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Prevalence and identification of shoulder pathology in athletic and nonathletic wheelchair users with shoulder pain: A pilot study

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Abstract—Although many wheelchair users report shoulder pain, the prevalence of specific pathologies remains controversial. Rotator cuff impingement, glenohumeral instability, and biceps tendonitis have been stated as the most commonly found pathology. This study investigated the prevalence and identity of shoulder pathology in athletic and nonathletic manual wheelchair users (MWCUs). Fifty-two MWCUs (26 athletes, 26 nonathletes) completed a survey regarding the nature of their injury, sports involvement, history, and presence of current and/or past shoulder pathology. Subjects currently experiencing shoulder pain underwent a clinical examination of both shoulders. Analysis of variance ($p \leq 0.05$) determined if differences existed between the groups in demographic variables, history of shoulder pain, and clinical evaluation measures in those with shoulder pain. Chi-squared ($p \leq 0.05$) analysis verified the frequency distribution and association by groups and involved limbs for the clinical shoulder test measures. No difference was found in the incidence of shoulder pain, past or present, between athletes and nonathletes. Collectively, 61.5% (32/52) of the subjects reported experiencing shoulder pain, with 29% reporting shoulder pain at the present time. Years since onset of disability ($p = 0.01$) and duration of wheelchair use ($p = 0.01$) were found to be greater in individuals who reported a history of shoulder pain. Of the painful shoulders tested, 44% revealed clinical signs and symptoms of rotator cuff impingement, while 50% revealed signs of biceps tendonitis. Instability was found in 28% of the painful shoulders. These findings indicate that involvement in athletics neither increases nor decreases the risk of shoulder pain in the manual wheelchair population. Bicipital tendonitis with impingement syndrome was the most common pathology.

Key words: shoulder pathology, wheelchair propulsion.

INTRODUCTION

The National Health Interview Survey on Disability reported in 1999 that more than 2.3 million individuals in this country have disabilities requiring the use of a wheelchair [1]. Manual wheelchair users (MWCUs) are included within the disability groups of spinal cord injury (SCI), lower-limb amputation, stroke, multiple sclerosis, rheumatoid arthritis, spina bifida, poliomyelitis, and hip fracture, as well as other groups. More than 176,000 veterans use manual wheelchairs for mobility, with 44,000 manual wheelchairs distributed annually at a cost of over $28 million, according to the Veterans Health Administration

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Abbreviations: ANOVA = analysis of variance, HSD = honestly significantly different, ICC = intraclass correlation coefficient, MWCU = manual wheelchair user, SCI = spinal cord injury, VA = Department of Veterans Affairs.

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Prosthetics Department and the Veterans Health Administration National Prosthetics Database. MWCUs rely on their upper limbs for most activities. Demands of wheelchair propulsion, as well as the weight-bearing required for transfers and activities of daily living, expose the upper limbs to excessive stresses. The upper limb is structured for mobility rather than stability, and these increased demands may predispose individuals to injury.

Large discrepancies in the prevalence of upper-limb pain exist in the literature. It has been reported that 31 to 73 percent of MWCUs experienced shoulder pain since beginning to use the device (31% [2], 34.5% [3], 51.4% [4], 59% [5], 73% [6]). However, the literature does support the shoulder as the most common site of pain reported by the wheelchair population. Additionally, there is not agreement regarding the specific pathologies that most often create the problems. Impingement has been cited as the most commonly occurring pathology [2], while others have cited bicipital tendinitis as the most frequent diagnosis in MWCUs with shoulder pathology [3]. Researchers have stated that MWCUs demonstrate degenerative injuries, impingement syndrome, rotator cuff tears, glenohumeral instability, avascular necrosis, acromioclavicular joint degeneration, and distal clavicle osteolysis [2,3,7–9].

