

Chapter Five

Overuse Syndrome of the Upper Limb in People With Spinal Cord Injury

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This chapter is addressed to the clinician reader; the person to whom the injured individual goes in order to complain of upper limb pain.

Numerous investigations and reports (1–12) have described the type and frequency of injuries among individuals with spinal cord injury in various sports (Table 1). The majority of these studies, however, are retrospective, involving either interviews or questionnaires. There has been no study published to date that looks exclusively at overuse injuries in these individuals, specifically those who use wheelchairs. Given the increased demands placed on the upper limb of sportspersons in wheelchairs, one would expect that overuse-type injuries would be a major problem.

This chapter reviews several overuse injuries of the upper limb that are frequently encountered. In addition to the diagnosis and treatment of each entity, the pathophysiology, as it relates to this population, will be described.

A GENERALIZED APPROACH TO OVERUSE INJURIES

Definition

Most sports-related injuries can be classified into one of two major types: acute macrotraumatic injuries, which are the result of a one-time inciting event, or chronic microtraumatic injuries, which occur over time

Table 1. Breakdown of 50 injuries reported by 19 elite wheelchair athletes over a 1-year period.

Type of Injury	N	%
Strain	24	48
Abrasion	11	22
Contusion	5	10
Blisters	3	6
Fracture	3	6
Sprain	2	4
Laceration	1	2
Illness	1	2

and are often secondary to repetitive motions. Injuries in the latter group (also referred to as overuse or overload injuries) account for up to 50 percent of all sports-related injuries (13).

Pathophysiology

Generally, a tissue's response to any type of injury is inflammation. This inflammatory state is the initial phase of healing, lasting approximately 1–4 days. With overuse injuries, the inflammatory process becomes self-perpetuating, leading to the destruction of other surrounding tissues (13).

As the consequence of repetitive microtraumatic tensile overload, overuse injuries eventually lead to a disruption of the tissue's ability to repair itself (14). This results in the formation of scar tissue in place of the proper tissue matrix (i.e., bone, tendon, muscle, or ligament), which results in a decreased total tissue function for sport activity (14). With continued use, in the face of these tissue alterations, the individual may eventually experience symptoms in the form of pain, weakness, or diminished performance. It is, therefore, imperative that during treatment, this chronic inflammatory process be minimized to ensure adequate and proper tissue healing.

Overuse injuries most commonly affect the musculotendinous unit resulting in tendinitis, tenosynovitis, and/or muscle soreness. Other tissues that can be involved include: bursae (bursitis), bone (stress fractures), nerve (compression neuropathies), and cartilage (i.e., radiohumeral articular injury).

Treatment and Rehabilitation

The treatment and rehabilitation of musculotendinous overuse injuries can be divided into four overlapping phases: (I) Inflammation and Pain Control; (II) Mobilization; (III) Strengthening; and (IV) Functional Restoration and Maintenance (15).

Phase I

Phase I is the initial stage of sport injury treatment. It incorporates measures that control both pain and inflammation while limiting further tissue damage. The PRICE (protection, relative rest, ice, compression, and elevation) protocol is commonly used and augmented with anti-inflammatory medications. Phase I usually lasts from 1 to 2 weeks, but can persist for up to 6 weeks.

Protection in the form of immobilization (i.e., casting and splinting) is seldom required for extended periods of time with overuse injuries. Ice is used frequently during the first 24–48 hours postinjury to decrease both pain and edema, while compression bandages and elevation of the injured area are used to minimize swelling. A variety of heating modalities (i.e., heating pads, ultrasound, and whirlpool baths) can be utilized in the subacute postinjury period (1–2 days) if inflammation has been properly controlled. Heat acts to diminish painful muscle spasms and increase blood flow to the area, enhancing the healing process. Alternating

ice and heat, known as contrast treatment, can also be used in the subacute phase.

Phase II

The mobilization phase of rehabilitation begins as soon as inflammation is controlled. The main goal of this phase is to regain and maintain normal range of motion of the injured body part. Prolonged immobilization of a joint will eventually lead to contracture formation and subsequent further deterioration in function.

Phase III

The strengthening phase of rehabilitation begins when from 80 to 85 percent painless range of motion is attained. It starts with isometric exercises and subsequently progresses to isotonic and isokinetic exercises as tolerated, making sure not to lose gains achieved with Phases I and II.

