0278-5919/95 $0.00 + .20

# PREVENTION AND REHABILITATION OF OVERUSE INJURIES OF THE ELBOW

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This article discusses an approach to prevention and rehabilitation of overuse injuries of the elbow. A physical therapy protocol that may be applied for medial or lateral epicondylitis is featured as a practical application of the theory discussed.

## TYPES OF INJURY

The elbow joint and surrounding structures are subject to a wide variety of injuries. Sports that involve throwing or striking an object with the hand involve large amounts of force created by coordinated muscle actions from the entire body, resulting in a high velocity motion at the distal end of the kinetic chain. Musculotendinous overload can occur if the structures surrounding the elbow are not adequately prepared to convert the force supplied by the proximal muscle groups into a controlled application of force. In addition, improper mechanics (especially during follow through) can create ligamentous, capsular, or bony injuries at the joint from inadequate absorption of energy.

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Contact sports involve loads that can result in bruising and contusions about the elbow. Falling or tackling can result in bony injuries to any part of the elbow. A skier clearing gates with his forearm, or a motocross racer landing after a jump are examples of activities that involve movement of the body at high speeds. These activities can be performed without injury, but when an accident throws the skier into the trees or the motocross racer onto the ground at 50 miles per hour, the types of injuries that can occur to the soft tissue as well as the bones are unlimited.

The term *overuse syndrome* is commonly used to describe an insidious inflammation of a structure as a result of repeated loading beyond its structural capacity.[1] Although any single episode of overloading may not require clinical attention, the combined effects of multiple episodes can result in an increasingly painful condition that significantly affects even basic function. Overuse injuries about the elbow can occur in many different populations, from preadolescent throwing athletes, to assembly line workers, to septuagenarian golfers. Technically, the treatment can be similar for many overuse syndromes,[5,7] but in order to best serve the patient it is important for the clinician to take into account many different factors, such as age, probable mechanism of injury, livelihood, financial considerations secondary to being injured, and expectations for return to activities.

An assembly line worker and a professional athlete may be equally at risk to suffer re-injury during the rehabilitative period because of impatience due to financial considerations. The clinician must try to determine if the personality of the patient will predispose him or her to failure during the rehabilitative process, owing to either a tendency to overwork or to ignore a structured program. Recognizing these possibilities at an early stage may help the clinician prevent problems with rehabilitation.

## PRINCIPLES OF REHABILITATION

The first priority of rehabilitation implies that the clinician should design a program to prevent further damage to the injured structures. Avoiding the offending activity through selective rest is initiated. Elbow injuries often require a splinting device to immobilize the area prior to starting a rehabilitation program. To prevent complications that are common with prolonged immobilization it is desirable to apply the least restrictive immobilization that will protect the injured structures during the inflammatory and healing phases. Specific types of splints are discussed elsewhere in this volume, but in general the clinician should understand:

1. The function of the injured structures.
2. The extent of the injury (amount of functional compromise).
3. Anticipated timetables for return to function.
4. Estimated degree of patient compliance.

With this knowledge the clinician will be able to choose the least restrictive bracing alternative that will still provide adequate protection for the involved structures.

### Ligament Versus Musculotendinous Versus Bony Injuries

Ligament injuries result from episodes of excessive joint motions. The aftermath of this type of injury will usually be some degree of laxity in the plane of motion that is normally controlled by a healthy ligament. Bracing requirements for acute or postsurgical ligament injuries include restriction of the affected plane of motion with restriction of other planes. An acute grade 1 hyperextension injury of the elbow does not require casting, but instead is treated by temporary use of a shoulder sling, with frequent passive range of motion (ROM) in all pain-free ranges (not to exceed full extension as compared with the opposite elbow). Most musculotendinous injuries can be treated similarly, that is to say with whatever rehabilitative measures are necessary to prevent further injury owing to active or resisted motions being performed before enough healing has taken place to support such muscle actions. In all cases it is necessary to have an understanding of the functions of the injured structures in order to protect from overload and re-injury.

## PHILOSOPHY OF RANGE OF MOTION EXERCISES

Once the injury has been stabilized and further damage prevented, the next priority is to restore functional motion as soon as possible. There is a general relationship between how quickly and vigorously one begins range of motion exercises and speed of return to function (Fig. 1).

