

Occupational Health and the Performing Arts

An Introduction

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Objective: Workplace hazards in the performing arts cause injuries, disabilities, and deaths every year. Occupational health professionals are familiar with most of these hazards and are particularly qualified to contribute to efforts to reduce them. This article reviews current health issues in the performing arts and highlights opportunities for occupational health contributions. **Methods:** Recognized experts in performing arts medicine were consulted and articles illustrating performing arts health issues were reviewed. Literature sources included medical databases, unindexed art-health publications, and popular press articles. **Results:** Resources discussing hazards and health issues in theater, dance, voice, and instrumental musicians were located and reviewed. **Conclusions:** Treatment providers have a history of involvement with segments of the performing arts. The occupational health approach to workplace health issues can effectively complement these efforts. Sources of further information on performing arts health concerns are available.

Occupational health problems associated with the performing arts have been familiar since at least 1713, when Bernardino Ramazzini described the disorders of musicians, actors, singers, and voice trainers in his *Diseases of Workers*.¹ In contrast to the visual arts, where many of the workplace hazards are related to toxic materials, in the performing arts, high rates of musculoskeletal problems have been a major focus of attention. In studies of dancers and instrumental musicians, large majorities of subjects have reported both acute and chronic disabling musculoskeletal disorders.^{2,3}

The numbers and severity of these disorders have resulted in the development of special relationships between performing artists and interested health care providers, including orthopedists, physiatrists, neurologists, and other specialists. Dedicated members of these specialties established the Performing Arts Medicine Association (PAMA) in 1989 with the goal of improving health care for performing artists. Over time, interested physical therapists, occupational therapists, performing artists, and others have contributed to these efforts. As a result, a clinical expertise has developed

around the health problems of performing artists and the importance of prevention has been increasingly appreciated.

The combination of clinical and preventive efforts is familiar to occupational health professionals who understand that this approach is essential in an attempt to reduce injuries and illnesses in a specific work sector. Performing artists have been the central focus of these efforts, but hazards can affect all workers and the performing arts work sector also includes a number of behind-the-scenes workers such as stage crew members, set construction workers, hair, makeup, and costume workers, writers, film crews, and others.

Working professionals in the performing arts are not the only ones affected by these exposures; students, part-time, and non-professional participants can also be at risk. Participants at any of these levels can experience injuries or illnesses and may seek health care for performing art-related concerns. In these situations, a detailed occupational health history, including a history of avocational activities, is essential. Familiarity with performing arts is helpful in obtaining complete information and guides to the occupational histories for some performing art activities and exposures are detailed in the sections that follow.

The importance of the occupational approach to this work sector was recognized by the National Institute for Occupational Safety and Health (NIOSH) when it published its *Arts, Entertainment, Leisure and Recreation* newsletter in 2010 as part of the National Occupational Research Agenda (NORA).⁴ This report focused on data for full-time workers included in the North American Industry Classification System's Code 71 (Arts, Entertainment, and Recreation), though it was noted that there are also many part-time workers in this sector. The most common sources of injuries and deaths in this sector were due to contact with objects or equipment and falls on floors or working surfaces.⁴

Few statistics are available for injury rates in the performing arts overall. Most performing arts organizations have not been required to report their injury rates to regulators,⁵ but there are some indications that rates may be higher than suspected. Rates for lost time injuries and illnesses among dancers and choreographers in companies that were required to report in 2013 were 262.3 per 10,000 full-time employees (FTEs). This is more than twice the rate (109.4) for all occupations and industries.^{6,7} One safety-conscious performing arts organization that has been reviewed reported medically diagnosed injury rates that were significantly higher than some high-risk professions such as police, firefighting, foundry work, and construction.⁸

