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Shoulder Injury and Pain among Person's with Spinal Cord Injury

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Over 11,000 individuals with spinal cord injury (SCI) are affected each year within the United States resulting in the loss of lower limb function, with 30% – 50% encountering shoulder pain and injury as a result of exorbitant stress typically caused by mobility, locomotion, and prehension (Popowitz et al., 2003). In addition, the shoulder has been a primary joint associated with injury and pain of individuals with SCI with a prevalence of 30% - 70% with musculoskeletal disorders and shoulder pain complications that increase in age in comparison to the general population (Apple, 2001; Gellman, Sie, & Waters, 1988; Pentland & Twomey, 1994b; Curtis et al., 1999; Gironda, Clark, Neugaard, & Nelson, 2004; Samuelsson, Tropp, & Gerdle, 2004). Among the most common secondary complications that persons with SCI will develop, shoulder injuries and repetitive shoulder use account for over 71% of pain in the upper extremities, followed by wrist pain (53%), hand pain (43%), and elbow pain (35%) (Dalyan, Cardenas, & Gerard, 1999).

Boninger et al. (2005) studied those with SCI, noting the propensity to develop upper-limb pain and shoulder injury with repeated manual wheelchair use as a contributing factor. Similarly, Nichols, Norman, and Ennis (1979) reported the prevalence of shoulder injury and pain in 51% of their sample of SCI wheelchair users. Alm, Saraste, and Norrbrink (2008) also note how manual wheelchair users that rely heavily on their upper extremities for mobility are at an increased risk for injury and pain. The authors cite that even early on post-injury, soft tissues in the shoulders are not used to being used for transferring and wheelchair propulsion. Boninger et al. (2005) describe the overuse of shoulders for wheeling and transferring as repetitive strain injury (RSI) of the shoulder. Figoni (2009) discusses the difficulties individuals with SCI face in trying to rest their shoulders to decrease inflammation; however, unless caregiving assistance is available, shoulder uses constantly needed for manual wheelchair propulsion and completing activities of daily living (ADLs). Additionally, Alm et al. (2008) found that among 40% of participants who utilized manual wheelchairs for ascending ramps or outdoor inclines, chronic shoulder pain was often experienced.

Other studies have focused on the development of degenerative variations of the shoulder between males and females (Lal, 1998; Boninger et al., 2003). Lal (1998) found that females (89%) in comparison to males (65%) were more likely to develop degenerative complications within the shoulder. According to Hatchett et al. (2009), physiological characteristics differ greatly in relation to body length as women have shorter limbs, shorter humeral bones, and a narrower shoulder girdle in comparison to men. These anatomical differences may leave women at a disadvantage in performing upper extremity activities and may predispose women to injury after sustaining a SCI (Hatchett et al., 2009).

Shoulder Anatomy

The shoulder girdle is comprised of the clavicle, scapula and the humerus acting as a single working element (Reynolds, 2012). The humerus is the longest bone of the upper extremity that is part of the elbow and shoulder joints. The scapula is a thin and triangular bone reclining on the posterolateral aspect of the thorax covering ribs two through seven, and the clavicle which functions as a single structure connecting the axial skeleton and the upper extremities (Terry & Chopp, 2000). The four joints where the bones convene are the glenohumeral, acromioclavucular, sternoclavicular, and scapulothoraric, each joint acting as an integrated unit (Terry & Chopp, 2000).

The glenohumeral joint is a ball-and-socket joint that allows for the arm to move in a circular rotation, shaped by the articular surfaces of the humeral head and the glenoid cavity (Precerutti, Garioni, Madonia, & Draghi, 2010). According to Quillen, Wuchner and Hatch (2004), the glenohumeral joint is one of the frequently dislocated joints comprising for 90% of shoulder dislocations. The acromioclavicular (AC) joint is formed between the clavicle and the region of the scapula known as the acromion (Terry & Chopp, 2000). The AC joint is subject to injury when a shoulder become sprained, disrupted, detached or separated (Quillen et al., 2004). The sternoclavicular joint is the sole connection between the axial skeleton and the upper extremity (Terry & Chopp, 2000). Under normal conditions, the sternoclavicular joint allows 30-35 º of upward elevation, 35 º of forward and backward movement, and 44-50 º of rotation about the long axis of the clavicle (Rockwood, Green, Heckman, & Bucholz, 1991). The scapulothoracic articulation is not a joint in terms of two or more bones combined; this formation is a muscle and tendon mechanism that allows the scapula to slide without impediment along the upper back as the arm is elevated during the movements of the shoulder (Terry & Chopp, 2000).