Phase IV

The functional restoration and maintenance phase of rehabilitation was often neglected in the past. It is the basis for today's sport-specific training in sports medicine and involves the practice and analysis of functional tasks that are similar to those used during sport activities (i.e., throwing or hitting a tennis ball), as well as correcting any biomechanical deficits that may occur during such activities. The main purpose of this phase is to reduce the likelihood of reinjury while attaining the previous level of function (15). Phase IV is initiated when the involved joint or muscle has attained from 80 to 90 percent of normal strength and painless range of motion as compared to the contralateral side.

SPECIFIC OVERUSE INJURIES IN WHEELCHAIR SPORTS

Shoulder

Shoulder pain is quite common in both persons with disabilities who participate in sports and the nondisabled in the same pursuits, but it is very often seen in persons in wheelchairs. The main reason for this increased prevalence stems from the fact that this population relies entirely on the upper limb for both ambulation and weight-bearing tasks. The shoulder is poorly designed for this purpose, and thus becomes exposed to higher interarticular pressures in conjunction

with a more abnormal distribution of stresses across the subacromial area.

The shoulder joint has a greater range of motion than any other joint in the body, which comes at the price of an inherent instability. The radius of curvature of the humeral head is three times that of the glenoid socket (16) and thus, unlike the hip joint, the shoulder relies on ligamentous and muscular components for its main constraints (i.e., rotator cuff). A person who depends exclusively on a wheelchair for ambulation is exposing his/her shoulder to increased stresses and muscular imbalances, predisposing it to a variety of overuse injuries. Participants in wheelchair sports, especially those involved in track events, marathon road racing, basketball, and tennis, subject their shoulders to even greater stresses, resulting in an even larger abundance of overuse problems.

As opposed to the lower limb in the nondisabled population, the upper limb in both sport and nonsport wheelchair users is the main weight-bearing limb.

Impingement Syndrome/Rotator Cuff Tendinitis

The impingement syndrome and rotator cuff tendinitis are related conditions that involve pain and associated inflammation of the subacromial bursae and/or rotator cuff tendon. They both result from a repeated encroachment of the humeral head into the coracoacromial arch due to repetitive shoulder motions; namely abduction and internal rotation, causing the supraspinatus tendon to become impinged. In both persons with disabilities and in the nondisabled, these ailments are commonly seen in those who perform repetitive overhead activities (i.e., tennis serving). In the player with disabilities, this problem is compounded by the weight-bearing status of the upper limb.

The rotator cuff muscles (i.e., supraspinatus, infraspinatus, teres minor, and subscapularis) act as humeral head depressors and stabilizers, allowing the deltoid to abduct, extend, and anteriorly elevate the humerus while maintaining the instant center of rotation of the glenohumeral joint (17). Chronic repetitive microtraumatic activities, such as a tennis serve, lead to increased glenohumeral instability, with a resultant increased demand on the rotator cuff muscles to maintain the center of rotation. If the rotator cuff muscles are inadequate, the humeral head migrates anteriorly and superiorly, leading to a dynamic outlet stenosis and impingement. With repeated exacerbating

motions, rotator cuff tendinitis develops and subsequently may lead to a tear without the appropriate interventions.

The biomechanics involved in the propulsion of a wheelchair add another dimension to overload of these tissues. During wheelchair propulsion, the shoulder is maintained at approximately 70° of abduction (18). At the onset of the propulsive phase of motion, the shoulder is extended and internally rotated, and subsequently ends up flexed and externally rotated at the onset of the recovery phase. Due to these biomechanics, sportspersons in wheelchairs often have well-developed shoulder flexors, internal rotators, and adductors, but may have poorly developed external rotators and thoracoscapular muscles. This muscular imbalance, plus the repetitive nature of the wheelchair push, predisposes the rotator cuff to impingement.

Burnham, et al. (19), found a 26 percent incidence of impingement syndrome in 19 sports participants with paraplegia (38 shoulders). Overall, the shoulders with this problem demonstrated significant weakness of internal and external rotation as compared to the uninvolved shoulders. These findings indicate that rotator cuff weakness, resulting in inadequate humeral head depression and stabilization during shoulder movement, may play a role in the development of rotator cuff impingement syndrome in the wheelchair sport population.

In another study by Bayley, et al., 23 of 94 nonathletic persons with paraplegia were found to have chronic impingement of the shoulder with concomitant subacromial bursitis (20). Shoulder arthrography of these 23 subjects revealed that 15 had progressed to rotator cuff tears. The investigators also placed pressure transducers into the subacromial space of five persons with paraplegia without shoulder pain and discovered that during weight-bearing activities (i.e., transfers), the pressure exceeded the mean arterial values by 2.5 times. These findings led the authors to conclude that the high pressures, in addition to the abnormal distribution of stresses transmitted across the subacromial area during transfers or propulsion of a wheelchair, contribute to the high rate of rotator cuff injury in persons with paraplegia (20). Although this study did not specifically target sports participants who are wheelchair users, one would expect a greater number of shoulder problems with this population since larger subacromial pressures and stresses can be anticipated during exercise.