Secondary injury measures such as workers' compensation losses may not accurately reflect the underlying injury experiences in the performing arts. One study showed that although 86% of a sample of musicians sought professional care for playing-related symptoms, only 3% of those with workers' compensation insurance went on to file claims.⁹ Other reported injury measures in the performing arts are likely to suffer from inaccuracies that have also been described in other industrial settings,^{10,11} including fear of reprisals,¹² lack of management response, and acceptance that "suffering for one's art" with injuries is a part of the work.¹¹ As

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in other work settings, admitting to physical limitations or a history of on-the-job injuries may lead to judgments by coworkers¹³ and can limit a performing artist's future employment opportunities.^{14,15} These issues have complicated the estimates of the injury and illness experience in the performing arts and more standardized reporting would be useful. The performing arts exemption for reporting workplace injuries and illnesses to the Occupational Safety and Health Administration (OSHA) was removed in 2015,⁵ so additional data should be available in the near future.

Health research in the performing arts has focused strongly on certain art forms. Much of the clinical research on dance has concentrated on ballet, while music medicine has focused on classical musicians and classically trained voice professionals. Researchers may have found that access to these classical performers was easier because they often work in large groups with more regular employment, and at times, with benefits such as health care.^{2,16} The findings from these focused studies could apply to artists working outside these classical settings, but it is likely that the relevance of such findings to other performing art genres has some limitations.³ Fortunately, research on health issues in the nonclassical performing art forms is growing.

Professional, amateur, and student performing artists are athletes with some highly developed physical capacities in the areas of selected muscular strength, endurance, and coordination. The newly formed Athletes and the Arts, a collaboration of sports medicine and performing arts medicine organizations, has recognized a number of common characteristics in athletes and performing artists. Both play intensely every day, often through pain despite ongoing risks of career-threatening injuries, and both experience strong pressures to succeed.¹⁷ Sports medicine has collaborated with sports organizations to prevent injuries in athletes, for example, by limiting pitching and requiring rest in young baseball players.¹⁸ It is hoped that injury prevention for performing artists can also be advanced through these kinds of collaborations.

Stress can be a regular part of work in the performing arts. Performing artists often work as freelancers with long hours and high performance demands, but are often poorly paid, intermittently employed, and experience insecurities about their work.^{19–21} Periods of highly stressful preparation and auditioning can alternate with periods of tedium and loneliness.^{22,23} Touring demands can inflict poor diets, lack of exercise, and postural stresses during intervals of sitting, carrying equipment, and even resting.²⁴ Time zone changes can oblige artists to perform enthusiastically during sleep times and can push some performers to self-medicate for stress reduction, sleep, and wakefulness.²⁵ These problems can be exacerbated when the payment for performances includes, or is sometimes limited to, alcoholic beverages.²⁶

Performance anxiety is an important example of stress-related issues in the performing arts. In his essay "Concerning Anxiety," Epictetus, the first-century Greek philosopher, tellingly chose a singer and lyre-playing musician as a familiar example of anxiety during performance: "[O]ne who sings to the lyre is not anxious when he is performing by himself, but when he enters the theatre [he becomes anxious] even if he has a very good voice and plays well: for he not only wants to perform well, but also to win a great name, and that is beyond his own control."²⁷ Performance anxiety continues to be a problem for present-day performing artists, and when debilitating, this disorder has been labeled a "social phobia" in the *Diagnostic and Statistical Manual (DSM-V)*.²⁸ As many as 33% of musicians at all skill levels suffer debilitating forms of performance anxiety,^{2,29} a disorder that can be associated with shame and fear of loss of identity as an artist.³⁰ The overwhelming symptoms can, at times, dissuade young players from pursuing careers in performance and may be part of the reason that musicians at all ages have left the music workforce at rates greater than those leaving the general working population.²⁴

