Upper extremity disorders in performing artists

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ABSTRACT: *Studies in the past decade have shown that a significant proportion of instrumentalists report musculoskeletal problems severely affecting their musical performance. Musicians endure daily intensive use of their upper extremities, frequently placing them in bizarre positions. Their training schedules are rigorous and long term Predisposing factors to, and treatment for, overuse syndromes, tendinitis, and tendon trauma commonly encountered by musical performers are discussed at length. Nerve entrapment has also surfaced as a major problem in musicians, and the means of evaluation and treatment and the role of surgery are put forth. Techniques for studying and analyzing the difficulties faced by instrumentalists are summarized.*

Performing arts medicine is a distinct subset of occupational medicine. Its direct applications to upper extremity disorders of performing artists stem from approximately two decades of experience in dealing with special problems of athletes in sports medicine. Musicians, due to the nature of their vocation, present with an array of specialized problems. As a result of developing and maintaining a musical career, performers endure daily intensive use of their upper extremities, often placing them in bizarre positions. Performers frequently bear the weight of instruments on both hands with intense repetitive use of fingers, wrists, elbows, and shoulders. Speed and accuracy are of the essence. There is a strong element of competitiveness and an extraordinarily high demand on them.

While many sports careers end when athletes are in their late thirties or early forties, a musical career usually spans a lifetime of 70 or 80 years. Historically, musicians have been extremely misunderstood; for the most part, this is still true, but it is changing. Musicians frequently present to the uninitiated health care provider with a "mild injury." These mild injuries, however, may be potentially career-ending to the performer. A performer's skills are rarely transferrable to other fields, which may result in anxiety and depression. As opposed to many other occupational injuries, there is no secondary gain and these patients are fiercely driven to return to work. Litigation, workers' compensation, and malingering are rare in this group. Training schedules are rigorous and long-term, and there is a continuously increasing neuromuscular learning curve in this

setting. Even a mild injury can set musicians off from most of their repertoire.

Historically, there has been a lack of communication between the musician and physician. Frequently, the difficulty is simple jargon. Physical findings may be sparse and easily missed by the physician, especially those without a musical background. There is a need to watch musicians play, as symptoms may appear only during a performance. Even slight neuromuscular weaknesses can render finger joints unstable. Technical idiosyncracies can confound the evaluation of dystonia, compressive neuropathy, or overuse syndrome. There have been misconceptions on the part of the medical community that musicians are overemotional and that many of the presenting symptoms are psychosomatic. As more is learned, many problems are coming into sharper focus, and appropriate diagnosis and treatment are more frequently made today.

To date, relatively few epidemiologic studies have been conducted on this group of patients. The work has been primarily retrospective and descriptive, and little analytical work has been done to delineate problems. This too, however, is slowly changing. In 1988, Manchester[1] examined 246 university students and found 8.5 episodes of performance-related pain per 100 musicians. The male to female ratio was 2:1, and the keyboard/string to woodwind/brass ratio was 3:1. Tendinitis was seen in 16%. Overuse was seen in 50%. Seventy-one had an identifiable cause of performance-related pain, including increased playing time and changes in techniques and repertoire. Stress was a vital factor as problems increased close to recital times, in early fall at the beginning of the semester, and in late spring close to performance evaluations. These maladies occurred primarily in the 25- to 35-year-old age range, with hand and wrist problems encompassing 41% of the problems; neck, 38%; shoulder, 35%; forearm, 11%; and elbow, 10%.

In 1986, Martin Fishbein[2] surveyed 4,025 musicians. The response rate was 55%. Fifty-eight of the respondents reported musculoskeletal problems severely affecting performance, females more frequently than males. String players experienced greater difficulties than woodwind or brass. Of 1,378 string players, 10% had hand problems, primarily in the left hand. Wrist, forearm, and elbow problem distribution, however, was equal between left and right.

There is increased incidence of neck and shoulder problems in violinists and violists compared with cello and bass players. Seventy-five percent of pianists experienced right hand problems, while 34% had bilateral problems. Seventy-five percent of string instrumentalists had left hand problems, while 13% of flute and plucking instrumentalists experienced bilateral problems. Seventy-nine percent of woodwind instrumentalists had problems due to direct pressure on the right thumb. Forty-eight percent had entrapment neuropathy, 27% had overuse injury, and 15% had movement disorder.