Diagnosis

A complete history is required in order to adequately diagnose and treat any shoulder complaints. A detailed description of the pain should be included (i.e., sharp vs. dull, acute vs. chronic in onset, radiation, or the presence of night pain), which may indicate a rotator cuff tear. Any exacerbating activities should also be noted. Recent changes in technique or training regimen and any previous history of shoulder problems should also be determined. It is also helpful to have an adequate knowledge and understanding of the biomechanics of the individual's activities, especially those that seem to aggravate the condition.

A complete physical examination of the shoulder involves inspection, palpation, passive and active range of motion, neurological evaluation, stability testing, and any special tests or signs that are characteristic of specific entities (i.e., drop arm test for a rotator cuff tear).

Inspection of the shoulder can only be accomplished adequately with the patient's shirt removed. One strategy is to observe the person while the shirt is being doffed and to notice any discomfort or guarding in the process, especially with regard to overhead movements that would be consistent with the impingement syndrome or rotator cuff tendinitis. Disuse atrophy of the supraspinatus and infraspinatus (shoulder) muscles results in a prominent scapular spine and is common with chronic rotator cuff pathology. Tenderness at the rotator cuff insertion, easily exposed with passive extension of the shoulder, is consistent with rotator cuff tendinitis.

Passive range of motion should be carefully assessed, especially if the patient is unable to fully perform any of the active range of motion tests. One common method for evaluating active range of motion is the Apley scratch test, in which the subject is asked to touch the contralateral scapula from across the opposite shoulder (internal rotation and adduction), behind the neck (external rotation and abduction), and finally from the lower back (external rotation and adduction). Patients with rotator cuff pathology have difficulty performing the external rotation and abduction portion of this test. Persons with impingement syndrome or rotator cuff tendinitis may have pain with active or passive abduction in the arc between 60 to 120°. When the passive range of motion is greater than the active range of motion, a rotator cuff tear is often suspected.

There are several different impingement signs,

which decrease the subacromial space, resulting in a painful impingement of the supraspinatus tendon between the humeral head and the coracoacromial ligament. In the most well-known of these tests (as originally described by Neer and Welsh), the examiner internally rotates and flexes the arm, with the production of pain being considered a positive finding (21). Hawkins described another variation in which the arm is abducted to 90° and then internally rotated to its limit (22). The impingement injection test involves the placement of 10 ml of lidocaine into the subacromial space and if the impingement maneuvers become pain free, other causes of shoulder pain are less likely (23).

The drop arm test is used to evaluate the integrity of the rotator cuff, namely the supraspinatus muscle. The examiner abducts the arm and instructs the patient to slowly lower it or resist any applied downward resistance. A positive test is indicated by severe pain, inability to lower the arm slowly, or weakness with resistance, and is highly suggestive of a rotator cuff tear.

Diagnostic Tests

Radiographic evaluation of the impingement syndrome or rotator cuff tendinitis is usually not warranted unless a rotator cuff tear is suspected. Magnetic resonance imaging (MRI) and arthrography are the most common modalities used. MRI is more specific for partial tears, while arthrography is almost always positive in complete tears. The definitive diagnostic test for rotator cuff pathology, both acute and chronic, remains arthroscopy.

Treatment

The treatment and rehabilitation of impingement syndrome/rotator cuff tendinitis and the conservative management of rotator cuff tears are essentially the same, with the whole process divided into four overlapping phases as previously described. The main goals of Phase I are to decrease both pain and inflammation. Anti-inflammatory medications and ice are utilized during this phase of treatment. Ice can be applied for 20 minutes, 3 times a day, for from 1 to 2 days. Various heating modalities are added in several days if the inflammatory process is under control.

The individual is initially instructed to rest the involved shoulder by avoiding any movements that may aggravate the problem (i.e., overhead activity or internal rotation). In cases of severe discomfort, immobilization

with a sling can be utilized for several days, although this may be difficult with patients using wheelchairs, since they rely exclusively on their upper limbs for mobility and weight-bearing tasks. In order to avoid atrophy of the muscles distal to the injured shoulder, isometric exercises are instituted as early as can be tolerated. For example, the hand is exercised with a tennis ball or therapeutic putty while the wrist and elbow are contracted against the wall or the contralateral arm.