Performance anxiety can cause physical and psychological symptoms such as shortness of breath, dizziness, palpitations, sweating, and shaking, with errors in technique and memory. Treatments have included beta-blockers,³¹ exercise, nutrition, cognitive behavioral therapy,^{32,33} biofeedback,³⁴ music therapy hypnosis, yoga, Alexander technique, acceptance and commitment therapy, and others.³⁵ When beta-blocking drugs are given, they should be monitored by a physician and the treatment should be combined with some form of counseling. In a landmark survey of more than 2000 orchestral musicians in 47 orchestras, "stage fright" was the most frequently mentioned performance problem and many performers reported using beta-blocking medications without medical supervision.²⁹

Another area of concentrated research in the performing arts has been focal dystonia, an unusual disorder characterized by involuntary muscle contractions that often result in uncontrollable abnormal movements. There has been an increasing interest in this disorder, which can affect musicians, vocalists, and other professionals who engage in highly repetitive work tasks.^{36–41} For musicians, the disorder can cause career-threatening involuntary movements and often affects the most active muscles of fingers, lips, tongue, and even the lower limbs.^{42–44} Robert Schumann, a giant of early romantic music, may have had focal dystonia of the right middle finger,⁴⁵ and in 1964, another giant of piano, Leon Fleischer, developed focal dystonia that involuntarily curled up his fourth and fifth fingers. "Things got progressively worse . . . No way could I play the piano . . . My life fell apart."⁴⁶

As focal dystonia is usually painless and can present as a muscular speed, control, or dexterity issue, it is often initially misdiagnosed as an overuse disorder or tendon pathology.⁴⁷ For this reason, it is important for health care providers to observe performing artist patients, as they demonstrate the problem while performing. In most cases, a specific cause for focal dystonia cannot be identified, and treatments are limited.^{48,49} Helpful treatments have included medications, splinting, highly controlled botulinum toxin injections, and musical retraining therapy, but benefits have usually been reported in small case series and uncontrolled studies.^{50–53} New brain imaging studies and rare familial groups with focal dystonia are helping to better define and understand this puzzling disorder.⁴⁷

Hearing loss is another special issue in the performing arts that is discussed in more detail at the end of this article.

THEATER

The theater is a common work setting for many professionals in the performing arts. For actors, dancers, singers, instrumentalists, as well as other performing artists and behind-the-scenes workers, the theater environment, whether formal, informal, indoors, or on location, can present some common work hazards.

The modern formal theater setting has become increasingly complex, as young audiences who have experienced special effects and computer-generated images create a demand for spectacular new productions. As a result, there are increasing hazards associated with the work that occurs before, during, and after theater performances.⁵⁴

Before a performance, workers can encounter hazards associated with prop and scenery construction, costume creation, and hair, nail, and makeup services that have been discussed in a previous article. Other preparation duties can include moving scenery, work at heights on ladders, lifts, catwalks, or in the area above the stage (the "fly") near the curtains, lights, and scenery.

During a performance, the stage can be filled with loud noises, split second movements of people and heavy scenery, rapid changes between intense lighting and darkness, with clouds of stage fog and pyrotechnics, while dancing and even acrobatics occur close to the unprotected stage edge. And in the middle of all this,

performing artists are doing their best to emote and engage the audience.⁵⁵

After the show, especially in nonprofessional theaters, efforts to “strike” or clear the stage can be mixed with celebrations. This demolition work and material handling often involves the use of ladders, tools, and equipment that can be dangerous. Sometimes untrained cast members, even performers who are still wearing awkward costumes, offer to help disassemble and remove sets, scenery, and props while working not far from the edge of the stage.

Stage Surfaces

Stages are not all the same, and like other elements of theater productions, they are becoming more elaborate. Each theater and each performance can have a different stage configuration, with variations and options.⁵⁶

One of the most common variations is the “raked” stage, a stage that slopes downward toward the audience to create a better sight line to the back of the scene and improve depth perspective for sets. The “rake” gradient can be 1:12 (a vertical rise of 1 inch in every 12 horizontal inches) or even steeper. The rake forces performers on stage to adjust their movements and postures, and it makes high-heeled shoes especially risky.