Overuse syndromes

In 1992, Bengston and Schutt[3] reviewed a retrospective series of 73 musicians and found musicians' most common presenting diagnoses were overuse syndrome, tendinitis, focal dystonia, and nerve entrapment. This review will focus on overuse syndrome, tendinitis, and nerve entrapment in the upper extremities.

Lederman[4] described overuse syndrome as a constellation of symptoms associated with activity that exceeds the tissue's biological limits and leads to motor dysfunction. The most common symptoms are pain, weakness, tingling, fatigue, stiffness, and decreased dexterity.

Three concepts have been proposed to explain the cause of musculotendinous overuse. The first, advanced by Fry,[5] involves injury to muscles, tendons, ligaments, and joint capsules, and tendon sheath inflammation. Lederman[4] advocated the concept of injury to the musculotendinous junction secondary to overstretching of contracting muscles, known as eccentric contraction. Hochberg[6] advocated actual inflammation of the tenosynovium. The true nature of the pathology remains obscure as no pathologic dissection of the upper extremities has yet been done on musicians. What is known regarding overuse syndromes is that there is glycogen depletion in muscle, degeneration in muscle fiber, and edema. There is a relative increase in type I muscle fibers and a decrease in type II muscle fibers. Maximal voluntary contraction is diminished.[7]

A muscle is able to produce maximal work through its contraction when beginning at its resting length.[8] Furthermore, as one increases preload on a given muscle by exerting an external stretch, work capacity of the muscle decreases while potential for fatigue and eventual failure increases. Failure of muscle tendon units as a result of overuse usually can be detected at the musculotendinous junction.[9] Chronic submaximal stress may cause microtears at this junction, evoking a painful inflammatory response.

Predisposing factors include intrinsic and extrinsic phenomena. Intrinsic factors include the performer's physical strength, flexibility, size, anatomic variations, performing level, and playing style. For example, a long neck may present problems for violinists and violists. Small hands may get injured handling large instruments or playing pieces by Rachmaninoff, Paganini, Brahms, or Liszt. Many of these works were written for performers with large hands and hyperextensible joints. Hyperextensible joints, however, may be a problem since increased muscular effort is required to stabilize the distal joints of the hand, and this may cause musculotendinous overuse.

Extrinsic factors, such as time and intensity of playing or size and shape of the instrument, may affect the distribution of work load to the muscle groups involved. A sudden increase in practice time and intensity may stress and diffusely increase muscle tone. There may be a sudden change in technique, teacher, or instrument. Poor practice technique is also a culprit. Excessive repetition to master particularly difficult passages in a long program or continuous repetition of an entire program to learn the whole piece at once may be disastrous. A sudden change in repertoire—such as when a musician accustomed to the closed finger position of Mozart is suddenly confronted with the wide finger stretches of Brahms or Liszt—may also be detrimental. Music students may be misled into believing a

world-class career awaits them if they practice, when this may not be the case.

Tendinitis, tendon trauma, and overuse injuries

Tendinitis is a misused and overused term that does not truly point to an underlying pathologic condition. In the past, this constellation of problems has been called tenovaginitis, peritendinitis, tenosynovitis, intersection syndrome, deQuervain's syndrome, trigger finger, epicondylitis, rotator cuff impingement, repetitive strain disorder, cumulative trauma disorder, and tendon overuse injuries. These eponyms confuse patients and health care providers. Recent anatomic and pathologic studies classify this general condition into various subtypes:[10]

1. **Peritendinitis** describes an inflammation of the epitenon (outer layer of the tendon and its investing synovial sheath). The tissues present with local swelling, pain, crepitation, warmth, or generalized dysfunction.
2. **Peritendinitis with tendinosis** adds intratendonous degeneration with loss of collagen fiber orientation, scattered vascular ingrowth without obvious tendon inflammation, and tendon nodules.
3. **Tendinosis** describes intratendonous degeneration due to aging of microtrauma. It is noninflammatory and may present with nodule formation. This represents a loss of normal collagen fiber orientation and increased cellularity. This is also noted as mucoid degeneration.
4. **Tendinitis** is symptomatic tendon degeneration with an inflammatory response. This may be acute, subacute, or chronic, and can superimpose underlying tendinosis.