Phase II is begun when the pain and inflammation have been controlled; usually in from 1 to 3 weeks. The goal of this phase is to obtain and sustain full painless range of motion. Phase II lasts for about 2 weeks and involves gentle stretching, which is often combined with heat or ice. Stretching of the shoulder internal rotators, flexors, and adductors are emphasized, since these muscle groups are inherently tight in persons who use wheelchairs and also participate in sports. The abductors and internal rotators are stretched cautiously in order to avoid reaggravation, using the wall finger climbing technique and a door frame respectively.

Subacromial corticosteroid injections can be used in subjects not responding adequately to the initial anti-inflammatory treatments. These injections are used to optimize rehabilitation participation and progression and should never be used as a definitive treatment option alone.

Phase III, the strengthening phase of rehabilitation, begins when 80 to 85 percent of painless range of motion is attained. Strengthening of the humeral head depressors (i.e., the rotator cuff muscles) is emphasized, since this is most often the underlying deficiency. The subscapularis and infraspinatus/teres minor of the shoulder are isolated by performing resisted internal and external rotation exercises respectively with the arm held at the side. The resistance is initially static (isometric) and progressed to elastic bands tied to a support, usually a doorknob, as tolerated. The supraspinatus muscle is isolated for strengthening by abducting the arm to 90°, forward flexing the arm to 30°, and pointing the thumb down. The subject is instructed to slowly lower and elevate his/her arm initially without resistance and progressed to free weights or elastic bands as tolerated.

Phase IV, the functional restoration and maintenance phase, is begun when the affected shoulder has attained 80 to 90 percent of normal strength and full, painless range of motion; as compared to the other side. As mentioned earlier, this phase involves the practice of

functional tasks that are similar to those used during sports activities (i.e., serving a tennis ball).

A patient with a suspected rotator cuff tear who has failed to respond to conservative treatment should undergo an arthrogram or MRI in order to better characterize the injury. If a rotator cuff tear is indeed demonstrated, then surgical repair, with or without anterior acromioplasty, should be undertaken immediately, since the outcome is optimal if the procedure is performed within the first 3 weeks after injury (24).

After surgery, the patient's shoulder is immobilized in an abduction brace for 4–6 weeks and subsequently progressed through rehabilitation phases II–IV as tolerated. A total of 9–12 months of rehabilitation is usually required for full recovery after repair of a rotator cuff tear.

Bicipital Tendinitis

In the general population, bicipital tendinitis is secondary to an underlying impingement syndrome 90–95 percent of the time; whereas, isolated or primary bicipital tendinitis is rarely encountered (21). Although no study to date has specifically looked at the incidence of bicipital tendinitis in wheelchair users who participate in sports, one would suspect that this problem would be quite prevalent, given the high incidence of shoulder pathology in this population.

The biceps functions as both an elbow flexor and forearm supinator when the shoulder is stabilized, as well as a weak shoulder flexor. The long head of the biceps tendon originates from the superior portion of the glenoid fossa of the shoulder and traverses through the glenohumeral joint directly under the supraspinatus tendon. Several researchers theorize that the long head of the biceps also acts as a humeral head depressor similar to the rotator cuff (25). Because of the proximity to the rotator cuff tendon, the long head of the biceps tendon is susceptible to impingement between the humeral head inferiorly and the supraspinatus tendon and coracoacromial ligament superiorly.

Diagnosis

The patient with bicipital tendinitis complains of pain over the anterior aspect of the shoulder, usually radiating to either the anterior aspect of the arm or into the deltoid or base of the neck. It is often associated with activity and disappears when the arm is resting.

A complete physical examination of the shoulder should be performed as previously described. Tender-

ness to palpation in the bicipital groove of the elbow (between the greater and lesser tuberosities) is consistent with bicipital tendinitis, especially if the area of tenderness moves with both internal and external rotation. Specific impingement tests should also be performed.

Several different tests have been described for diagnosing biceps tendinitis. In Speed's test, the patient flexes the shoulder against resistance with the elbow extended and forearm supinated. This test is considered positive if there is pain in the bicipital groove (26). Yergason's sign is performed by having the patient supinate the forearm against resistance with the elbow flexed; with pain experienced in the bicipital groove representing a positive test (27).

Ultrasound and MRI have been shown to be very useful in the evaluation of the biceps tendon when the diagnosis is in question or the patient fails to respond to conservative treatment.