The etiology of shoulder pathology is also an area of discrepancy in the literature. Possible causes of the shoulder pathologies include time since onset of injury [3,4], the repetitive nature of wheelchair propulsion [9,10], the high-strength requirements placed by wheelchair propulsion on the shoulder muscles [2], loading of the joints at extremes of motion [2,3,11], and muscular weakness or imbalance [9,12]. Others have concluded that, in conjunction with high internal joint forces, the abnormal stresses applied to the subacromial area during wheelchair propulsion and transfers contribute to the high rate of shoulder problems in the paraplegic patient [2,6].

Studies have shown that individuals with disabilities who assume less active, sedentary lifestyles are more likely to have diminished functional capacity and rehabilitation potential [13]. Wheelchair athletes were found to have less frequent hospitalizations and less skin breakdown [13–15]. However, conflicting reports exist on the benefits or damage of increased training time and/or the demands on the shoulder, and the relationship to musculoskeletal overuse injuries in this population [16–18]. Lal et al. found that an increased level of wheelchair activity (independent mobility compared with assisted mobility) was correlated to degenerative changes in the shoulder [18], while Wylie and Chakera found the opposite in their sample [17]. In the nondisabled population, a similar discrepancy exists. Rosendal et al. found that lower fitness levels were strongly associated with the development of overuse injuries in military recruits [19], while Thomee et al. found that chronic overloading and increased competitive participation was associated with higher levels of patellofemoral pain [20].

Identifying shoulder pathology in MWCUs is an important initial step in understanding wheelchair propulsion mechanics and may assist in identifying the factors that may contribute to pathology. Improved knowledge of shoulder pathology and associated mechanics may lead to efforts to prevent the pathology. Additionally, no studies have been found that investigate the difference in shoulder pathology in an athletic-trained population compared with more sedentary wheelchair users. Comparing an athletic sample of MWCUs to a nonathletic sample may provide important information about whether or not sport activity has a protective effect on the shoulder joint. Given the large number of veterans using wheelchairs and the significant incidence of shoulder pathology in the wheelchair-using population, research that provides information on identifying the pathology and the impact of physical activity may ultimately lead to improving the quality of life of MWCUs. Therefore, this investigation identified and determined the prevalence of shoulder pathology in nonathletic versus athletic symptomatic MWCUs. We hypothesized the incidence of shoulder pathology would be greater in nonathletic wheelchair users with the most commonly occurring pathologies of rotator cuff impingement and glenohumeral instability.

METHODS

Following informed consent as approved by the University of Maryland at Baltimore Institutional Review Board, 52 manual wheelchair users (26 athletes, 26 nonathletes) participated in this study (**Table 1**). Subjects were recruited from community athletic leagues, the Mid-Atlantic Wheelchair Games, community support groups, and personal contacts. Inclusion criteria included use of a manual wheelchair for a duration of at least 1 year, as well as use for at least 50 percent of home and community mobility. Subjects were classified as athletes

Table 1.
Demographics of subjects (mean ± standard deviation).

Variable	Athletes (n = 26)	Nonathletes (n = 26)	All MWCU (n = 52)
Age (years)	41.7 ± 7.8	41.2 ± 11.0	41.3 ± 9.4
Duration of Disability (years)	20.0 ± 7.8	15.2 ± 14.0	17.6 ± 11.5
Duration of Wheelchair Use (years)*	19.8 ± 8.0	11.6 ± 10.4	15.6 ± 10.0
Gender	23 males, 3 females	18 males, 8 females	41 males, 11 females
Disabilities Represented in Sample			
Spinal Cord Injury	20	12	32
Spina Bifida	3	3	6
Amputation	2	2	4
Cerebral Palsy	1	1	2
Multiple Sclerosis	0	2	2
Other	0	6†	6

*Significant difference between groups (p = 0.003)
†Guillain-Barré (1), tropical spastic paresis (1), brain abscess (1), spinal cord stroke (1), multitrauma (1), postpolio syndrome (1)

if they were involved in organized, competitive wheelchair sports of recreational to elite levels of competition. Nonathletes were self-reported as not participating in athletic endeavors. Each participant completed a survey providing information on the nature of his or her disability, duration of wheelchair use, weekly activity level, weekly training regime, and history of shoulder injury/pain. Additional questions regarding frequency of pain episodes, activities that cause shoulder pain, and interventions taken were also included.