For dancers, the rake configuration causes alterations of finely tuned balance and foot position. Dancers note that a rake gradient places greater cardiovascular demands on them and choreography mastered on a flat surface requires increased stamina once transferred to the raked stage.⁵⁶ Traveling companies can encounter flat and variously raked stages while on tour, making stability more difficult and injuries more common. Studies of injury rates of performers on Broadway and London’s West End have noted raked stages as significant risk factors for new injuries and for the exacerbation of preexisting conditions.^{57–59} The Actors’ Equity Association in the United States and the Equity union in the United Kingdom have both issued guidelines for working on raked stages, including in some cases, consultations with specialists before beginning work on a raked surface.^{54,60}

Stages can also incorporate elements that make them more visibly dynamic such as raised rostra, revolving platforms, turntables, trapdoors, and motorized lifts. These structures may be fixed or movable, but even when they are unused and in the closed position, subtle differences in floor height can present trip hazards for performers.⁵ Movements of stage components can also be dangerous. In 2010, OSHA imposed a large fine on a theater for citations that included the potential crushing dangers in its moveable stage mechanism.⁶¹

Most theater shows have several scene changes. In bigger productions, these changes can be motorized and scenery slides along metal tracks embedded in the stage surface. These tracks are a potential trip hazard for performers and are especially problematic for those required to wear shoes with narrow-heels that can become stuck in the grooves.

A “sprung floor” is a floor built with extra shock-absorbent layers beneath the surface, giving it a softer feel and protecting dancers and other performers, especially when landing after jumps.^{62,63} Not all dancers have consistent access to sprung floors. In some theater productions, sprung floors have been removed because they were incompatible with the tracks used for moving scenery.⁶⁴

For dancers in particular, preparing for the qualities of the flooring is an important aspect of performance. Floors that are too slippery or too sticky can pose serious hazards for slips, trips, and falls.^{5,65} To prevent these occurrences, dancers use a variety of strategies, including treating shoes with rosin or diluted sugary drinks and scoring the soles of their shoes with scissors.⁵⁶ Treatment providers should be aware of these flooring problems and ask about the floors used for daily training and performances, especially if lower-extremity injuries persist in spite of treatment.⁶⁶



FIGURE 1. Transmitter under wig.

Costumes

In modern productions, costumes also have become increasingly complicated and may incorporate hardboard shells, heavy headwear, and even electrical mechanisms. Some costumes put considerable strain on the shoulder and neck muscles. This can affect the accessory muscles of respiration, and in the case of very tight corsets and other costume elements, there can be interference with breath mechanics that can significantly affect performers with singing or speaking parts.⁶⁷

Oversized headdresses, prosthetics, masks, wigs, and even heavy makeup may put strong forces on the neck. Asymmetrical headgear can also alter a performer’s center of gravity. Many theater performers wear microphones hidden under wigs or in headdresses, with a transmitter pack worn on a waistband under a costume. When the costume is tight, the transmitter may be difficult to hide, so it may be buried in the back of a wig or headdress, adding backward load to the head and neck (Fig. 1).⁶⁴

Producing wigs, beards, and other hairpieces usually requires highly repetitive work and exposure to a variety of hair treatment chemicals. Wearing these pieces often requires applying wig-lace glue or tape to the skin around the face. These glues come in both solvent (toluene and others) and acrylic, water-based versions that often include latex. Skin irritation is common and allergic contact dermatitis has been reported in sensitized individuals.⁶⁸

Stage Fog

Stage fog, haze, smoke, and dust effects give a performance space added interest. Over the years, many materials have been used in theaters and films to produce these effects, including asbestos snow⁵⁵ (reportedly used in *The Wizard of Oz* and during Bing Crosby’s *White Christmas* scene in *Holiday Inn*), burning tires,⁶⁹ talc, dry ice, wood and grain dusts, and other substances.⁵⁵ Currently, mineral oil mists, glycols, and glycerin are among the most commonly used fog and haze materials, and new techniques are making water mists, cryogenic fogs, and other sources increasingly available.