Treatment

Phase I of treatment is similar to all overuse syndromes, and involves decreasing pain and inflammation with the use of ice, nonsteroidal anti-inflammatory medication, and relative rest of the involved limb. Corticosteroid injection into the biceps sheath can be utilized as an adjunct to inflammatory control.

As the acute process resolves, Phase II is initiated. If the bicipital tendinitis is secondary to impingement syndrome, then the rehabilitation process is identical to that already described. If conservative care fails to resolve the problem in approximately 3 months, then MRI or arthroscopic evaluation should be considered to rule out a rotator cuff tear while further evaluating the biceps tendon. Surgical procedures for intractable bicipital tendinitis, either primary or secondary, range from debriding of the tendon with a subacromial decompression to biceps tenodesis (28).

Elbow

Overuse injuries involving structures in and around the elbow joint are often seen in sport populations. Throwing and racquet sport participants are more susceptible to this type of injury, with lateral epicondylitis being the most common entity seen. Other frequently encountered overuse injuries of the elbow region include: medial epicondylitis, entrapment of the ulnar nerve at the cubital tunnel (cubital tunnel syndrome), and entrapment of the median nerve by the

pronator teres muscle (pronator teres syndrome).

Several retrospective studies on injuries sustained by wheelchair sportspeople have noted the elbow to be a common source of complaint in this population (2–5,7,9,10). The elbow, like the shoulder, is exposed to greater stresses and strains in individuals who use wheelchairs and is thus predisposed to injury. In a study by Ferrara, et al., 17 percent of the 100 injuries reported by 87 wheelchair users participating in sports, involved the elbow, with the vast majority of these being the overuse type (7). One study reported that all wheelchair sportspeople over the age of 40 reported elbow overuse problems (6).

Lateral Epicondylitis

Lateral epicondylitis, or "tennis elbow" is an overuse injury which involves the extensors of the wrist at their origin. The extensor carpi radialis brevis tendon is always affected. In addition, extensor communis, extensor carpi radialis longus, and extensor carpi ulnaris tendon involvement is also seen occasionally. The etiology of this common diagnosis is a repetitive microtraumatic overloading injury of the tissue, resulting from concentric and eccentric extensor muscle activity during various rapid and stressful motions (29). The process is primarily degenerative, rather than inflammatory, and involves pathological changes within the tendon itself, not specifically the lateral epicondyle (30).

Tennis players develop lateral epicondylitis as the result of poor mechanics in both the overhead and backhand strokes as well as in off-center shots; each of which leads to either concentric or eccentric overloading of the wrist extensors at the elbow. Sports players using wheelchairs, especially marathoners and other racers, are especially vulnerable to the development of lateral epicondylitis. This is due to the repetitive forceful elbow extension, maximal pronation, and wrist flexion required for wheelchair propulsion, which can eventually result in eccentric overloading of the wrist extensors (31).

Diagnosis

The person with lateral epicondylitis presents with pain and tenderness over the forearm extensor mass and lateral epicondyle. Symptoms are exacerbated by forced extension of the wrist, especially with the elbow extended and forearm pronated. Gripping and passive wrist flexion may also produce pain in advanced cases.

Treatment

As previously discussed, Phase I deals with the control of pain and inflammation and utilizes rest, ice, elevation, and nonsteroidal anti-inflammatory medication, as well as a variety of heating modalities (if indicated). Rest rarely involves immobilization, but rather the elimination of the specific activities that cause or exacerbate the pain. The use of a forearm cuff or counterforce brace has been shown to constrain the extensor muscle groups, while maintaining forearm muscle balance, resulting in a decreased overload of the elbow tendons (30). The use of a cock-up splint, or even a cast, to decrease motion of the wrist extensors may be required for patients who are not responding to conservative treatment or who are noncompliant. Immobilization of the wrist in individuals who use wheelchairs may decrease their mobility and thus may require the short-term use of an electric wheelchair.

A variety of other modalities can be utilized in this phase, including electrical stimulation (high voltage), ultrasound, and iontophoresis of steroids or analgesics. The use of high voltage electrical stimulation for lateral epicondylitis early in the rehabilitation course has been shown to promote tissue healing, enhance local blood flow, and control pain.

Local corticosteroid injection may be considered when the above methods have failed to alleviate the pain and inflammation after a 3–4 week period. Injection of steroid directly into the tendon should be avoided, since this may lead to a rupture. Instead, it should be placed at the point of maximal tenderness, which is commonly distal to the tendon. After the injection, the subject avoids strenuous forearm activities for a period of 2 weeks. The injection may be repeated at a conservative rate, usually not more than every 3–4 months.