In any given situation, several processes may be operating at once. Patients present symptoms of focal pain, snapping, popping, swelling, tenderness, diminished dexterity, and occasional erythema. Initially, symptoms are mild and usually ignored. Symptoms may appear only during execution of specific techniques, such as seen in pianists playing octaves, chords, trills, and arpeggios. These involve wide finger stretches or chronic repetitive activity. Violinists or violists playing in higher positions require long finger stretches, chronic repetitive finger movement with the wrist in maximal flexion, supination, and ulnar deviation. Vibrato accentuates the problem. Symptoms frequently begin in the dorsum of the wrist and forearm, the origin of the extensor carpi radialis brevis at the lateral epicondyle of the humerus (tennis elbow), and the first dorsal extensor compartment known as deQuervain's syndrome.

Dorothy Taubman[11] described a scenario in pianists in which digital extensors may be affected because the hand is too close to the keyboard, necessitating metacarpophalangeal hyperextension with each finger stroke, which causes fatigue most commonly in the ring finger. On the flexor surface, digital flexors peritendinitis and tendinosis may cause painful digital or thumb triggering, although poor conditioning in athletes has been mentioned as a factor in tendon injury. In athletes, there are no objective criteria; the condition is probably multifactorial, having much to do with underlying tendon composition and duration and intensity of overload.

In 1986, Fry graded symptoms in five stages:[12]

- **Stage 1.** Pain at one site that is induced by playing and ceases after stopping
- **Stage 2.** Pain induced by playing, associated with weakness and loss of control
- **Stage 3.** Pain persisting after playing and induced by other activities
- **Stage 4.** Pain with activities of daily living
- **Stage 5.** Severe pain with no function

Performing artists may find themselves canceling performances, shortening practice times, and exhibiting serious deterioration in the ability to play. In many instances this problem may be self-limiting, but a significant number of days, months, or even years may pass before the musician seeks help. By this time, the patient is in deep despair.

Treatment of overuse injuries

As indicated by Fry[12] in 1986, treatment includes rest from all activities that initiate or perpetuate pain. This may include reducing the playing schedule and modifying harmful practice and performance techniques. The amount and quantity of rest may relate to the severity of symptoms. Initially, rest may include a short period of splinting, systemic or topical anti-inflammatories, and physical therapy that may emphasize thermal modalities, heat or ice, or iontophoresis. A program of stretching and strengthening exercises should begin very gently and slowly. Gentle passive, active, and active-assist range of motion exercises should slowly progress to resistive exercises. In selected refractory cases, local cortisone injection may be indicated. Rarely, surgery may be required. Modifications to activities of daily living are helpful. Some activities unrelated to performance perpetuate symptoms. A common aspect of physical training is the performance of specific exercises to stretch out the muscle-tendon complexes most involved in a given activity.

The efficacy of a muscle-stretching regimen to prevent injury and increase efficiency of performance has been well demonstrated by athletes.[13] The same is undoubtedly true for musicians. Stretching increases muscle flexibility, maintains range of motion, and increases the strength of the musculotendinous unit, permitting it to more efficiently store energy and contract. It is critical to return to playing slowly. Early overuse can be detrimental physically and psychologically and may ultimately delay return to full performance.

It has been well shown in the laboratory that immobilization deconditions muscles, tendons, and ligaments. Human muscle biopsy studies show that type I muscle fibers atrophy with immobilization.[14] Their cross section decreases, and the potential for oxidative enzyme activity is reduced. Aerobic capacity of the muscle fibers rapidly decreases, primarily in fiber types affected by the chosen sport. For example, type I (slow twitch) fibers are affected in marathon runners, while type II (fast twitch) fibers are affected in athletes engaged in activities that require speed.[15] The same is true for performing artists.