If no work is done at all, there may be some improvement when the patient tries to return to normal activities, but this will be less than the possible improvement that the patient could attain. If the injured site is worked too forcefully, the patient will be worse off than if they had not worked at all. The challenge to the clinician and the patient is to strike the best balance between not enough and too much work, owing to the serious consequences of working too hard (i.e., heterotopic ossification).[9] The patient's return to a full range of motion should resemble a smooth undulating up slope (Fig. 2) rather than a jagged

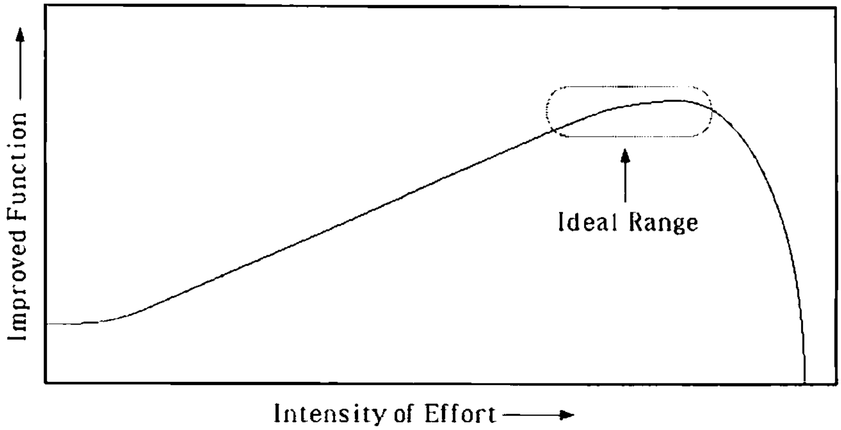


Figure 1. Intensity of effort as it relates to functional improvement.

saw blade, with each high point and subsequent loss of motion representing an episode of overwork (Fig. 3).

By using pain as a guide when performing ROM exercises, one can minimize the time lost and any unnecessary pain caused by pushing too forcefully with passive ROM (PROM). The authors teach the patient to relax during PROM exercises, because muscles surrounding the injured area will involuntarily contract in response to painful stimuli.[1] The therapist should begin having the patient move the elbow with small, controlled motions in a range of motion that is pain free. The range of motion should increase while the patient learns to relax muscles

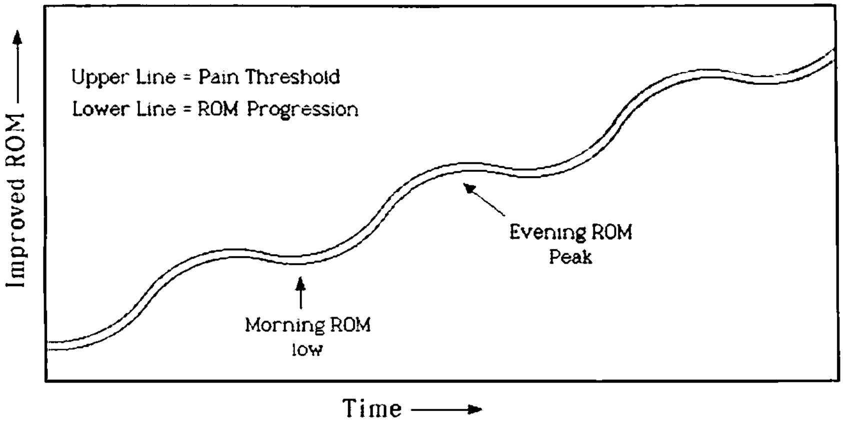


Figure 2. Normal range-of-motion progression.