Phase II, the flexibility phase, is initiated in 1–2 weeks if pain and inflammation are controlled or the patient presents with a chronic injury. Patients with lateral epicondylitis often demonstrate inflexibility of the wrist flexors and forearm supinators. Deep-heating modalities (i.e., ultrasound) prior to passive stretching improve collagen extensibility, leading to a more efficient stretch.

When nearly full, pain free range of motion is attained, Phase III, the strengthening phase of rehabilitation, is initiated. Wrist extensors and flexors, as well as forearm pronators and supinators, are the muscle groups targeted. Isometric exercise of the wrist extensors and

flexors can be accomplished by gripping a tennis ball or therapeutic putty. Exercises are advanced to progressive resistance with the use of free weights or a wrist roll. Forearm pronators and supinators are strengthened with a weighted rod. Concentric/eccentric strengthening of all four muscle groups is accomplished with the use of resistive tubing. As with other overuse injury strengthening programs, resistance is added as tolerated. Failure to achieve adequate return of strength is the most common reason for treatment failure and/or recurrence.

The functional restoration and maintenance phase (Phase IV) is initiated when the targeted muscle groups have regained 80–90 percent of normal strength with painless range of motion. In order to prevent a recurrence of lateral epicondylitis, proper functional biomechanics and external risk factors must be addressed. For tennis players, correcting an improper backhand stroke or changing to the two-handed technique can decrease stresses on the lateral epicondyle. Racquet string tension should be no higher than 55 pounds, and the subject should be measured for the proper grip size by the Nirschl technique (32). This method measures the distance from the tip of the ring finger to a point on the proximal palmar crease in between the ring and middle fingers. The use of a counterforce brace can decrease lateral epicondylar stresses by a variety of proposed mechanisms (30,33) but should be at least one inch in width and positioned properly over the forearm.

For the wheelchair sportsperson, lateral epicondylitis can be prevented by finishing the push phase of propulsion with the forearm and wrist in neutral or slight supination, as opposed to the hyperpronation and ulnar deviation that is frequently utilized.

If symptoms remain despite a conservative treatment trial of 6 months to 1 year, surgical release and debridement of degenerated tissue may be required. Postoperatively, the elbow is protected with a splint for a period of 2 weeks. Rehabilitation from Phase II can be initiated at that time as tolerated. Full strength of the wrist extensors returns at an average of 4–5 months postoperatively (33).

Ulnar Neuropathy at the Elbow

The ulnar nerve is susceptible to chronic repetitive tension or traction stresses at the elbow, which may eventually lead to inflammation, adhesions, and a compressive neuropathy (33). Entrapment of the ulnar nerve at the elbow is the most common upper limb

nerve injury in the nondisabled sport population. It is most often seen in baseball pitchers, tennis players, javelin throwers, skiers, and weight lifters. In the wheelchair sportsperson, ulnar neuropathy at the elbow is second only to carpal tunnel syndrome in upper limb neuropathy incidence (34).

Burnham, et al. reported that 19.4 percent of 56 arms studied in 28 wheelchair athletes, had electrodiagnostic evidence of ulnar neuropathy at the elbow and proximal forearm (34). They concluded that entrapment of the ulnar nerve at the elbow and proximal forearm of wheelchair athletes usually occurs at the two heads of the flexor carpi ulnaris. The authors theorized that the heavy, repetitive contraction of this muscle, as is required by wheelchair athletes, leads to the ulnar nerve becoming damaged, entrapped, or both. Other possible etiologies of this syndrome in wheelchair sports include repetitive flexion and extension of the elbow, which increase pressure in the cubital tunnel, as well as prolonged pressure on the elbow and proximal forearm when resting against the wheelchair armrest.

Diagnosis

The patient with ulnar neuropathy at the forearm complains of pain and paresthesias down the medial aspect of the forearm and hand. Clinical findings include a positive Tinel's sign posterior to the medial epicondyle of the elbow or proximal forearm, intrinsic muscle weakness (advanced cases), decreased sensation in the fifth and medial aspect of the fourth fingers, and reproduction of symptoms with elbow flexion for up to 5 minutes. Nerve conduction velocity measurements, which show slowing across the elbow, are a very sensitive test for this syndrome: new techniques allow for precise localization of the entrapment (35).

Treatment

Conservative management of ulnar neuropathy at the elbow and proximal forearm includes protection with an elbow pad, avoidance of prolonged elbow flexion (nighttime extension splint), and anti-inflammatory medications. Exercises targeting elbow flexibility and forearm flexor strength are started as tolerated by the patient.