A progressive program of stretching, strengthening, and conditioning is initiated. Prior to muscular exercise, pre-stretching increases efficiency and work capacity of the contractile components of skeletal muscle. Heat also causes greater enzymatic activity and less metabolism, increasing the efficiency of muscle contraction. There is also an increase in collagen elasticity and the force production capacity of muscle. Essentially, this is the basis of the warm-up.

Many programs have been proposed for return to playing. For example, in 1991, Richard Norris recommended starting with slow, easy pieces and gradually progressing to faster, more difficult ones. Some musicians start with two 5-minute intervals separated by a 60-minute rest interval, progressing over a period of 30 to 70 days to a maximum of 50 minutes of playing with a minimum of 10 minutes rest in between. Others start with 2 minutes per day for two days, accelerating to 3 minutes daily up to 25 minutes with 5-minute breaks. The common denominator is the onset of a rest period at the first sign of fatigue. Many high-pressure professionals are unable to initiate complete rest for a period of 12 weeks as recommended. They may start with two weeks of complete rest and then a graded return.[16]

Close attention must be given to instrument design and the elimination of maladaptive playing styles. This must be done under the auspices of an experienced music instructor. For example, Dorothy Taubman[11] observed that playing piano with curled fingers is clearly more stressful than playing with straight fingers. Great masters like Vladimir Horowitz discovered this on their own, and Horowitz played with straight fingers his whole life. Striking a piano key is primarily a flexion of the metacarpophalangeal joint. Doing so with the proximal and distal interphalangeal joints flexed pre-stresses and strains the intrinsic muscles, causing extrinsic contraction to the lumbricals and interossei. This predisposes muscle tendon units to fatigue and injury. Attention must be turned toward the correcting of improper posture and the economy of muscle action in the upper extremity, eliminating unnecessary and inefficient muscle contractions. This is the basis of the Alexander[17] and Feldenkrais[18] techniques. Usually, with distal overuse, proximal upper extremity musculature is neglected and needs to be stretched, strengthened, and conditioned, including the trapezius, rhomboids, supraspinatus, serratus anterior, and levator scapular muscles. Paraspinal muscles in the neck need to be addressed also.

Extremity or instrumental orthotics may unload compressed areas, allowing instrument weight to be borne by more proximal muscle groups, such as the trunk or the floor. This facilitates playing by allowing the neck or upper extremity to be placed in a more comfortable position. Occasionally, the instrument's shape may be altered to facilitate playing. This may range from playing with a lighter viola to playing with a curved flute. A custom-molded chin and clavicle rest for the violin or viola may make supporting the instrument with the head and neck effortless, reducing the necessity for extreme neck flexion or anterior rotation of the shoulder girdle, which lead to fatigue, pain, and neuropathy. Significant comfort can be achieved by simple modification without compromising performance quality. In general, with appropriate treatment, 60% to 90% of these musicians eventually return to full performance schedules.[19]

Nerve entrapment syndromes

Initially thought to be rare in musicians, nerve entrapment syndromes have surfaced as a major problem. Twenty percent of patients presenting with upper extremity complaints to performing arts clinics in this country have compressive neuropathies.

As peripheral nerves travel from the intervertebral foramen to sensory receptors or motor endplates, they pass through anatomically tight spaces at various levels in the extremity. These spaces are bounded by fibrous tissue and or bone. Peripheral nerves slide back and forth as extremities flex and extend at various joints. For example, chronic repetitive movement of the arm in positions that increase overall pressure in these fiber osseous tunnels leads to local ischemia of the nerve and myelin nerve sheath. Secondary inflammation accentuates the problem, causing formation of a constricting scar around these fibrous tunnels and creating intrafascicular edema within the nerve. If this continues, writing becomes jeopardized and the nerve becomes tethered, causing microtears and stretching injuries. This may cause demyelination, which may or may not be reversible. Musicians are particularly susceptible to this type of nerve injury.