Subjects who reported to be currently experiencing shoulder pain answered questions on the behavior of their shoulder pain and underwent a clinical evaluation of the shoulder complex. The evaluation consisted of goniometric measurements of active shoulder range of motion [21,22] and measurement of upper-limb muscle strength (shoulder flexion, extension, abduction, adduction, external rotation, internal rotation, elbow flexion, elbow extension) taken by handheld dynamometry (Chattilon Medical Dynamometer, CSC Force Measurement Inc., Agawam, MA). Clinical special tests were the Neer Test for rotator cuff impingement [23,24], "load and shift" for anterior instability [21,22,25], sulcus sign test for multidirectional instability [21,22,25], and Speed's Test for bicipital tendonitis [21,22]. Clinical shoulder tests were graded as "present" or "absent." One physical therapist with experience in shoulder pathology performed the specific tests and the order of the tests was randomized. All tests and measurements were performed on both upper limbs, three repetitions, with the subject seated in his or her personal wheelchair with trunk stabilization as needed. The clinical test findings were classified as "positive" if the subject was graded "present" on a minimum of two of the three repetitions. The shoulder reported to be the most painful was defined as the involved limb in subjects with bilateral shoulder pain for strength and range of motion comparisons. For shoulder evaluation analysis, both limbs of subjects currently experiencing pain were used for analysis. For the strength measures, the three trials were averaged for each upper limb and used for analysis.

DATA ANALYSIS

We used analysis of variance (ANOVA) ($p \leq 0.05$) to determine if intertrial differences existed in the strength measures. Intraclass correlation coefficients (ICCs) were calculated to verify the reliability of the measurements. The acceptable threshold for moderate reliability was set at $R \geq 0.60$ and high reliability was set at $R \geq 0.80$. ANOVA ($p \leq 0.05$) established if differences existed between the groups (all athletes versus all nonathletes, and athletes versus nonathletes undergoing shoulder evaluation) in demographics variables (age, duration of disability, duration of wheelchair use) and shoulder evaluation findings in those currently experiencing shoulder pain. An Honestly Significantly Different (HSD) Tukey test was applied post hoc to significant findings with a Type I error threshold of p = 0.05. No family-wise error correction was applied, given the small sample size of this pilot study. Chi-squared analysis ascertained the frequencies and relationship of clinical findings between groups and between involved and uninvolved limbs.

RESULTS

No difference was found between the groups in any demographic variable. The mean age of the sample was 41.3 ± 9.4 years, duration of disability = 11.6 ± 11.5 years, and duration of wheelchair use = 15.6 ± 10.0 years. A variety of disabilities was represented in the sample of both athletes and nonathletes (**Table 1**). Several participants reported being ambulatory earlier in the onset of their disability, but ultimately were required to use the wheelchair as their primary means of mobility. Therefore, a difference between duration of disability and duration of use of the wheelchair was found in this diverse sample. Fifteen subjects (28.8%) stated that they were currently experiencing shoulder pain, while 32 of the 52 subjects (61.5%, 17 athletes, 15 nonathletes) reported experiencing shoulder pain since the onset of their disability. As indicated in **Table 2**, in addition to night pain, lifting a gallon of milk, reaching overhead, transfers, and propelling up a ramp/incline were most often associated as painful activities.

The nonathletic group, both with and without current shoulder pain, stated 0 hours of athletic training or competition weekly, while the athletes with shoulder pain self-reported an average weekly participation of 8.2 ± 6.3 hours, and those without pain reported 10 ± 4.2 hours per week. Sports participation included wheelchair basketball, football, tennis, softball, road racing, hand cycling, and track and field events. Both groups reported intermittent participation in recreational leisure activities such as hunting, fishing, bowling, and/or gymnasium workouts.

