**PICO Question: For adult traumatic complete spinal cord injury patients (levels T1-T12) how effective is an upper extremity exercise program compared to an upper extremity educational program for decreasing chronic shoulder pain and overuse injuries after 1 year post-injury?**

**Introduction**

Currently, there are 250,000-400,000 individuals living with a spinal cord injury (SCI) in the United States and about 50% are classified as having paraplegia as a result of the injury.1 Out of these individuals with paraplegia, up to 60% report experiencing shoulder discomfort.2 This discomfort is often attributed to degeneration as a result of consistent upper extremity weight bearing for functional activities, repetitive wheelchair propulsion, and poor biomechanics.3 Additionally, the prevalence of shoulder pain is significantly greater in adults who have had to transition to manual wheelchair mobility versus those who began wheelchair mobility during childhood.4 For this reason, this review of literature focuses on adult traumatic SCI.

Research has shown that manual wheelchair users often have tight anterior shoulder musculature and weak posterior shoulder musculature. These factors can increase a manual wheelchair user’s risk for overuse injuries and chronic pain.3 The most common cause of shoulder pain in individuals with SCI is subacromial impingement secondary to complications with the rotator cuff, long head of the biceps, and/or subacromial bursae.5 Surgical intervention is typically not an optimal choice for SCI patients due to shoulder post-surgery protocol most often involving complete rest of the joint, thereby, decreasing an individual’s ability to be independent with daily care/mobility.6 An exercise protocol emphasizing these muscle groups can improve pain and function during weight bearing activities.3, 6

Various modes of exercise have been used in previous research to examine their effectiveness of improving pain and function in individuals with paraplegia such as shoulder muscle strengthening, shoulder muscle stretching, shoulder aerobic endurance exercise, and upper extremity circuit training.3, 5,6,7, 8,9 It is increasingly difficult as an individual with SCI ages to perform an UE exercise program that does not aggravate the upper extremities and increase shoulder pain. Since individuals with paraplegia significantly rely on the upper extremities, specifically shoulder girdle depression, it is important to figure out a way to strengthen these muscles while also decreasing pain in order to decrease the risk of disability.10

Often, shoulder pain or dysfunction leads to decreased ability to perform functional activities such as transfers, bed mobility, and wheelchair mobility, which leads to an overall decreased functional indpendence.10, 11 Reports demonstrate that 26% of individuals need some help to complete functional activities and 28% have experienced a decrease in level of independence.11 If an individual with SCI has decreased independence, this has the potential to have a negative impact on the individual’s quality of life.

Educational programs have also been established with the goal of improving upper extremity biomechanics, shoulder pain, and maximizing independence with functional activities. These programs vary in terms of type and mode of education such as educational handout materials, informational videos, and physical teaching sessions aimed at improving the biomechanics of mobility. Studies have shown that participation in educational programs such as these can improve techniques of the functional activities, improve patient compliance, and improve overall independence.11

**Research Evidence**

A wide variety of research study designs were included in the review of literature. Three of the eight studies reviewed were conducted as randomized control trials (RCTs) in which two groups of subjects were used to compare two different interventions or compare one intervention with a control group.3, 6,11 Each study varied as to the type of subject groups and methods of intervention. One study by Mulroy et al6 compared an upper extremity exercise protocol with an education intervention. A second, by Curtis et al, 3 compared an upper extremity exercise protocol with a control group, and the last by Rice et al11 compared a standardized education protocol versus a traditional education protocol. The two studies comparing exercise interventions found significant evidence to support positive effects of a shoulder exercise program on decreasing shoulder pain.3, 6 This is important as it suggests that the exercise program was not only more effective than the education protocol, but also more effective than when compared to a control group. Both studies implemented similar shoulder exercise protocols consisting of shoulder stretching and strengthening, however, the Curtis et al study did not individualize the exercise program as far as progressing resistance, repetitions, and sets of the exercises.3 The study by Rice et al, comparing education, did not reveal statistically significant results. This can be attributed to the lack of objective measures used to determine the effect of education on transfers as well as a high drop out rate due to the one-year length of the study.11

