. Reliability and Validity Analysis of the Transfer Assessment Instrument *Arch Phys Med Rehabil.* 2010(In Press).

95. Goetz LL, Nelson AL, Guihan M, et al. Provider adherence to implementation of clinical practice guidelines for neurogenic bowel in adults with spinal cord injury. *J Spinal Cord Med.* 2005;28(5):394-406.

96. Duchnick JJ, Letsch EA, Curtiss G. Coping effectiveness training during acute rehabilitation of spinal cord injury/dysfunction: a randomized clinical trial. *Rehabil Psychol.* May 2009;54(2):123-132.
97. Cooper R. *Wheelchairs: A Guide to Selection and Configuration*. New York: Demos Medical Publishers; 1998.
98. Masse LC, Lamontagne M, O'Riain MD. Biomechanical analysis of wheelchair propulsion for various seating positions. *Journal of Rehabilitation Research & Development.* 1992;29:12-28.
99. Dyson-Hudson TA, Kirshblum SC. Shoulder Pain in Chronic Spinal Cord Injury, Part I: Epidemiology, Etiology, and Pathomechanics. *The Journal of Spinal Cord Medicine.* 2004;27(1):4-17.
100. Cooper RA, Robertson RN, VanSickle DP, Boninger ML, Shimada SD. Methods for Determining Three-Dimensional Wheelchair Pushrim Forces and Moments - A Technical Note. *Journal of Rehabilitation Research & Development.* Apr 1997;34(2):162-170.
101. Quinones R, DiGiovine CP. Using a Single SMARTWheel: Effects on Wheelchair Deceleration. *RESNA.* Atlanta, GA2006.
102. Cowan RE, Boninger ML, Sawatzky BJ, Mazoyer BD, Cooper RA. Preliminary outcomes of the SmartWheel Users' Group database: a proposed framework for clinicians to objectively evaluate manual wheelchair propulsion. *Arch Phys Med Rehabil.* Feb 2008;89(2):260-268.
103. Breivik EK, Bjornsson GA, Skovlund E. A comparison of pain rating scales by sampling from clinical trial data. *Clin J Pain.* Mar 2000;16(1):22-28.
104. Downie WW, Leatham PA, Rhind VM, Wright V, Branco JA, Anderson JA. Studies with pain rating scales. *Ann Rheum Dis.* Aug 1978;37(4):378-381.
105. Kremer E, Atkinson JH, Ignelzi RJ. Measurement of pain: patient preference does not confound pain measurement. *Pain.* Apr 1981;10(2):241-248.
106. Bryce TN, Budh CN, Cardenas DD, et al. Pain after spinal cord injury: an evidence-based review for clinical practice and research. Report of the National Institute on Disability and Rehabilitation Research Spinal Cord Injury Measures meeting. *J Spinal Cord Med.* 2007;30(5):421-440.
107. Curtis KA, Roach KE, Applegate EB, et al. Reliability and validity of the Wheelchair User's Shoulder Pain Index (WUSPI). *PARAPLEGIA.* Oct 1995;33(10):595-601.
108. Diener E, Emmons RA, Larsen RJ, Griffin S. The Satisfaction With Life Scale. *J.Pers.Assess.* 02 1985;49(1):71-75.
109. Whiteneck GG, Charlifue SW, Gerhart KA, Overholser JD, Richardson GN. Quantifying handicap: A new measure of long-term rehabilitation outcomes. *Archives of Physical Medicine & Rehabilitation.* 1992;73:519-526.
110. Hall K, Dijkers M, Whiteneck G, Brooks C, Krause J. The Craig Handicap Assessment and Reporting Technique (CHART): metric properties and scoring. *Topics in Spinal Cord Injury Rehabilitation.* 1998;4:16-30.
111. McClure LA, Boninger ML, Oyster ML, et al. Wheelchair repairs, breakdown, and adverse consequences for people with traumatic spinal cord injury. *Arch Phys Med Rehabil.* Dec 2009;90(12):2034-2038.