We found a significant difference in the onset of disability (years, $p = 0.01$) and duration of wheelchair use (years, $p = 0.01$) between the MWCUs who reported experiencing shoulder pain at any time since the onset of their disabilities compared with those reporting never having experienced shoulder pain (**Figures 1** and **2**). A total of 15 subjects (6 athletes, 9 nonathletes, mean age = 44.2 ± 10.6 years, duration of disability = 19.6 ±

Table 2.
Frequency distribution of painful activities as reported by subjects with history of shoulder pain ($n = 32$). Subjects were asked if these activities caused shoulder pain.

Activity	"Yes" Response (n)
Pain at Rest	16
Pain When Sleeping	21
Self-Care Activities of Daily Living	
Pain with putting on a shirt	12
Pain with pulling on pants	11
Pain with tucking shirt into back of pants	9
Pain with washing/styling hair	15
Pain with washing your back	9
Transfers	
Pain with bed to wheelchair	19
Pain with shower/tub to wheelchair	18
Pain with car to wheelchair	20
Propulsion	
Pain with level surfaces	13
Pain on inclines/ramps	25
Pain on downhill/declines	9
Pain with Reaching Behind Your Head, Elbow Out to Side	18
Pain with Lifting a Full Gallon of Milk to a Counter (Shoulder-Level)	17
Pain with Lifting a Full Glass to a Counter (Shoulder-Level)	7
Pain with Reaching Straight Overhead	18

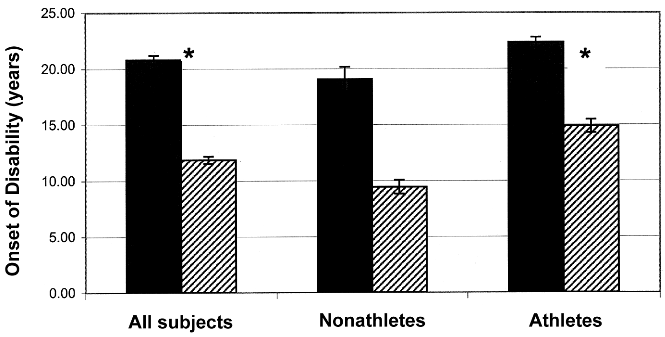

Figure 1.
Onset of disability (mean ± standard error, years) vs. history of shoulder pain (all subjects: n = 32, athletes n = 17, nonathletes n = 15). Solid = subjects reporting experiencing shoulder pain since onset of disability. Hatched = subjects reporting no shoulder pain since onset of disability. * = significant difference ($p < 0.05$) between MWCUs reporting a history of shoulder pain and those reporting no history of shoulder pain.

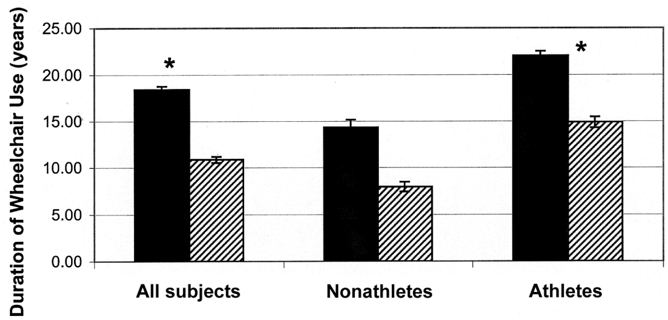

Figure 2.
Duration of wheelchair use (mean ± standard error, years) vs. history of shoulder pain (all subjects: n = 32, athletes n = 17, nonathletes n = 15). Solid = subjects reporting experiencing shoulder pain since onset of disability. Hatched = subjects reporting no shoulder pain since onset of disability. * = significant difference ($p < 0.05$) between MWCU reporting a history of shoulder pain and those reporting no history of shoulder pain.

14.6 years, duration of wheelchair use =15.6 ± 10.6 years, weight = 174.3 ± 41.3 lb) reported to be currently experiencing shoulder pain.