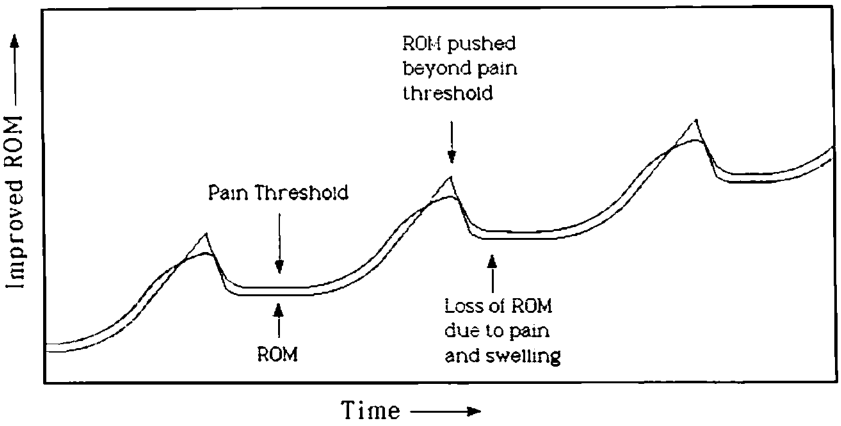


**Figure 3.** Range-of-motion progression impaired due to overwork.

surrounding the elbow. One should spend a greater proportion of the therapy session on painfree ROM with a patient who is apprehensive and tense. This method allows the patient to break the subconscious conditioning that tells the individual that motion equals pain. As long as the patient is unable to relax, motion *will* equal pain, but by combining instruction of conscious relaxation techniques with enough pain-free repetition to retrain the subconscious reflexes, lasting results will follow. The patient must be able to relax before real progress can be made, because there will be pain involved. A patient so trained will more closely approach the optimum pace of ROM improvement because they will consistently take their stretching to a true pain barrier (one that cannot be crossed without causing actual tissue damage).

## Types of Range of Motion Exercises

ROM exercises can be done in several different ways depending on the needs of the patient and the status of the tissues to be stretched. The first type of motion is PROM. This is done by keeping the affected body part as relaxed as possible while the part is being moved by an outside force. Whenever possible it is preferable to teach the patient to do PROM exercises independently (i.e., using the other hand). This allows the patient to do the exercises more consistently than if they must rely on someone else to assist them.

Active range of motion (AROM) usually begins once the patient has proven to be successful with a regimen of PROM exercises. During the AROM phase, the goal is to minimize the difference between the AROM limit and the PROM limit. AROM should be limited to painfree range. A terminal stretch at the end of each repetition is usually necessary to reach maximum ROM (Fig. 4).

## Limitations of Range of Motion

Sometimes it is necessary to limit a patient's ROM during the inflammatory and healing phases. Limitations may be imposed in one or more planes, and protected by use of fixed or removable casts, splints, or slings. The clinician should strive to use the least restrictive bracing option that will adequately protect the healing structures, while allowing and encouraging the patient to perform all nonlimited ROMs several times daily. Limitation of motion can lead to disuse atrophy of the proximal structures[5] and joint contractures.[8] In all cases, functional ROM is to be encouraged as soon as possible.

In some cases (particularly any individual with a history of arthrofibrosis) the use of continuous passive motion (CPM) can help the patient by allowing them to relax while being continuously moved through a safe range of motion. The increase in time spent moving versus time spent still, and the increase in total motion accomplished also may inhibit the formation of scar tissue,[8] and be beneficial for tendon healing.[6]

## Restoration of Functional Strength

The term *functional strength* is used to define the patient's ability to use their arm and hand for normal activities. Strength requirements vary

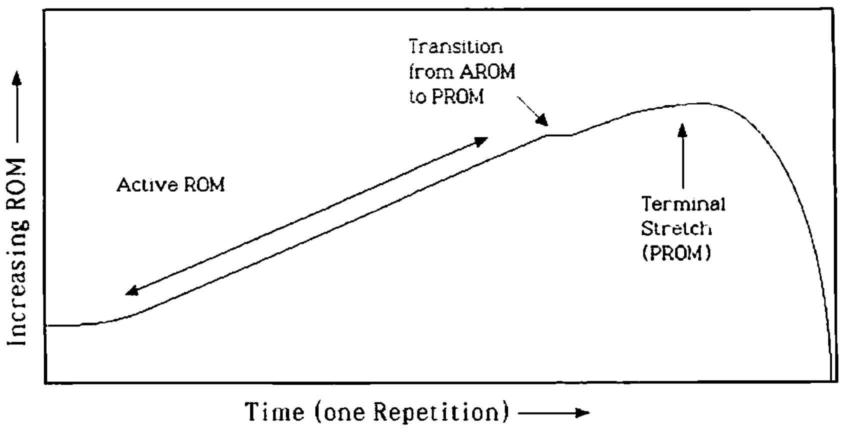


Figure 4. Single repetition of active range of motion with terminal stretch.

greatly, but professional rock climbers and armchair quarterbacks make the same progression from rest during the inflammatory phase, to range of motion exercises and strength training. This training should progress to a level of challenge that matches that of normal activities before the patient can be considered ready to return to skill-oriented training activities.

Returning to functional levels of strength requires each phase to be completed in a specific order to insure patient safety. Reactivation of the neuromuscular complex, progressive resistance exercises, and integration of skill training are all crucial to a full recovery, and should be approached in the manner discussed in the next section.