Maintenance of stressful, proximal muscle girdle postures, while executing rapid finger movement, may cause this problem in violinists and violists. Cervical nerve roots become compressed by bone or disc material that escapes into the intervertebral foramen, where cervical roots exit. Another source of compression is degenerative joint disease in the neck. This is common in violinists because of the tendency to have their necks flexed and turned to the left side.

At the brachial plexus level, nerves may become compressed by a cervical rib or under the tendon of the pectoralis minor, known as thoracic outlet syndrome. More distally, the ulnar nerve may be compressed at elbow level (cubital tunnel syndrome) or at the wrist's canal of Guyon. At the same time, the median nerve can be trapped in the elbow's pronator inlet, or more commonly, in the wrist's carpal tunnel. The radial nerve compresses in the radial tunnel of the proximal forearm. This may present with motor palsy of the posterior interosseus nerve or a pain syndrome known as radial tunnel syndrome, which may be associated with tendinitis at the origin of the extensor carpi radialis brevis. Digital nerves may become compressed because of their subcutaneous position. A flute or clarinet may cause direct pressure on the side of the finger, causing nerve compromise. Playing the English horn, while suspending it in the air, may cause ulnar nerve compression secondary to extreme positions of elbow flexion.

Thoracic outlet syndrome in flutists is quite common. Reducing hyperabduction of the right shoulder and diminishing internal rotation of the left shoulder can be quite helpful. Cervical radiculopathy is found in keyboard players primarily on the right side and in violinists on the left side. This is associated with the neck being tilted four to six hours daily.

Symptoms in these conditions include painful numbness

(dysesthesia), weakness, loss of dexterity, and a sense of "swelling or perked circulation." Duration of symptoms varies from several days to years and may be continuous or intermittent. In chronic cases, trophic changes in the hand and arm may result in frank muscle atrophy and complete loss of movement. Discomfort usually begins at a specific site and may radiate proximally and distally on the arm. Multiple nerves may become involved, or a single nerve may be compressed in more than one location (double crush syndrome). Compression of a peripheral nerve in one location may sensitize it, making it more susceptible to compression at another site.[20]

Evaluation of nerve entrapment syndromes

A thorough history must be obtained. Underlying metabolic disorders, such as diabetes, alcoholism, thyroid dysfunction, or rheumatoid disorders, must be elicited. A complete work history, related or not to performing arts, must be sought along with possible old acute trauma. The possibility of primary nerve disease or syringomyelia must not be forgotten. A comprehensive physical examination completes the initial evaluation.

In evaluating performing artists, one must see them in action. I have had musicians play for me in bathing or aerobic exercise attire to fully evaluate posture, position of the neck and shoulder girdle, and relative positions of both arms to the fingertips. If a specific set of movements brings on a symptom, I elicit this directly. I have patients exhibit a broad range of playing techniques. While I do not pretend to be a music instructor, I comment on specific techniques liable to cause muscle tendon strain or nerve compression. A thorough neurological exam includes evaluation of sensory and motor function, reflexes, and the presence or absence of pseudomotor signs, such as skin tone, color changes, sweat patterns, swelling, skin turgor, or rigidity. Sensory function is evaluated by testing sharp/dull perception, two-point discrimination, stereognosis, threshold light touch perception, static and moving two-point discrimination, and vibratory perception and position. Motor function is evaluated by testing specific muscles and muscle groups in the hand, forearm, elbow, upper arm, and neck.

There are a battery of provocative tests that increase the pressure across the particular fiber osseous tunnel one wishes to study. The Phalen's test involves passive wrist flexion at 90 degrees for 45 seconds for the median and ulnar nerve at the wrist. The elbow flexion test involves full supination and flexion of greater than 120 degrees for one minute for the cubital tunnel at the elbow. Supination against resistance or resisted middle finger extension tests for radial tunnel syndrome. One evaluates pronator syndrome by resisted finger flexion and forearm pronation with direct percussion over the anterior elbow. Dysesthesia caused by any of these maneuvers constitutes a positive exam. Tinel's test, involving direct percussion of the nerve at the area of possible compression, is less specific or sensitive. The thoracic outlet may be evaluated by Adson's test—the disappearance of the ipsilateral radial pulse when the involved arm is maximally elevated to shoulder level with the neck tilted and turned in the direction of the arm.