It is unlikely that neural compressive symptoms related to a repetitive activity will subside without a prolonged abstinence from that activity (36). It is, therefore, recommended that a patient who fails to respond to conservative management in 3–4 months or

has a progressive motor or sensory deficit, should be referred for surgical decompression and possible transposition of the nerve. An injection carefully placed in the perineural area is helpful prior to surgery as a means to predict operative success.

Wrist

The repetitive stress of wheelchair propulsion predisposes the wrists of individuals who use wheelchairs to a variety of overuse tendinitis injuries. These problems are magnified in wheelchair sportspersons, because of the larger forces required to generate the speeds needed, as well as the physical demands of their particular sport. Improper push techniques in which the wrists are in hyperflexion may eventually lead to wrist flexor tendinitis. This problem is especially prevalent in individuals with quadriplegia who lack the wrist extension required to oppose and control wrist flexion during this motion. In the person who participates in wheelchair racing, there may be a repetitive hyperpronation of the forearm during the end of the propulsion cycle, which may eventually lead to the development of specific wrist tendinitis entities as well as lateral epicondylitis, as already mentioned (37). Commonly injured wrist tendons in wheelchair users who participate in sports include: extensor digitorum longus, extensor carpi ulnaris, flexor carpi ulnaris, and abductor pollicis longus/extensor pollicis brevis (DeQuervain's tenosynovitis).

The etiology, symptomology, and treatment of the various wrist tendinitis overuse injuries are similar. For this reason, only De Quervain's tenosynovitis will be discussed in detail here, since it is the most common wrist overuse injury encountered in the wheelchair sportsperson and can thus be used as a model for the diagnosis and management of the other wrist tendinitis syndromes.

De Quervain's Tenosynovitis

De Quervain's tenosynovitis is an inflammatory process of the abductor pollicis longus and extensor pollicis brevis tendons as they traverse through the first dorsal compartment of the wrist. It is commonly encountered in persons participating in racquet and throwing sports that require repetitive radial and ulnar deviation. Participants in wheelchair races will often finish the push stroke with their wrists in ulnar deviation; this repetitive motion predisposes them to De Quervain's tenosynovitis.

Diagnosis

Subjects will complain of pain in the radial aspect of the wrist with aggravating activities. Clinical evaluation will reveal swelling, tenderness, and crepitus over the first extensor compartment at the radial styloid. Like all tendinitis syndromes, the pain increases with passive stretching of the involved tendon (ulnar deviation) and/or with contraction of the affected muscle(s) against resistance (abductor pollicis longus and extensor pollicis brevis). Diagnosis is confirmed with Finkelstein's test, in which there is pain when the wrist is passively deviated in the ulnar direction while the thumb is held adducted in the palm.

The differential diagnosis includes carpometacarpal degenerative joint disease, which is also prevalent in wheelchair sportspersons. A positive axial grind test of the thumb (i.e., with pain and crepitus) is consistent with this syndrome.

Treatment

Initial treatment for any tendinitis syndrome at the wrist involves avoiding any aggravating motions, immobilization in a splint as needed for comfort, nonsteroidal anti-inflammatory medications, ice, and heating modalities. In sport participants who are wheelchair users, alterations in the method of mobility may be required for short periods of time.

As the inflammatory process is controlled, range of motion and isometric strengthening exercises are begun, concentrating on the muscles involved (38). Concentric and eccentric isotonic exercises are added as tolerated. Corticosteroid injection can be utilized in patients failing to respond to the initial anti-inflammatory techniques after a period of 2 weeks.

Surgical decompression of the first extensor compartment should be considered in those failing to respond to conservative treatment within 4–6 weeks (including several corticosteroid injections), as well as participants with recurrent symptoms. Postoperatively, the patient may be placed in a thumb spica cast for 2 weeks, at which time gentle range of motion exercises are begun and continued for 2 additional weeks. Strengthening exercises are added at 2 weeks and progressed as tolerated. Full return to sport is generally possible usually by 1 month or when painless grip is obtained (39).

Hand

The hands of individuals who use wheelchairs, like

the wrists, are exposed to a variety of repetitive strains and stresses predisposing them to an assortment of soft-tissue disorders. Compression of the median nerve in the carpal tunnel (carpal tunnel syndrome) and the deep branch of the ulnar nerve in Guyon's canal have both been reported to occur frequently in wheelchair athletes (11,34).