The remaining five studies were each conducted with a different design: time series, exploratory study, quasi-experimental, clinical trial, and a cohort study. Overall, these studies did not demonstrate statistically significant results. This can be attributed to the much smaller sample sizes used and the lack of comparison intervention or control group used, which decreased the statistical power of the studies. An advantage seen throughout these smaller studies is a low report of dropout and the utilization of an individualized exercise programs. It can be hypothesized that the decreased amount of subjects allowed for a decreased chance of drop out and the ability of the researchers to provide a more individualized approach, thus making participants feel as if he/she is receiving higher quality of care. The individualized program is important since research has demonstrated that individuals with paraplegia need to have shoulder strength of at least 50% of their 1RM to perform most functional tasks.7 If an individual is not given an appropriate exercise protocol, he/she may not demonstrate improved strength or function due to too low of weights, or may increase his/her risk of injury if the resistance is too high. A set individual protocol will also decrease the risk of individuals modifying their exercise program on their own, which could potentially place him/her at greater risk for injury.

Outcome measurements also varied widely among the studies. Six of the eight studies included more than one outcome measurement increasing the potential to receive significant results and improving the statistical power. Many also used various tools to measure strength such as upper extremity dynamometers, UE cycle ergometers for aerobic capacity, and wheelchair propulsion speed. Only two studies included a measure for quality of life with one using the SF-36 and SQOL6 and the other using the International SCI QOL data set.8

Serra-Ano et al also included measurement of fat free mass and fat mass via the DEXA to evaluate the effect of the upper extremity exercise program on overall physical health.7 In this study, the researchers also chose to use an additional disabilities measurement, the Disabilities of Arm, Shoulder, and hand (DASH) questionnaire, which is used to rate the level of difficulty the individual experiences during different activities.7 Mulroy et al also used an additional disability measure, the Physical Activity Scale for Individuals with Physical Disabilities (PASIPD), to assess functional ability during household activities, leisure activities, and work-related activities.6 The use of disability scales is important for this population in terms of effectiveness, education, and compliance. If an exercise program only decreases pain, but does not decrease pain during functional activities, thereby decreasing level of disability, than an individual will likely not be motivated to continue the program.

The Rice et al study11 comparing educational programs only used one outcome measure and was vastly different from the other seven studies. The Transfer Assessment Instrument (TAI) was used to assess the quality of transfers performed in individuals who use wheelchairs as their primary mode of mobility after two different educational programs had been implemented. The TAI has been found to have a moderate interrater reliability and significantly variable intrarater reliability. This is due to inconsistencies of training individuals to perform the scale and the fact that the scale also allows room for subjectivity of assessment of the transfer performed. Using only one measurement and using a measure that has not been widely accepted or validated are potential reasons why the study was unable to reveal results that were statistically significant.11

The Wheelchair User’s Shoulder Pain Index (WUSPI) was the most frequently used outcome measurement with only one study, conducted by Rice et al11, excluding the WUSPI measurement due to its focus on measuring solely transfer ability. The WUSPI is a 15-item questionnaire with a visual analog scale for evaluating shoulder pain during different functional activities such as transfers, wheelchair mobility, and various individual ADLs.6,7 According to researchers, the WUSPI was chosen due to being widely accepted and previously validated demonstrating a high internal consistency, high reliability, and high test-retest reliability.3, 5, 6, 8, 10

Various modes of exercise programs all resulted in a decrease in WUSPI score such as a combination of shoulder strengthening and stretching, upper extremity resistance training, strengthening via a double-poling ergometer, strengthening via upper extremity circuit resistance training, and a scapula-focused strengthening program.3, 5, 6, 7, 8, 10 The only exercise protocol study that did not reveal a decrease in WUSPI score was a study by Dyson-Hudson et al, which analyzed the effects of a 12-week upper extremity ergometer exercise by comparing an intervention group with a control group.9 Importantly, the study did find that upper extremity aerobic exercise did not cause an increase pain, which was previously hypothesized.