112. Stenlund B, Goldie I, Hagberg M, Hogstedt C. Shoulder tendinitis and its relation to heavy manual work and exposure to vibration. *Scandinavian Journal of Work, Environment & Health.* 1993;19:43-49.
113. Stenlund B, Goldie I, Hagberg M, Hogstedt C, Marions O. Radiographic osteoarthrosis in the acromioclavicular joint resulting from manual work or exposure to vibration. *British Journal of Industrial Medicine.* 1992;49:588-593.
114. Collinger JL, Boninger ML, Koontz AM, et al. Shoulder biomechanics during the push phase of wheelchair propulsion: a multisite study of persons with paraplegia. *Arch Phys Med Rehabil.* Apr 2008;89(4):667-676.
115. Pain terms: a list with definitions and notes on usage. Recommended by the IASP Subcommittee on Taxonomy. *Pain.* Jun 1979;6(3):249.
116. *The 2009 Annual Statistical Report for the Model Spinal Cord Injury Care System.* Birminghma, AL: National Spinal Cord Injury Statistics Center;2009.
117. Lambert MJ. Psychotherapy outcome and quality improvement: introduction to the special section on patient-focused research. *J Consult Clin Psychol.* Apr 2001;69(2):147-149.
118. Hatfield DR, Ogles BM. The influence of outcome measures in assessing client change and treatment decisions. *J Clin Psychol.* Mar 2006;62(3):325-337.
119. Lundqvist C, Siosteen A, Blomstrand C, Lind B, Sullivan M. Spinal cord injuries. Clinical, functional, and emotional status. *Spine.* Jan 1991;16(1):78-83.
120. Dalyan M, Cardenas DD, Gerard B. Upper extremity pain after spinal cord injury. *Spinal Cord.* Mar 1999;37(3):191-195.
121. May L, Day R, Warren S. Evaluation of patient education in spinal cord injury rehabilitation: knowledge, problem-solving and perceived importance. *Disabil Rehabil.* Apr 15 2006;28(7):405-413.
122. Airhihenbuwa CO, Obregon, R. A critical assessment of theories/models used in health communication for HIV/AIDS. *Journal of Health Communication.* 2000;5:5-15.
123. Clark NM, Nothwehr F, Gong M, et al. Physician-patient partnership in managing chronic illness. *Acad Med.* Nov 1995;70(11):957-959.
124. Pollock N. Client-centered assessment. *Am J Occup Ther.* Apr 1993;47(4):298-301.
125. Immink MA, Wright DL. Motor programming during practice conditions high and low in contextual interference. *J Exp Psychol Hum Percept Perform.* Apr 2001;27(2):423-437.
126. Ste-Marie DM, Clark SE, Findlay LC, Latimer AE. High levels of contextual interference enhance handwriting skill acquisition. *J Mot Behav.* Mar 2004;36(1):115-126.
127. Magill RA. *Motor learning: concepts and applications*. 6th ed. Dubuque, IA: Brown & Benchmark; 2001.
128. Winstein CJ. Knowledge of results and motor learning--implications for physical therapy. *Phys Ther.* Feb 1991;71(2):140-149.
129. Knowles M. *The Adult Learner: A Neglected Species*. 3rd ed. Houston, TX: Guld Publishing Company; 1984.
130. Silfverskiold J, Waters RL. Shoulder pain and functional disability in spinal cord injury patients. *Clin Orthop Relat Res.* Nov 1991(272):141-145.
131. Bonaparte JP, Kirby RL, Macleod DA. Learning to perform wheelchair wheelies: comparison of 2 training strategies. *Arch Phys Med Rehabil.* May 2004;85(5):785-793.

132. Lowther M, Mutrie N, Scott EM. Identifying key processes of exercise behaviour change associated with movement through the stages of exercise behaviour change. *J Health Psychol.* Mar 2007;12(2):261-272.
133. Nawoczenski DA, Ritter-Soronen JM, Wilson CM, Howe BA, Ludewig PM. Clinical trial of exercise for shoulder pain in chronic spinal injury. *Phys Ther.* Dec 2006;86(12):1604-1618.
134. Curtis KA, Tyner TM, Zachary L, et al. Effect of a standard exercise protocol on shoulder pain in long-term wheelchair users. *Spinal Cord.* Jun 1999;37(6):421-429.
135. Kerstin W, Gabriele B, Richard L. What promotes physical activity after spinal cord injury? An interview study from a patient perspective. *Disabil Rehabil.* Apr 30 2006;28(8):481-488.
136. Ajzen I, Fishbein, M. Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentic-Hall; 1980.
137. Blue CL, Wilbur J, Marston-Scott M. Exercise among blue-collar workers: application of the theory of planned behavior. *Res Nurs Health.* Dec 2001;24(6):481-493.
138. Benson WFH, Alice H. Advocacy Suggestions for Nursing Home Residents and their Families. http://www.nccnhr.org/public/50_152_430.CFM. Accessed September 12, 2007.
139. *ACSM's Guidelines for Exercise Testing and Prescription*. Seventh Edition ed. Baltimore, MD: Lippincott William and Wilkins; 2006.