## Neuromuscular Reactivation Complex

Patients who have had injuries or surgeries not involving complete tears of a muscle or tendon can usually begin isometric (without motion) muscle activation very early in the rehabilitation progression. In cases in which the musculotendinous complex is not at risk, gentle isometric contractions can be done immediately if there is no pain or resultant increase in swelling to the affected area.

Patients at risk should wait the appropriate time as determined by the clinician, and only then begin with slow, gentle muscle contractions. These contractions can be done isometrically by applying gentle pressure against a brace (if one is used), or, in the case of nonlimited ROM patients, gentle AROM will suffice for initial muscle activation. Fewer problems with muscle atrophy, impaired neuromuscular response, and prolonged reeducation time will arise if the patient is encouraged to use their muscles in a safe manner. In addition to simple reactivation of single muscles, AROM exercises will retrain the proper agonist/antagonist group actions for the motions performed. Early establishment of these functions in all planes of motion will help coordinate muscle group actions when outside resistance is applied.

## Progressive Resistance Exercises

When active range of motion (AROM) exercises cease to be a challenge, the patient should progress to exercises that challenge the abilities of the involved structures without overstressing them. It is important to teach the patient to exercise the affected structures with progressively increasing intensity on a daily or twice daily basis. Instructions should be given to avoid progressing to the point of creating pain.

In the case of elbow, forearm, and wrist injuries it is usually prudent to begin resistance exercises with single plane and single joint exercises to ensure maximum safety. It is easier to keep individual exercise motions under control when the segments both proximal and distal to the one being exercised are held in a static position. Isolating wrist motions can be easily done by holding the forearm on the thigh while in a seated position (Fig. 5).

Once the patient has achieved proficiency with single plane and single joint exercises, the next step is to introduce multiplane and multijoint exercises that more closely approximate normal function. The patient should do straightforward, easily repeatable exercises on a daily basis for their home program. More complicated exercises that require skilled assistance (such as proprioceptive neuromuscular facilitation techniques) should be saved for clinical appointments with a trainer or therapist.

Exercise programs should start with simple movements and increase in complexity to prepare the individual for return to their livelihood and sporting activities. For maximum effectiveness, programs must include emphasis on both concentric and eccentric muscular control. Concentric muscle contractions (which bring the origin and insertion closer together) are emphasized in isotonic and isokinetic strengthening programs, but proficient control of eccentric (lengthening) contractions is an often overlooked aspect of strengthening programs. Eccentric control is necessary for integration of skill in the rehabilitative process. Muscles are capable of handling greater loads eccentrically than under static or concentric loads.[3] Introduction to activity that could create a

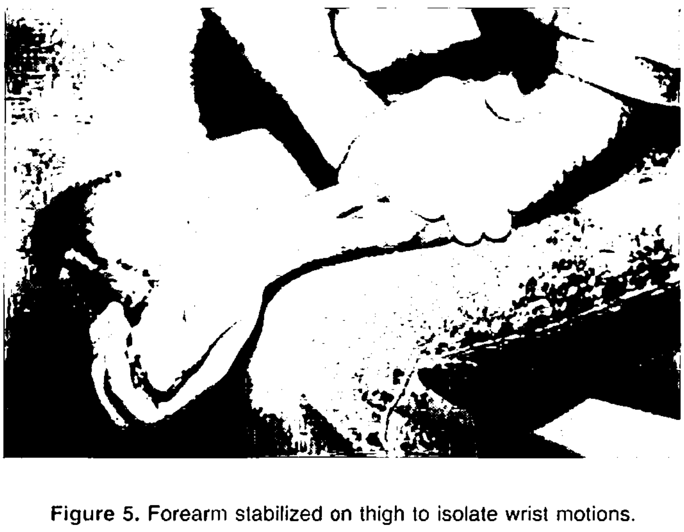

Figure 5. Forearm stabilized on thigh to isolate wrist motions.

condition of eccentric overload before adequate training has occurred may cause injury that might have otherwise been avoided.

There are many methods available to train specific muscle actions. Muscles may be trained in a concentric or eccentric manner. The most precise method of obtaining objective test information employs the use of isokinetic equipment that has eccentric capability. Although these computerized machines can give very detailed testing information, reliance upon them for training has definite drawbacks. The cost of the machines limits access to the relatively few clinics that can afford them. To achieve maximum reliability of test information, the machines are often limited to single joint and single plane exercises that do not fully prepare a patient for return to activity.