Mulroy et al was the only study to directly compare a shoulder exercise intervention with a shoulder education intervention.6 Individuals either underwent a 12-week shoulder strengthening and stretching program, or a one-hour educational session with associated handouts. Results revealed that the intervention group was able to decrease WUSPI scores, increase shoulder strength/torque, increase frequency of social activity, and improve QOL scores. The education intervention group demonstrated no changes in scores in any of outcomes measured and neither group demonstrated significant changes in wheelchair propulsion speed. The interventions were unequal as the exercise group performed their exercises daily and the education group only received one, one-hour session. It is possible a more comprehensive and consistent educational intervention would change the results. Researchers conclude that regular performance of a shoulder strengthening and stretching home exercise program is effective in reducing shoulder pain, improving functional mobility, and improving overall quality of life.6

Consistent with the Mulroy et al study, the results from another study by Rice et al11 focusing on only the comparison of transfer education interventions did not reveal statistically significant results. A small significance was shown for dependent transfers at one-year follow up, but was not considered clinically significant. Overall, neither the use of the protocol driven transfer education course or the traditional transfer education course were effective at improving the quality of the transfer.11

There were many limitations present throughout the eight studies. First, all three of the RCT studies resulted in high-drop out rates possibly due to the fact that they were on average, longer duration studies. High-drop out rates may also be attributable to the high number of secondary complications that individuals with SCI are at risk for causing many to drop out for reasons unrelated to a direct-effect from the study. Additionally, many of the studies had low sample sizes and low number of women represented in the groups making the results difficult to be applied confidently to the general SCI population. Again, this may be as a result of the increased prevalence of SCI among men1 and a lesser percentage of women volunteering to participate in the studies. Many of the studies also did not use a control group, which decreases the strength of evidence found making it difficult to know if the same effects would have resulted on healthy subjects. Due to the high prevalence of upper extremity pain in individuals with paraplegia, it may have been difficult to find enough subjects whom were healthy and not currently experiencing pain.

Another common limitation throughout studies was the lack of screening for baseline joint pathologies (rotator cuff tear, subacromial impingement, etc.). Though shoulder injury pathology was an exclusion criterion for many of the studies, many subjects may have been subjected to overuse injuries and were unaware of it. Having an undiagnosed joint pathology could affect the individual’s ability to respond positively to exercise or educational programs. Also, many did not control the participant’s activities outside of the study. Activity level outside of the given exercises, HEP, or education protocol could potentially reduce an individuals chances of responding to the treatment and/or increase the individual’s risk for repetitive injuries or chronic pain.

**Conclusions/Discussions**

Overall, the results of the review of literature show that a consistent upper extremity exercise program either at home or in a clinic can improve shoulder pain during functional activities, general physical fitness, neuropathic pain, and if performed correctly, does not place an individual at increased risk of injury. The positive affect on pain also demonstrates improvements in reported quality of life, daily activity, and improvements in body composition. Results regarding education intervention were not statistically significant and very few studies analyzing education protocol were available. Given this information, it can be concluded that education is still an important part of a rehabilitation program, but should not be the only intervention when addressing chronic shoulder pain and overuse injuries in individuals with paraplegia.

The original PICO question was answered as my review of literature demonstrates that a shoulder exercise program would be more effective in reducing chronic pain and shoulder injuries in individuals with thoracic level spinal cord injuries. However, level of representation of research regarding educational interventions and shoulder pain were very low. Recommendations for more research comparing equal duration shoulder exercise and shoulder education programs, and comparing various educational interventions should be made. Future research should examine the effects of educational interventions focusing on verbal and printed instructions regarding risks for shoulder injury, pathology, and how to avoid them. Also included should be classes in which patients are taught to improve techniques of a variety of functional activities such as wheelchair mobility and ADLs versus only looking at techniques during transfers.