Many performers have complained about respiratory health effects such as asthma and respiratory irritation from chemical stage fogs. Study results have been mixed about the occurrence of asthma,⁷⁰ but many of these materials are respiratory irritants that could exacerbate underlying asthma⁷¹ and possibly cause reactive airways dysfunction syndrome.⁷² Respiratory irritants can affect all



FIGURE 2. Stage fog flowing into orchestra pit.

performers, especially during exertion, but may be particularly troublesome for vocal performers and wind instrumentalists (Fig. 2).

The glycol fogs are hygroscopic and can have a drying effect on the eyes, nose, and throat. In addition, some of these aerosols have been reported to include particles and pyrolysis products that are small enough to enter the small airways.^{73,74} In 2000, a study of 439 adult Broadway actors showed that performers with elevated glycol fog exposures reported more symptoms overall, and mild chronic effects were reported in those with peak glycol and mineral oil exposures. Performers with the highest exposures to mineral oil had a statistically significant group decrease in forced vital capacity, but this group measure remained within normal ranges.⁷⁵

Guidelines for exposures to theatrical fogs from glycols, glycerin, and oil mists have been developed,^{76,77} but research is incomplete and fogs should still be used with caution.⁷⁸ The guidelines for theater fogs were derived from standards developed for other industries where aerosol composition is quite different.⁷⁴ These guidelines have not been shown to be appropriate for children, the elderly, or members of the cast, crew, and audience who have underlying health issues. Respiratory hazard exposures are familiar problems to occupational health professionals and effective reductions of stage fog exposures could utilize standard industrial control methods, such as directed air flow and strategically placed exhaust ventilation.

Pyrotechnics

The use of pyrotechnics in theaters can create harmful sound levels, eye-damaging light flashes, thick smoke, and toxic airborne chemicals.^{55,79} Open flames and fireworks have little place in theaters or other enclosed spaces. Yet, theaters, clubs, and other venues keep using them, often with disastrous results that include performer and audience deaths.⁸⁰ Fire laws and inspection rules may not be enforced in all performance settings,⁸⁰ so experienced, licensed professionals who are aware of local laws and published standards are usually needed to supervise the use of pyrotechnics when they cannot be eliminated.⁸¹

Stage Weapons

Fights, weapons, and death scenes on stage may seem simple, but they can be sources of real injury and death for performers. Blank guns still contain dangerous charges,⁸² dulled stage knives and swords can still cut deeply,⁸³ and protective harnesses for staged hangings do fail.⁸⁴ Real weapons, no matter how disabled, should never be brought to the theater. Fights and use of weapons on stage

should be well planned and choreographed using documented safety guidance.⁸⁵

Scenery Changes and the Backstage Area

Performers in a theater face many issues and challenges beyond developing the skills required for the performance itself. Not only must they learn the on-stage choreography, but they also need to know the choreography of the scenery changes, both on- and off-stage. Scene changes can be highly complex and it is essential that performers be given adequate time to familiarize themselves with these technical aspects of the show. Unfortunately, due to the high cost of rehearsing in the theater itself, some productions only allow a few days for these on-site technical rehearsals. As a result, good working relationships between a highly professional cast and crew are necessary to keep these accidents to a minimum.

The backstage area is usually very dark and only minimal working illumination is allowed in order to prevent a “flood” of extraneous light on the stage. At times, even exit signs have been covered. Space is usually very limited in the “wings,” to the sides of the stage, yet this area must provide room for the performers, scenery, props, stage crew, sound technicians, and dressers for side-stage costume changes.