A knowledgeable therapist can provide manual resistance to train distal upper extremity motion and strength in any plane or combination of planes of motion. A training session can consist of concentric contractions, eccentric contractions, or any combination of techniques during the same exercise set. Certain manual resistance exercises can be done by the patient without skilled assistance, and should be taught during the early phases of strength training, but these techniques cannot be relied upon to restore full strength and function. Manual muscle testing is not as accurate or precise as isokinetic testing for objective measurement of strength, but as a training method manual resistance exercise is unmatched in terms of versatility. The need for skilled assistance with late-phase workouts puts limits on this type of training in terms of patient convenience and potential cost of prolonged treatment.

A third option is to use commonly available weightlifting equipment. Eccentric contracting can be trained by providing assistance through the concentric phase of the lift (because the weight is too much for the patient to manage alone). The patient is then permitted to handle the eccentric phase alone (with proper spotting for safety). This method is a common body-building technique that many athletic patients may have had previous exposure to, and when limited to the distal upper extremity this technique often can be accomplished by the patient alone assisting with the uninvolved arm. Drawbacks with weight training include the potential risks inherent with elevation of weight to create resistance (Does the patient who needs assistance have adequate safety mechanisms available? What happens if there is a need to reduce the load *immediately*?). In order to train motions more realistically, there is also the need for access to cable and pulley machines, to create resistance in planes not limited to the vertical pull of gravity. Becoming reliant on machinery limits the patient's options for time and location of exercises, and potentially increases the cost of rehabilitation. All of these factors can have a negative effect on training program compliance.

One of the best combinations of versatility, convenience, and low cost is elastic resistance training. This kind of training provides resistance in nearly all planes of motion, and it emphasizes concentric and eccentric control. Resistance is completely controllable by the patient and can be safely reduced on an immediate basis. The equipment is portable and low in cost, and well suited to home program use. These factors provide the patient optimum convenience when scheduling exercise sessions, thus enhancing compliance. With proper initial instruction and availability of follow-up instruction, elastic resistance devices function very well as the mainstay of nearly any patient's home strengthening program. The authors use the Body Lines Resistance System (Innovation Sports, Irvine, CA, 714-859-4407).

During the strength phase of rehabilitation the patient can make consistent progress can be made with a daily home program of exercises, using clinic visits to monitor the patient and advance the program when he or she is ready. The clinician may choose to employ any combination of the strength training methods discussed to achieve the goals of the individual patient.

## Integration of Skill Training

Although strength training concentrates on regaining the ability to apply force, attention also should be directed toward relearning the skills necessary for force application to be useful. Functional limitations and basic skill requirements determine how complex a program is needed, but in general, all programs should address potential deficits in proprioceptive abilities and hand-eye coordination.

Basic proprioceptive deficits can be detected and addressed by observation and instruction during strength training. The patient should be able to move smoothly through all useful ranges of motion during both concentric and eccentric contractions. The patient should pay close attention while doing strength exercise repetitions slowly (no faster than one full repetition per two seconds). Once control has been established, removing visual cues by having the patient close their eyes while performing exercise under supervision (with verbal cues as needed) can also be a helpful technique for improving proprioceptive abilities.

Hand-eye coordination is another skill that should be addressed prior to return to sport. These skills return quite naturally for most, but patients should prepare for return to their normal activities by practicing versions of those activities that have been modified to reduce the chance of re-injury. It is in this area that strength and skill training overlap. Carpenters should start with a light hammer for short periods of time and progress incrementally towards what will be normal for them. Baseball coaches should begin with painfree throwing and catching of a tennis ball before progressing to longer distances and a real baseball. These types of activities incorporate the plyometric and ballistic work done in late stage strength training into useful activities.

In every case care should be taken to insure that patients do not reinforce bad habits that might lead to reinjury. Rehabilitation from injury offers time for mechanical re-evaluation that might not otherwise take place. The clinician should work closely with the athletic trainer, physical therapist, and coach (as applicable) to help avoid recurrence of injury.

## INJURY PREVENTION

Common medical conditions, such as tennis elbow (lateral epicondylitis), golfer's elbow (medial epicondylitis), and student's elbow (olecranon bursitis) all place the elbow at risk. In many cases the possibility of developing a condition such as this is not considered until it has actually happened. Potential for injury can be recognized and action taken to prevent overuse or traumatic injuries from occurring in both sport and the workplace.