The ability of either an exercise program or education program to improve chronic shoulder pain and decrease the risk of injuries is very applicable to the creation of a physical therapy plan of care for individuals with SCI. In inpatient rehabilitation settings, patients can be given a shoulder HEP early on in the rehabilitation process in hopes of eliminating chronic shoulder pain and overuse injuries in the future. In outpatient settings, patients experiencing chronic shoulder pain can be given the HEP to improve pain, maximize functional activities, and maximize overall mobility. The initial HEP in either setting should focus on anterior shoulder muscle stretching and posterior shoulder muscle strengthening.6 For exercise progression inside and outside of the clinic, a program targeting scapular muscles could be added as well as upper extremity ergometer exercises, and other available forms of upper extremity resistance training.5, 7,11

This evidence supports that in addition to providing education on pressure relief and LE management, PTs should also be educating patients on the importance of a consistent UE shoulder program for improving functional activities and decreasing pain.3 Further education should also emphasize the lack of increase of shoulder pain after implementing a shoulder exercise program in order to improve a patient’s compliance and decrease a patient’s fear regarding exercise performance.9 Finally, this information can also be applicable to individuals with paraplegia who are not currently in pain, but may desire to increase physical activity, improve overall fitness, and decrease risk of co-morbidities secondary to a sedentary lifestyle.7

This review of literature will be the foundation of my Capstone project. I plan on using the positive results from these studies to create a set of educational materials for adults with traumatic thoracic level SCI regarding shoulder pain/injury prevention for acute and chronic SCIs. Additionally, I plan on creating a shoulder exercise HEP for acute and chronic individuals with paraplegia including a variety of ways in which the individual exercises can be progressed. This information will be shared with my clinical site and area inpatient/outpatient neurology clinics, as well as a presentation to PHYT 785 during the spinal cord injury portion of the course. My hope is to increase awareness of the issue of chronic shoulder pain/pathology, and to provide various students and therapists with evidence-based exercise intervention/HEP ideas.

**References**

1. North Carolina Spinal Cord Injury Association. Spinal Cord Injuries. NCSCIA Website: <http://www.ncscia.org/trifold.pdf> 2013. Accessed September 15, 2013
2. Pellegrini A, Pegreffi F, Paladini P, Verdano MA, Ceccarelli F, Porcellini G. Prevalence of shoulder discomfort in paraplegic subjects. *Acta Biomed*. 2012;83(3):177-182.
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):421-429.
4. Sawatzky BJ, Slobogean GP, Reilly CW, Chambers CT, Hol AT. Prevalence of shoulder pain in adult- versus childhood-onset wheelchair users: A pilot study.*J Rehabil Res Dev*. 2005;42(3 Suppl 1):1-8.
5. 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):1604-1618. doi: 10.2522/ptj.20060001.
6. Mulroy SJ, Thompson L, Kemp B, et al. Strengthening and optimal movements for painful shoulders (STOMPS) in chronic spinal cord injury: A randomized controlled trial. Phys Ther. 2011;91(3):305-324. doi: 10.2522/ptj.20100182; 10.2522/ptj.20100182
7. Serra-Ano P, Pellicer-Chenoll M, Garcia-Masso X, Morales J, Giner-Pascual M, Gonzalez LM. Effects of resistance training on strength, pain and shoulder functionality in paraplegics. Spinal Cord. 2012;50(11):827-831. doi: 10.1038/sc.2012.32; 10.1038/sc.2012.32.
8. Norrbrink C, Lindberg T, Wahman K, Bjerkefors A. Effects of an exercise programme on musculoskeletal and neuropathic pain after spinal cord injury--results from a seated double-poling ergometer study. Spinal Cord. 2012;50(6):457-461. doi: 10.1038/sc.2011.160; 10.1038/sc.2011.160
9. Dyson-Hudson TA, Sisto SA, Bond Q, Emmons R, Kirshblum SC. Arm crank ergometry and shoulder pain in persons with spinal cord injury. Arch Phys Med Rehabil. 2007;88(12):1727-1729. doi: 10.1016/j.apmr.2007.07.043
10. Nash MS, van de Ven I, van Elk N, Johnson BM. Effects of circuit resistance training on fitness attributes and upper-extremity pain in middle-aged men with paraplegia. Arch Phys Med Rehabil. 2007;88(1):70-75. doi: 10.1016/j.apmr.2006.10.003
11. Rice LA, Smith I, Kelleher AR, Greenwald K, Boninger ML. Impact of a wheelchair education protocol based on practice guidelines for preservation of upper limb function: A randomized trial. Arch Phys Med Rehabil. 2013. doi: 10.1016/j.apmr.2013.06.028; 10.1016/j.apmr.2013.06.028