The rotator cuff is the support structure for the shoulder joint consisting of four muscles, the subscapularis, supraspinatus, infraspinatus, and tares minor which act as a dynamic steering mechanism for the humeral head (Quillen et al., 2004; Terry & Chopp, 2000). The four muscles that make up the rotator cuff control three types of movement that include abduction, internal rotation, and external rotation. The supraspinatus muscle initiates abduction, the infraspinatus and tares minor muscles control external rotation, and the subscapularis muscle allows for internal rotation (Reynolds, 2012). Together, the muscoskeletal mechanism composes the most versatile joints in the body allowing the upper extremity to rotate up to 180° in three different planes as well as enabling the arm to perform a versatile range of functions (Quillen et al., 2004).

Shoulder Injury and Pain

The shoulder is the most common source of complication among people with SCI since the shoulder's primary function is for flexibility and movement as opposed to weight bearing (e.g., transferring) (Boninger, Cooper, Fay, & Koontz, 2003). Jain, Higgins, Katz and Garshick (2010) reported that for those without SCI, shoulder pain is the third most frequent musculoskeletal condition followed by back and knee pain. Various studies have indicated a prevalence of pain ranging widely from 36% to 100%, with such wide prevalence differences due to study research design and participant variability such as age, weight, and gender (Sie, Waters, Adkins, & Gellman, 1992, Nichols et al., 1979; Pentland, & Twomey, 1994b; Gellman et al., 1988). A qualitative study conducted by Sie et al. (1992) revealed that of 239 individuals with SCI, 53% of person's with tetraplegia and 16% of individuals with paraplegia reported shoulder pain. The causes of shoulder pain are believed to be multifaceted; however, many studies typically show the length of time since injury increases the risk for shoulder injury (Gellman et al., 1988; Sie et al., 1992; Pentland & Twomey, 1994b).

In relation to the prevalence of injury and pain, many studies over the past few decades have involved a physical examination and imaging studies in their research design studying those with SCI. Bayley, Cochran, and Sledge (1987) conducted a physical examination on 94 veterans with complete paraplegia. With thirty-one patients reporting a history of shoulder pain and twenty-three showing signs of impingement, 65% of veterans were found to have rotator cuff tears. Related studies have shown a primary pathological development among individuals with paraplegia include subacromial impingement syndrome with bursitis, tears of the rotator cuff, bicep tendon or both (Bayley et al., 1987; Burnham, May, Nelson, Steadward, & Reid, 1993; Escobedo, Hunter, Hollister, Patten, & Goldstein, 1997; Gellman et al., 1988). Furthermore, the most common shoulder injuries among individuals with SCI involve shoulder impingement syndrome (SIS) and rotator cuff tears. Page (2011) for example found SIS accounted for 44-65% of all shoulder related complaints during doctor visits, and Escobedo et al. (1997) revealed 57% presented rotator cuff tears among veterans with paraplegia.