The arrival of scenery in a wing can obstruct a performer’s next stage entry point, so each cast member needs to be in the right place at the right time in order not to be trapped. All this has to take place in absolute silence, making it difficult for stage crew members to alert a performer of imminent danger. In the early days of production, it is often this off-stage choreography that instills the most fear in performers.⁶⁴

The back side of a stage set can look like a construction site, with scaffolding, ladders, and temporary stairways. What appears to the audience to be a second floor or a balcony may be a small stand accessible only by a narrow ladder navigated in the dark in an awkward costume. These ladders and elevated platforms are regular causes for injuries.⁸⁶ Scenery is often propped up and held in position by stage weights made of 20 to 30 pounds of cast iron that are painted black. As a result, they not easily visible and are common trip and foot injury hazards, especially for performers in soft dance shoes or bare feet.⁵⁶

“The Fly” and Fall Protection

The term *fly* refers to the area above the stage where the lighting, scenery, grid, and parts of the rigging may be located. Some theaters have a fly tower where flat scenery or cloths can be flown straight up or down during scene changes and these towers can be greater in height than the visible stage itself. Performers need to know their positions during scene changes in order to be in the right place when scenery is flown in or out. If a performer is inadvertently in the way of a piece of scenery as it descends, a serious collision can result.⁵⁶ During the 2009 Tony Awards, this kind of position problem led to a collision between large moving set piece and a performer causing facial fractures and other head injuries.⁵⁴ In theaters without a tower, scenery is often moved from the wings on metal rollers. This scenery may have heavy chains on the bottom to act as weights, and stage lamps can be attached. The rapid movements of these heavy objects during scene changes can also be hazardous.

Flying stunts usually require performers to wear harnesses hooked to wires suspended from the grid. These harnesses are cumbersome and uncomfortable, and are usually hidden beneath the performer’s costume. A technician is needed to ensure that the harnesses are safely fitted, especially when performers have to wear them for a considerable time before or after the actual flying takes place. Harnesses usually include groin straps and can cause local injury, restrict body movements, affect breathing patterns, and even trigger orthostatic intolerance or suspension trauma. Plans must be

in place ahead of time for emergency rescue during these performer emergencies or during fires or power equipment failures. Today, sophisticated automated systems allow for complex flying patterns and interaction between multiple aerial artists, making safety an even greater concern. Recent deaths associated with suspension apparatuses prove how dangerous this activity can be.⁸⁷ Guidance is available to create strict policies to control many risks associated with this aerial work and contingency plans that must be put in place by the production team.^{88,89}

Fall protection in the theater can be a difficult issue. OSHA has recognized that guardrails are not appropriate at the edge of the stage during shows, but insists that fall protection regulations still apply, and other solutions need to be found.⁸⁷ Every year experienced professional and amateur performers are injured and killed by falls from stage edges, scenery, and other structures.⁹⁰ Guidance for these issues is available.⁹¹ Temporary guardrails,⁹² orchestra pit nets, fall arrest gear, and rehearsals that keep performers more than 6 feet from the stage edge can offer some protection. It is important to remember that in the theater, as in construction sites, constant vigilance is necessary because even experienced workers can have momentary lapses in concentration at a leading edge that can result in devastating, permanent injuries.⁹⁰

DANCE

Among the arts and artists, dancers are probably the most vulnerable to physical injury because of the constant physical activity and extreme kinds of movement in dance.⁹³ According to a study from 1975 that compared the physical and mental demands of 61 common sports and other activities, ballet dancing was reported to have among the highest athletic demands, second only to professional (American) football.⁹⁴

Mastering dance techniques requires repetitive physical loading that, at times, may exceed the limits of human anatomical-physiological capabilities, and consequently may lead to injuries.⁹⁵ Joint forces of up to 12 times the body weight have been measured in the ankle joints of ballet dancers while “en pointe.”^{96,97} This highly demanding position can lead to injury if performed incorrectly or if performed by dancers too young and poorly prepared for pointe work. Physical damage can also be caused by forcing turnout to a position with the feet pointing in opposite directions at 180° when anatomical external hip rotation cannot accommodate this position. This is true especially at very young ages when the musculoskeletal system can be more vulnerable to injury.^{98,99} Understanding dance injuries and differential diagnoses can help to identify effective treatments¹⁰⁰ and appropriate preventive measures, but when working with dancers, it is also important to become familiar with the nature of dance and of dancers.³