Equipment designed to prevent elbow injury can be as obvious as elbow padding on a mountain bicycle downhill racer, or as subtle as wrist rest pads for a laptop computer. In each case there is a recognized risk, and action has been taken to reduce the potential for injury. There is no way to anticipate or prevent every potential injury, but using available safety equipment, along with proper preparation and conditioning can reduce the incidence of nonaccidental injuries both in the workplace and on the playing field.

Conditioning to prevent injuries should follow the same progression as rehabilitation from injury. The same physical attributes (flexibility, strength, and coordination) need to be addressed, but the timetable for progression is not limited by considerations of tissue healing of injured structures. Below is the description of the typical program that we use for rehabilitation and prevention of medial and lateral epicondylitis, incorporating the principles discussed.

### Treatment: Medial/Lateral Epicondylitis Protocol

*Note:* To make this program specific for conditioning (prevention of injury), eliminate priority 1, and advance through priorities 2 to 4 on an "as needed" or "as tolerated" basis.

*Priorities*

1. *Reduce inflammation.* Eliminate activities that reproduce symptoms. Apply anti-inflammatory modalities (if limited to home program, instruct the patient in cross-friction ice cup massage technique, to be done for 3 minutes at a time, several times daily). Start the patient on an appropriate dosage of anti-inflammatory medication.
2. *Normalize pain-free ROM.* Patients with high levels of pain may need to begin with shoulder pendulum exercises (Fig. 6). As soon as this much motion is comfortable, add specific elbow ROM exercises, including extension (Fig. 7) and flexion (Fig. 8), forearm pronation (Fig. 9) and supination (Fig. 10), and wrist flexion (Fig. 11) and extension (Fig. 12). These should all be done as slow AROM, with a passive terminal stretch held for at least

Figure 6. Shoulder pendulum exercise.

Figure 7. Elbow extension.

Figure 8. Elbow flexion.

**Figure 9.** Forearm pronation.

Figure 10. Forearm supination.

5 seconds each repetition (see Fig. 4). Exercises should be done 3 times daily, working toward 2 sets of up to 20 repetitions in each plane. The goal of this phase is to reach a full, painfree ROM as compared to the noninvolved side. During this time we encourage the patient to remain as active as possible by doing exercises and activities that need not involve the arm. This will allow the patient to maintain their level of overall fitness and speed their return to normal activities.

3. *Begin strengthening.* When the individual has a full pain-free ROM, begin resisted exercises. Elbow flexion and extension, forearm pronation and supination, and wrist flexion and extension are done 1 to 2 times daily, working towards 2 sets of at least 15 repetitions. The authors instruct the patient to do these independently using elastic resistance. Grip strength is also addressed at this time. Symptomatic patients will start with a soft "nerf" ball,

Figure 11. Wrist flexion.

and work up to thera-putty and racquetball squeezes performed 3 to 5 times daily, working up to 50 repetitions. During the first several weeks we keep the work at a subfatigue level. The authors try to determine the maximum workload that the patient can sustain without replicating symptoms or creating muscular fatigue during or after the exercise, and work at that level every day. In the absence of symptoms, the intensity of exercise can be increased after 4 to 8 weeks (when motor unit recruitment is essentially complete[2]) to a level that fatigues the muscles, thus requiring a day or two off for recovery. If this exercise is started too quickly, symptoms may reappear, thus slowing progress. If the patient is unable to make progress during this phase, the physician may decide that a corticosteroid injection is warranted. If this has been done and progress is still not forthcoming, surgical intervention may be necessary.

Figure 12. Wrist extension.

4. *Return to function.* As the patient regains strength to approximately 80% of the noninvolved side without symptoms, they begin retraining the skills that will be necessary for return to function. For example, tennis players can hit for short periods of time, but keeping score is forbidden. All work is done at a level low enough to prevent recurrence of symptoms. Patients prone to reinjury should keep a training diary that details what work they have been able to do successfully (without pain during or after), and they should not to attempt to increase their work volume or intensity by over 5% per day.

## SUMMARY

Rehabilitation from injury and prevention of injury are terms that describe differing aspects of the same challenge. The clinician must be continually aware of the principles of rehabilitation and their order of priority (prevent further damage, restore motion, restore strength, reestablish coordination) while supervising patients' progress toward their goals. If patients are made aware of these principles at an early stage, and taught to take as much responsibility as possible for their own rehabilitative course, they will be more likely to reach their own ideal compromise of safety and speed of progress. In addition to helping with rehabilitation from injury, knowledge and self-awareness that patients obtain during this process may help in the prevention of future injuries.

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