Subacromial Impingement Syndrome. Subacromial impingement syndrome (SIS), otherwise known as "swimmer's shoulder" has been a primary concern for individuals with SCI (Bayley, et al., 1987; Dalyan et al., 1999; Sie et al., 1992). The impingement disorder disturbs the structures of the subacromial space and the components within that space with a variety of contributing factors (Michener, McClure, & Karduna, 2003). Evidence of these causal factors do exist in support of the anatomical complications that include inflammatory tendons and bursa, deterioration of the tendons, fragile and/or dysfunctional rotator cuff muscle, weak scapular muscle, posterior glenohumeral capsule tightness, soft or bony tissue abnormalities within the borders of the subacromial outlet, and dysfunctions of the spinal column (Michener et al., 2003). In addition, SIS can lead to degenerative joint disease within the joints of the shoulder girdle and tears of the rotator cuff tendon (Neer, 1983; Fu, Harner, & Klein, 1991; Bigliani & Levine, 1997; Budoff, Nirschl, & Guidi, 1998; Michener et al., 2003). The SIS tendon or bursa of the subacromial space when inflamed can cause significant narrowing of the subacromial space, potentially affecting the compression of the tissues alongside the borders (Fu et al., 1991; Bigliani & Levine, 1997; Ogata & Uhthoff, 1990). In addition, the degeneration of tendons within the subacromial space has been found in patients with SIS as a result of inflammation or strenuous tension during shoulder activities (Paletta, Warner, Warren, Deutsch, & Alcheck, 1997; Ogata & Uhthoff, 1990; Banas, Miller, & Totterman, 1995; Tuite, Toivonen, Orwin, & Wright, 1995; Toivonen, Tuite, & Orwin, 1995) and can lead to rotator cuff injury (Seeger, Gold, Bassett, & Ellman, 1988).

With glenohumeral joint kinematics possessing six degrees of freedom, the dominant motion of inferior translation is 60-150 and 30-60 of superior translation within healthy, fully functioning individuals, although in patients with SIS, range of motion is significantly decreased (Graichen et al., 2001; Ludewig & Cook, 2000; Lukasiewicz, McClure, Michener, Pratt, & Sennett, 1999; Greenfield et al., 1997). In addition to the contributions the glenhumeral joint has on movement, the scapulothoracic (scapular) is responsible for upward/external rotation, and posterior tilting during glenohumeral elevation; a critical joint often injured during high levels of frequent activity (Michener et al., 2003). The shoulder movements that bring about greater elevation as contact with coracoacromial arch become closer include superior or anterior translations of the humeral head within the glenoid (Flatow et al., 1994).

Overuse or injury can present poor external rotation of the humerus (Flatow et al., 1994) and waning external rotation resulting in particularly problematic issues (Lukasiewicz et al., 1999; Ludewig & Cook, 2000). Overall, the pain related with SIS contributes to loss of shoulder function associated with ADL (e.g., grooming, bathing) (Lewis, Dekel, & Green, 2001). Overtime, SIS can result in inflammation of the rotator cuff tendon and bursa, and if untreated, can lead to rotator cuff tears (Seeger et al., 1988).

Rotator Cuff Tear. As shoulder pain by SIS negatively impacts ability to perform ADLs, other shoulder injuries and shoulder pain have been a contributing factor as well. It is estimated that 90-95% of abnormalities of the rotator cuff are a result of tension overload, overuse, and traumatic injury (Budoff et al., 1998). The rotator cuff, a common source of pain and disability is a musculotendinous unit that corresponds in conjunction with the deltoid allowing for elevation of the shoulder. The term impingement syndrome has been associated with symptoms relating to the rotator cuff in the absence of a full-thickness tear of the cuff and can range in severity from acute tendinitis to a full-tear (Budoff et al., 1998). Injuries related to the rotator cuff can be caused by intrinsic factors such as intra-substance tearing (tears that occur within the middle layer of the tendon) or chronic tendinitis due to overuse, aging, avascularity, or the supraspinatus, a relatively weak muscle located in an area susceptible to overuse and injury (Budoff et al., 1998).

The prevalence of rotator cuff tear is 65% to 71% among individuals with SCI (Goldstein, Young, & Escobedo, 1997) with very similar rates found by Akbar et al. (2010) when comparing persons with SCI to the general population (63% vs. 15%). Data presented by Akbar et al. (2011) revealed that among 317 patients with paraplegia, 156 (49%) patients had rotator cuff tears and consisted of partial-thickness rupture (74 shoulders), full-thickness rupture (173 shoulders), unilateral rotator cuff tear (64 patients or 41%) and bilateral tears in 92 patients (59%). Additionally, age played a significant factor for those with rotator cuff tears who were younger and utilized a wheelchair for a shorter duration of time and reported less pain.