Thirteen subjects underwent clinical shoulder evaluation, while two subjects (one athlete, one nonathlete) refused the evaluation following the survey. No difference was found in the demographics (age, onset of disability, duration of wheelchair use, body weight) of the two groups currently experiencing shoulder pain. Five of the subjects (two athletes, three nonathletes) evaluated suffered from bilateral shoulder pain, for a total of 18 painful shoulders (n = 7 athletes, n = 11 nonathletes). The ICC values for the strength and range of motion measures were all found to be excellent, with a range of R = 0.94 to 0.99. There was no difference in the clinical findings of strength or range of motion between the groups. Additionally, no difference was found in range of motion or strength between the involved (painful) limb and the uninvolved limb with the groups collapsed. **Tables 3** and **4** indicate the range of motion and strength (expressed as percentage of body weight) by groups.

Chi-squared analysis revealed no significance of group membership or presence of any of the specific shoulder pathologies in the involved painful limbs ($p \leq 0.05$). The clinical tests revealed 50 percent (9/18) of the group experienced painful shoulders presented with bicipital tendonitis, with 44.4 percent (8/18) presenting with impingement. Similarly, anterior instability (positive load and shift) was found in 44.4 (8/18), with four nonpainful shoulders demonstrating instability. These findings did indicate a significant association of groups ($p = 0.02$), in that all four nonpainful shoulders with instability were among the nonathlete group. Five of the nine shoulders experiencing bicipital tendonitis were among those positive for impingement, while two with anterior instability also were positive for bicipital tendonitis and three for impingement. Multidirectional instability (positive sulcus sign) was found in 27.8 percent (5/18) of the painful shoulders, and in two of the eight nonpainful shoulders.

DISCUSSION

Researchers have reported increased musculoskeletal problems in groups of athletic MWCUs [16]. However, Wylie and Chakera found that moderate physical activity protected shoulders from degeneration with 45 percent of the inactive groups' shoulders showing degenerative changes compared to only 18 percent in the active group [17]. Converse to our hypothesis, involvement in athletics was found to neither increase nor decrease the incidence of shoulder pain in this sample of MWCUs.

Increasing time since injury, as well as increasing age, contributes to a decline in strength and range of motion [3,4,26]. Upper-body strength measurements have been found to be higher in active individuals with SCI than in those who are sedentary. Specifically, individuals

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Table 3.
Shoulder range of motion of involved limb, in degrees, by group (mean ± standard deviation). No significant difference between groups ($p > 0.05$).

Variable	Athletes (*n* = 5)	Nonathletes (*n* = 8)
Flexion	152.5 ± 11.0	146.9 ± 16.1
Extension	63.8 ± 15.9	65.9 ± 9.7
Abduction	149.0 ± 20.9	152.4 ± 15.7
External Rotation	86.2 ± 23.2	91.5 ± 12.6
Internal Rotation	53.5 ± 15.3	48.2 ± 10.4

Table 4.
Strength of involved upper limb, by groups, expressed as percentage of body weight, (mean ± standard deviation). No significant difference between groups ($p > 0.05$).

Variable	Athletes (*n* = 5)	Nonathletes (*n* = 8)
Shoulder Flexion	11.9 ± 6.7	15.5 ± 10.4
Shoulder Extension	11.5 ± 5.5	15.8 ± 8.1
Shoulder Abduction	9.7 ± 4.9	15.4 ± 12.2
Shoulder Adduction	15.5 ± 5.6	20.9 ± 12.1
Shoulder External Rotation	13.2 ± 6.2	14.0 ± 6.7
Shoulder Internal Rotation	12.9 ± 5.1	18.2 ± 10.5
Elbow Flexion	12.8 ± 8.9	22.4 ± 10.1
Elbow Extension	13.0 ± 6.8	20.7 ± 10.0

participating in weight lifting and in field events such as throwing games demonstrated greater strength values [27]. The current study did determine that individuals who reported a history of shoulder pain had longer duration since the onset of their disability and duration of wheelchair use. However, the study did not support this finding, in that no difference was found in the strength or range of motion measures of athletes compared to nonathletes. A potential bias and limitation of this study is the use of a convenience sample. Although not involved in athletics, the individuals who were willing to participate may have been more active and may not represent the population of nonathletic wheelchair users.