Treatment of nerve entrapment syndromes

Once a clinical diagnosis is made, a period of relative rest and splinting is followed by rehabilitation. A therapist may desensitize the hand and arm with various modalities and facilitate nerve gliding with special exercises. Tendon and ligament stretching exercises are followed by a muscle- strengthening program. Special instructions are given to facilitate activities of daily living. Performance and practice modifications are discussed, and a specific plan for return to play is instituted. Night splinting can continue for several months if needed. Most patients respond well to this protocol. For some, more aggressive treatment may be needed. Other conservative modalities include nonsteroidal anti-inflammatories and oral or injected steroids. With the latter, care must be taken to avoid intratendonous or intraneural injection, which may cause permanent damage.

Thoracic outlet syndrome is usually treated with a vigorous program of stretching and strengthening the anterior and posterior shoulder girdle muscle and paraspinal musculature. Surgery is almost never recommended in thoracic outlet syndrome.

Role of surgery in the treatment of performing artists

Many consider surgery a last resort. Musicians usually present late in the course for surgical treatment. I believe there are several reasons for this:

- Every music teacher or nonsurgical arts medicine practitioner has at least one horror story about a poorly indicated or badly performed operation that resulted in a crippling, career-ending outcome.
- There is general ignorance about potential benefits of well-performed surgery.
- Patients have a fear of being out of control during surgery and think they will never be the same after the operation.

In 1992, Dawson[21] outlined indications for surgical treatment of musicians. They include the release of refractory stenosed tenosynovitis in wrists or digital tendons—deQuervain's syndrome or trigger digits and compressive neuropathy not responsive to conservative measures.

Nonperformance-related conditions may have an impact on performance and may be amenable to surgical correction. I recently treated a pianist for a crippling digital osteoarthritis of the proximal interphalangeal joints with arthrodesis. In a short time, she returned to playing comfortably. She had come to me after several years of playing with significant pain. Prominent music educators told her the problem was poor playing technique and to avoid surgery at all cost.

Other conditions, such as Dupuytren's contracture, have no nonsurgical treatment and, if allowed to progress unimpeded, will end the instrumental musician's career. In many upper-extremity trauma or tumor situations, surgery is the conservative approach. It allows earlier joint mobilization and muscle retraining, facilitating an early return to performing. Surgery is a valuable adjunct in our armamentarium. While it should be used judiciously to achieve maximal benefit, it should never be dismissed.

Techniques of study

Communication is increasing between the conservatory and clinic. The fruits of this ever increasing cooperation are increasingly evident. These issues are being examined in the laboratory as well. Frequently, musicians can demonstrate difficulties to physicians and music teachers simultaneously. Video increases musicians' awareness of the subtleties of their playing techniques, helping musicians correct inefficient movements that can cause a repetitive strain problem. Pioneers, such as Dorothy Taubman, devoted a lifetime to studying playing techniques in the interest of preventing injury and treating already injured musicians.

Ultimately, much of what we will know about these problems will emanate from the laboratory. Over the past 20 years, force transducers, multichannel electromyograms (EMGs), video imagers, computer simulations, biofeedback, and an array of highly sophisticated biomechanical techniques previously used for the analysis of gait and throwing arm are now being focused toward the biomechanical underpinnings of musical technique. In trying to more clearly understand muscle groups involved with such discreet movement, techniques have been adapted for piano, flute, clarinet, brass, and percussion. Increasing attention is also focused toward popular musicians as they slowly enter the fold of music medicine. In coming years, we anticipate a flood of theoretical and practical information to treat injured musicians and, more importantly, to prevent problems.

The musical community needs to understand that they are essentially high-powered athletes. Organized conditioning programs must be a part of musical training on individual and institutional levels. Multidisciplinary approaches toward music education have been very successful in Europe for the past 15 years.

Performing artists need to train muscle groups they use most often and maintain excellent aerobic fitness, similar to professional football players or marathon runners. While demands are different, they are certainly no less stressful. This realization goes a long way in preventing performance-related musculoskeletal problems in musicians.

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