Rotator cuff repair surgeries for individuals with SCI have created much debate. Goldstein et al. (1997) found that among five individuals with SCI who underwent shoulder surgery for rotator cuff tear, four individuals or five shoulders had not improved with the probability due to supraspinatus atrophy, upward displacement of the humeral head, and those with tears in more than one muscle. Conversely, Robinson, Hussey, and Ha (1993) reported success with rotator cuff surgery in individuals with paraplegia, although the surgery required five to seven weeks of postoperative hospitalization and two to four months before transferring and wheelchair propulsion was at functional ability. Due to the consequences of immobility accompanying rotator cuff surgery in individuals with SCI, conservative treatment has been a preferred option (Bayley et al., 1987; Goldstein et al., 1997). However, Subbarao, Klopfstein, and Turpin (1994) reported that among those whom participated in conservative therapy, results were ineffective due to primary contributing factors to RSI from wheelchair propulsion and the fact that transfers could not be prevented.

Upper Extremity Pain. Upper extremity pain (UE) is prevalent in people with SCI especially as the individual ages and there is a significant increase in physiological complications (Dalyan et al., 1999). Shoulder pain and injury have been associated among people with SCI due to the high demand or stress placed on shoulders along with weak or unconditioned muscles (Apple, 2001). Additionally, upper limb pain is identified to impede with a wide range of functional activities such as self-care, transfers, ambulation and pressure relief (Curtis et al., 1995; Dalyan et al., 1999). Turner, Cardenas, Warms, and McClellan (2001) notes the incidence of chronic pain in people with SCI ranges from 11% to 94%. The

Consortium for Spinal Cord Medicine (2005) reported on multiple studies that shoulder pain in chronic SCI individuals is common in both paraplegia and tetraplegia at a prevalence of 30% to 60% respectively. Furthermore, Sie et al. (1992) interviewed a total 239 persons with SCI (136 with tetraplegia and 103 with paraplegia) who were outpatients for the presence of UE pain of the shoulder, elbow, wrist and hand. They found 55% of participants with tetraplegia reported UE pain, most commonly at the shoulder, while 64% of patients with paraplegia reported UE pain. A similar study by Pentland and Twomey (1994b) involving 52 persons with SCI paraplegia found 39% reported pain in the shoulder, 39% in the elbow, and 40% in the hand and/or wrist. Likewise, a study conducted by Turner et al. (2001) suggested 75.6% of the respondents reported they had experienced upper extremity pain after their SCI and 69.1% stated they were presently experiencing pain.

Nichols et al. (1979) surveyed 708 individuals with SCI and found 51.4% of the respondents suffered from shoulder pain. The pain was particularly in the shoulder and predominantly associated to wheelchair usage and transfers. Nichols et al. (1979) was one of the first researchers to note a correlation between chronic SCI and shoulder pain. Consequently, Curtis et al. (1995) developed a Wheelchair Users' Shoulder Pain Index (WUSPI) to measure the functional cost of shoulder pain in individuals who use wheelchairs. Curtis et al. (1999) reported that over 75% of long-term wheelchair users experience shoulder pain and 64% reported hand or elbow pain since beginning to use a wheelchair. Subbarao et al. (1995) reported there is a high incidence of shoulder pain during the first year after injury and another spike in pain reporting for individuals after 15-20 years post injury.

Preventative Measures

Lal (1998) sought to identify preventative strategies among 53 patients with SCI at the Rehabilitation Institute of Chicago. The participants were exposed to experimental and radiological examination from the time of injury for a period of 15 years. Results suggested that individuals with SCI who were older (92%), female (89%), and had higher levels of wheelchair activity (72%) are more likely to develop degenerative changes in the shoulders. Conversely, Finley and Rodgers (2004) found no significant difference of shoulder pain past or present between athlete and non-and wheelchair users, but collectively 61.5% of the participants reported pain with 29% reporting pain during the present time (Finley & Rodgers, 2004).