Current findings indicated that 29 percent of the sample reported current shoulder pain, with a total of 18 painful limbs. The clinical evaluation showed that bicipital tendonopathy was the most commonly occurring pathology (9/18) in this sample, with concomitant impingement in more than half of those individuals (5/9). Bayley et al. discovered that nearly 31 percent (29/94) of subjects with paraplegia had shoulder pain, and further investigation revealed that 23 (79%) had a diagnosis of impingement syndrome [2]. In contrast, Gellman et al. reported bicipital tendonitis as the most common pathology [3].

Impingement syndrome, especially when chronic, has been shown to involve the rotator cuff tendons and/or the long head of the biceps [23,24,28]. It is possible that the Neer impingement maneuver created contact of the supraspinatus and the long head of the biceps with the coracoacromial arch, resulting in a positive impingement test [29]. Without the use of a longitudinal study and further diagnostic measures, it is not possible to determine whether the impingement or the biceps tendinopathy was the primary pathology and which was secondary. Instability was found in 8 of 18 painful shoulders in the current study. Of the eight subjects with anterior instability, more than half also had a second positive finding (2 = biceps tendinopathy, 3 = positive impingement). It has been well documented that impingement and tendon inflammation can result from instability [29–32]. Interestingly, instability was also found in four nonpainful shoulders. The presence of instability may be an adaptation to the demands of manual wheelchair propulsion and activities and may allow these individuals to remain independent. However, impingement syndrome is known to be a secondary condition of instability, and these individuals may be at risk for developing further pathology [32]. Because evaluations were not performed on all subjects, the incidence of asymptomatic shoulder instability is not known.

Several researchers have stated that reaching overhead [5,6,26], transfers [4–6,26], and propelling a wheelchair [4–6,26] are the activities most associated with shoulder pain in the manual wheelchair population. The results of the current survey support these previous findings, with propulsion up an incline reported as painful by 78 percent of those subjects who had a history of shoulder pain. Future research would benefit from the use of a more detailed, validated survey in conjunction with comprehensive shoulder evaluations of both symptomatic and asymptomatic individuals.

CONCLUSIONS

Involvement in athletics neither increases nor decreases the risk of shoulder pain in the manual wheelchair population. Clinicians should therefore encourage and educate all MWCUs on the benefits of activity, including competitive sports. Activities most associated with shoulder pain include transfer, propulsion, and reaching overhead. Impingement syndrome, including involvement of the bicipital tendon, is the most commonly occurring pathology. Further research into shoulder function during various activities of daily living is needed for researchers to understand the mechanisms of these pathologies.