Carpal Tunnel Syndrome

Carpal tunnel syndrome (CTS) is caused by a compression of the median nerve as it traverses the carpal tunnel. A variety of etiologies have been described, including: diabetes mellitus, pregnancy, hypothyroidism, rheumatoid arthritis, ganglion cysts, osteoarthritis, and flexor tendinitis. Wheelchair users with paraplegia have been reported to have an increased incidence as compared to the nondisabled population (40,41). One study (40) found that the carpal tunnel pressures of persons with paraplegia were significantly elevated in wrist extension as compared to individuals without paraplegia, whether or not either had clinically proven carpal tunnel syndrome. Another study demonstrated significant slowing of median nerve conduction velocities across the carpal tunnel immediately after the subjects propelled a wheelchair (42). Burnam and Steadward reported a 46 percent incidence of CTS by electrodiagnostic criteria in 28 sports participants who are wheelchair users, with a substantially lower number of these patients having clinical evidence of CTS (34).

The possible etiologies for CTS in the wheelchair user include repetitive extrinsic pressures over the carpal tunnel as well as frequent wrist extension posturing, both of which occur during wheelchair propulsion. A survey of wheelchair marathon racers revealed that most of them handle the push rims with their thumbs and thenar eminences initially, but when they tire they switch to their palms, placing more stress on the carpal tunnel (1). Repetitive strain and overuse of the wrist flexor tendons, which is commonly encountered in the wheelchair sportsperson, can lead to inflammation, which may encroach the median nerve in the carpal tunnel (34).

Diagnosis

Patients with CTS often complain of pain and paresthesias in the sensory distribution of the median nerve (i.e., hand and 3.5 radial digits) occurring initially at night. With progression, the complaints become more constant and occasionally radiate as high as the elbow

or shoulder. Weakness and atrophy of the thenar muscles may eventually occur, leading to the complaints of clumsiness and "dropping things."

Physical examination may reveal a positive Phalen's test and/or positive Tinel's sign. In the former, the patient is instructed to hold his/her palms together for one minute. Pain and numbness in the sensory distribution of the median nerve is considered a positive test. Tinel's sign, considered to be less sensitive than Phalen's test (43), is performed by percussing over the median nerve at the carpal tunnel with either a finger or reflex hammer. A positive test elicits pain and numbness in the sensory distribution of the median nerve.

The patient with CTS may also show decreased two-point discrimination in the median nerve innervated fingers. Thenar muscle weakness and atrophy can be demonstrated in more advanced cases.

Electrodiagnostic evaluation, both nerve conduction studies and EMG, are widely considered to be the definitive test for CTS. Median nerve conduction velocity slowing across the carpal tunnel and/or EMG signs of denervation of the thenar musculature are considered positive tests.

Treatment

For mild cases (i.e., intermittent symptoms), treatment is initially conservative. A volar splint, which holds the wrist in neutral, is worn at night and during inciting activities. The use of padded gloves has also been reported to be beneficial for wheelchair users when participating in sports. Nonsteroidal anti-inflammatory medications and corticosteroid injection into the carpal tunnel may also be utilized as an adjunct to treatment if wrist flexor tendinitis is the suspected cause of the median nerve entrapment.

In patients who respond favorably to conservative methods, a biomechanical analysis of wheelchair propulsion is required in order to address any possible reagravating motions or activities; such as, constant hyperextended wrist and repetitive pressure on the heel of the hand with each stroke.

If a patient does not respond to conservative measures for more than 4-6 weeks, or in patients with severe symptoms (i.e., marked nerve conduction slowing or progressive weakness), surgical consultation for transverse carpal ligament release should be considered. Postoperatively, return to wheelchair sporting activities is usually accomplished within 6 weeks.

CONCLUSION

Overuse injuries to the upper limbs of sportspersons who use wheelchairs appear to be very common. Both the incidence and prevalence of such injuries seem to be highest in wheelchair marathon racers, track and field athletes, tennis players, and basketball players. The two most commonly encountered entities are impingement syndrome/rotator cuff tendinitis and carpal tunnel syndrome, although a wide variety of other diagnoses do occur.

The treatment and rehabilitation of overuse injuries to the upper limbs of this population of wheelchair users can be difficult, since these individuals rely almost exclusively on their upper limbs for both mobility and weight-bearing tasks. Both consideration of physical findings and biomechanical errors or deficiencies must be addressed in order to ensure full recovery and/or prevent recurrence. By approaching these patients similarly to nondisabled competitors and incorporating a basic familiarity with the wheelchair sportsperson, however, the clinician can be better prepared to treat the disabled sports population.

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