A conceptual model presented by Rimmer, Chen, and Heish (2011) recommends utilizing four groups of professionals to assist with prevention of shoulder pain. First, rehabilitation professionals can educate individuals using wheelchairs by teaching appropriate wheelchair propulsion techniques along with strengthening and stretching exercises. This will in turn reduce or minimize stress on the shoulders. Assistive technology professionals can offer power wheelchairs or powered assist wheels to consumers to prevent repetitive shoulder injuries. Health promotion professionals can discuss effective and safe exercise programs (i.e. land or aquatic) to strengthen shoulder musculature, and Rimmer et al. (2011) suggested policy advocacy groups have the ability to suggest health care coverage for funded fitness program memberships and power-assist wheelchairs. If power wheelchairs are not an option, light weight wheelchairs can be beneficial to decrease shoulder injuries associated with body weight and rolling resistance (Boninger et al., 2005).

Evidence supports the ability of exercise to reduce multisystem disorders in individuals with SCI. Musculoskeletal decline, fatigue, and pain have been cited to improve throughout the course of remaining physically active. Hetz, Latimer, and Ginis (2009) examined patterns of participation in fitness related activities and ADL among 48 participants with SCI. The results suggested participants with higher levels of fitness spent more time participating in specific ADL including maneuvering and cleaning. Additionally, the amount of time spent participating in moderate and heavy intensity physical activity for leisure correlated positively with time spent engaging in specific ADL. Overall, the study identified the benefits associated with physical activity for optimizing ADL participation.

Liem, McColl, King, and Smith (2004) conducted a cross sectional analysis of 352 individuals who sustained a SCI for more than 20 years. Of the participants, 12% had upper extremity joint issues including shoulder and non-shoulder problems. The data illustrated women and those who used it wheelchair longer since injury reported more upper extremity problems than men and those with a shorter period of time post-injury. The role of exercise for individuals with shoulder injuries in increasing quality of life cannot be underestimated. Research in the past decade has displayed positive effects of regular exercise for shoulder injuries in relation to pain, self-concept, and overall quality of life among individuals with SCI (Ginn & Cohen, 2004; Hicks et al., 2003; Ludewig & Borstad, 2003).

Several studies have focused on the benefits of exercise for individuals with shoulder injuries. In a study conducted by Nawoczenski, Ritter-Soronen, Wilson, Howe, and Ludewig (2006) with 41 manual wheelchair users, 21 had a previous diagnosis of shoulder injury and 20 had none. They participated in an eight week scapula focused exercise intervention. The results suggested significant improvements in pain, enhancing function, and satisfaction in wheelchair users in the intervention group. Similarly, Mulroy et al. (2011) randomly assigned 80 individuals with SCI and shoulder pain to an exercise/movement optimization intervention group or a control group. After a 12-week intervention group of shoulder strengthening and stretching exercises, individuals in the exercise group reported a one-third decrease in shoulder pain while the control group remained unchanged. Outcome measures of shoulder pain, muscle strength, activity, and quality of life were assessed and improvements were also reported by the intervention group. In addition, Gutierrez, Thompson, Kemp, and Mulroy (2007) surveyed 80 participants with shoulder pain in order to investigate correlations between shoulder pain scores, quality of life, physical activity, and community activities. Participants who reported lower engagement in physical activity reported lower quality of life scores and experienced higher levels of shoulder pain and injuries.

Exercise encompasses many well-known physical activity strategies such as rehabilitating the functional demands of the muscle system, enhancing cardiovascular fitness, and improving muscle and joint flexibility. Higher levels of cardiorespiratory function among individuals with SCI are often associated with physical activity just as in cases of ambulatory individuals. Jacobs, Nash, and Rusinowski (2001) reported major increases in cardiorespiratory function and increases in maximum oxygen uptake and strength after 12 weeks of circuit training for ten individuals with SCI.

The level of physical inactivity after a SCI differs significantly from the pre-injury state in which most individuals are relatively young and physically active. The importance of regular physical activity for individuals with SCI has been increasingly recognized, in particular the physical benefits of exercise for promoting functional independence (Nash & Horton, 2002). Unlike individuals without disabilities, exercise options are limited for individuals with SCI who also possess shoulder injuries. It is widely acknowledged that shoulder injuries and pain of person with SCI are a consequence of overuse and increase stress imposed by reliance of the upper extremity for ambulation (Harvey & Herbert, 2002).