REFERENCES

1. National Health Interview Survey on Disability. Trends and differential use of assistive technology devices: United States, 1994–1999. 1999.
2. Bayley JC, Cochran TP, Sledge CB. The weight-bearing shoulder: The impingement syndrome in paraplegics. J Bone Joint Surg Am. 1987;69(5):676–78.
3. Gellman H, Sie I, Waters RL. Late complications of the weight-bearing upper extremity in the paraplegic patient. Clin Orthop. 1988;233:132–35.
4. Nichols PJ, Norman PA, Ennis JR. Wheelchair user's shoulder: Shoulder pain in patients with spinal cord lesions. Scand J Rehabil Med. 1979;11(1):29–32.
5. Curtis KA, Drysdale GA, Lanza RD, Kolber M, Vitolo RS, West R. Shoulder pain in wheelchair users with tetraplegia and paraplegia. Arch Phys Med Rehabil. 1999;80(4):453–57.
6. Pentland W, Twomey LT. The weight-bearing upper extremity in women with long-term paraplegia. Paraplegia. 1991;29:521–30.
7. Boninger ML, Towers JD, Cooper RA, Dicianno BE, Munin MC. Shoulder imaging abnormalities in individuals with paraplegia. J Rehabil Res Dev. 2001;38(4):401–8.
8. Campbell CC, Koris MJ. Etiologies of shoulder pain in cervical spinal cord injury. Clin Orthop. 1996(322):140–45.
9. Burnham RS, May L, Nelson E, Steadward R, Reid DC. Shoulder pain in wheelchair athletes. The role of muscle imbalance. Am J Sports Med. 1993;21(2):238–42.
10. Rodgers MM, Gayle GW, Figoni SF, Kobayashi M, Lieh J, Glaser RM. Biomechanics of wheelchair propulsion during fatigue. Arch Phys Med Rehabil. 1994;75:85–93.
11. Veeger HE, Meershoek LS, van der Woude LH, Langenhoff JM. Wrist motion in hand rim wheelchair propulsion. J Rehabil Res Dev. 1998;35(3):305–13.
12. Miyahara M, Sleivert GG, Gerrard DF. The relationship of strength and muscle balance to shoulder pain and impingement syndrome in elite quadriplegic wheelchair rugby players. Int J Sports Med. 1998;19(3):210–14.
13. Stotts KM. Health maintenance: Paraplegic athletes and nonathletes. Arch Phys Med Rehabil. 1986;67(2):109–14.
14. Keast D, Cameron K, Morton AR. Exercise and the immune response. Sports Med. 1988;5(4):248–67.
15. Shephard RJ. Benefits of sport and physical activity for the disabled: Implications for the individual and for society. Scand J Rehabil Med. 1991;23(2):51–59.
16. Curtis KA, Dillon DA. Survey of wheelchair athletic injuries: Common patterns and prevention. Paraplegia. 1985;23:170–75.
17. Wylie EJ, Chakera TM. Degenerative joint abnormalities in patients with paraplegia of duration greater than 20 years. Paraplegia. 1988;26(2):101–6.
18. Lal S. Premature degenerative shoulder changes in spinal cord injury patients. Spinal Cord. 1998;36(3):186–89.
19. Rosendal L, Langberg H, Skov-Jensen A, Kjaer M. Incidence of injury and physical performance adaptations during military training. Clin J Sport Med. 2003;13(3):157–63.
20. Thomee R, Renstrom P, Karlsson J, Grimby G. Patellofemoral pain syndrome in young women. I. A clinical analysis of alignment, pain parameters, common symptoms and functional activity level. Scand J Med Sci Sport. 1995;5(4):237–44.
21. Boublik M, Hawkins RJ. Clinical examination of the shoulder complex. J Orthop Sports Phys Ther. 1993;18(1):379–85.
22. Clarnette RG, Miniaci A. Clinical examination of the shoulder. Med Sci Sports Exerc. 1998;30(4 Suppl):S1–S6.
23. Neer CS. Impingement lesion. Clin Orthop. 1983:173:70–77.
24. Neer CS, Welsh PR. The shoulder in sports. Orthop Clin North Am. 1977;8:585–91.
25. Baker CL, Merkley MS. Clinical evaluation of the athlete's shoulder. J Ath Train. 2000;35(3):256–60.

26. Subbarao JV, Klopfstein J, Turpin R. Prevalence and impact of wrist and shoulder pain in patients with spinal cord injury. J Spinal Cord Med. 1995;18(1):9–13.
27. Kofsky PR, Davis GM, Shephard RJ, Jackson RW, Keene GC. Field testing: Assessment of physical fitness of disabled adults. Euro J Appl Physiol. 1983;51(1):109–20.
28. Gerber C, Terrier F, Ganz W. The role of the coracoid process in the chronic impingement syndrome. J Bone Joint Surg Br. 1985;67B(5):703–8.
29. Burns WC, 2nd, Whipple TL. Anatomic relationships in the shoulder impingement syndrome. Clin Orthop. 1993;294: 96–102.
30. Neviaser RJ, Neviaser TJ. Observations on impingement. Clin Orthop. 1990;254:60–63.
31. Warner JJ, Micheli LJ, Arslanian LE, Kennedy J, Kennedy R. Patterns of flexibility, laxity and strength in normal shoulders and shoulders with instability. Am J Sports Med. 1990;18(4):366–75.
32. Fu FH, Harner CD, Klein AH. Shoulder impingement syndrome: A critical review. Clin Orthop. 1991(269):162–73.

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