Activities of Daily Living (ADL)

One component of the rehabilitation process for individuals with SCI is learning adaptive methods when performing activities of daily living (ADL). Adaptive methods include learning assistive technology (AT) which refers to products, equipment or devices that are used to improve, maintain, or increase the functional independence for individuals with disabilities (Brodwin, Siu, & Cardoso, 2012). Findings due to shoulder injuries in individuals with SCI as indicated by Alm et al. (2008) show limitations from the inability to use their shoulders during activities of daily living (ADL) were common. Furthermore, high level intensity shoulder use during ADL's including transferring and propulsion increases the risk for injury and shoulder pain (Gellman et al., 1988; Bayley et al., 1987; Boninger et al., 2003; Newsam, Lee, Mulroy, & Perry, 2003). As car transfers and chair loading become more difficult, many individuals report a reduction in activities to avoid the strain of transfers. Individuals with SCI often lift up or down during a transfer which adds a considerable amount of stress to the shoulders (Boninger et al., 2002). Another consideration is the height of the transfer that often leads to overuse of the shoulder due to continuous overhead activities and repetitive motions. As previously stated, individuals with SCI rely heavily on the function of their upper limbs for weight bearing tasks, ambulation, and ADL. While shoulder injuries and pain may not initially limit the ability to perform ADLs, it does have functional costs such as rapid fatigue, and low tolerance for prolonged work or leisure activity over time (Harvey & Herbert, 2002).

Economic Concerns. Meislin, Sperling, and Stitik (2005) state that shoulder pain was the third most common musculoskeletal grievance, following back and knee pain, and produced an annual direct expense of approximately seven billion dollars in the United States. The ability to remain or become independent is directly related to earning income in order to provide resources for supplies, modified home or van, and/or a personal attendant (Bach, Vega, Majors, & Friedman, 2003; Craig, Hancock, & Dickson, 1999). Brodwin et al. (2012) cited a 1993 National Council on Disability study which indicated the human component importance of assistive technology. In the report, 62% of adults were able to be less reliant on family members for ADL assistance and 58% were able to reduce the cost of paid assistance. According to an economic analysis by the Alexander Law Group (2013), personal care attendants for assistance with ADLs suggest an annual median cost of $39, 420 for those who require an attendant. Environmental control systems (ECS) for voice activated or switched controlled wireless ECS for safe access to electrical appliances can range from $1, 995 to $2,350, and other AT devices (e.g. reachers, extenders) can add up as well.

The economic cost for treatment and rehabilitation include procedures, medications, office visits, rehabilitation and hospital costs as well as diagnostic tests and procedures. Indirect costs focus on a loss of income as a result of injury, costs for specialized services (e.g., personal care attendant), and family burden costs (Putzke & Richards, 2001). Kuijpers, Tulder, Heijden, Bouter, and Windt (2006) investigated 587 participants with shoulder pain over a six month period of time. Approximately 50% of total indirect costs were directly related to sick leave from paid work. Treatment by mainly physiotherapists accounted for 37% of the total direct costs but only 14% of the total costs (Kuijpers et al., 2006).

Discussion

When a person has acquired a SCI, certain physiological changes occur leading them towards greater risk of secondary complications. Although shoulder injuries are a significant secondary concern for many people with SCI, much of the literature and research conducted is scarce or outdated. For life care planners, having a clear understanding of the implications shoulder injury and pain has on an individual is critical to consulting with relevant specialists regarding medically probable future medical care needs, as well as improving overall quality of life. For persons with SCI that use a manual wheelchair for propulsion and who may also perform transfers, planning future medical care needs must be cognizant of the negative impact of aging and RSI chronic pain potential treatment needs.

Life care planners have a gambit of things to consider in consultation with the treating specialist including potential need for pain medications, assistive technology such as power assist wheels and/or powered wheelchairs, relevant exercise equipment for prevention, and aids for independent function. Although the literature review cited in the present study suggests a wide range of reported RSI and related chronic pain for different individuals with SCI, life care planners must consider the individualized characteristics of the individual being evaluated. Researchers indicate there are a number of demographic factors that make some with SCI more susceptible to shoulder injury and pain than others. The decision as to whether or not to include future medical care costs for RSI related problems must be carefully considered and weighed against the medical probability that such problems will occur.

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