Dance includes a wide variety of styles of movement, from ballet, modern, and jazz dance to break dancing, hip-hop, various ethnic-based dances, and other dance forms. Dancers from one genre are likely to participate in other forms. Most of the medical research on dance has focused on ballet dancers, with approximately 1000 scientific articles and 100 reviews currently found under “ballet dancers” in the National Library of Medicine collections dating from the mid-1950s.^{101–107} Recently, more studies are being reported in the literature that cover other dance varieties, including modern/contemporary,^{108,109} flamenco,¹¹⁰ street dance,^{111,112} DanceSport,¹¹³ Irish dance,¹¹⁴ Broadway musical theater,¹¹⁵ and tap.¹¹⁶ Lower extremity injuries have long been the focus of this research because of their high incidence in ballet, but injuries to the back, neck, and shoulders have also been observed and may be more common in other dance forms.^{57,103,109,111,117} Health care professionals working with dancers should be careful to ask about their chosen genre and other dance activities in which they participate.

Reported injury rates in dance vary, but injury rates among surveyed dancers are alarmingly high, often 79% to 96% annually,^{118–124} and career-affecting injury rates among dancers of 84% to 95% have been documented in multiple studies.^{123,124} One prospective study of 52 professional ballet dancers (27 female, 25 male) observed over one performance year demonstrated that 50 dancers (96%) had at least one dance-related injury that prevented full participation in normally scheduled dance activities for 24 hours or more. A mean of 6.8 injuries per dancer were reported and more than 60% were overuse injuries, resulting in approximately 55% of the reported lost time. Mean lost time was approximately 4 days in the females and 9 days in the males.¹²⁵ These high injury rate trends in ballet have also been found among nonballet dancers from hip-hop,¹¹¹ Irish dance,¹¹⁴ Broadway,⁵⁷ other genres, and among dance students.¹²³

Injury rate measures in dance suffer from the same influences that have also been described in industrial settings,¹²⁶ including management response,¹²⁷ fear of reprisals,^{12,128} and acceptance that injuries are part of the work.¹¹ Epidemiologists have noted that somewhat inconsistent definitions of injury among dancers have complicated the topic, but this issue is now being addressed by the Standard Measure Consensus Initiative of the International Association for Dance Medicine and Science (IADMS).¹²⁹

Dancers often suffer injuries for a long time before seeking help, and diagnosis may be complicated by the generally high pain tolerance noted in dancers.¹¹³ Diagnostic radiology may demonstrate findings that are more severe than suspected from the history.^{130,131} For health care providers, this means that it is important to ask dancers how long they have been symptomatic and try to get some realistic estimate of a dancer's level of pain by asking whether the condition has limited dance practice or performance in any way.

In training for most dance genres, dancers strengthen some muscle groups selectively while others remain much less developed. Ballet dancers, for example, may have underdeveloped core strength,¹³² with strength imbalances in the lower trunk muscles and portions of the quadriceps.³ Many dancers have tight lateral quadriceps and iliotibial (IT) bands, but weak medial quadriceps (vastus medialis), which can contribute to patellar mistracking. Another common muscular imbalance is tight calf muscles (gastrocnemius and soleus) and weak anterior muscles, such as tibialis anterior. This imbalance can lead to medial tibial stress syndrome, often identified by dancers as “shin splints.”¹³³ Weaknesses that cause strength imbalances can leave joints vulnerable to injury, but corrective exercise programs can help prevent many of these injuries.^{134,135}

In ballet, the hip and pelvis are areas of frequent injury,^{104,119,122} and common diagnoses include stress fractures, “snapping hip,” sciatica, avulsion injuries, and acetabular labral tears. Stress fractures are frequent, but because they are often poorly visualized on radiographs, they can easily be mistaken for muscular or soft tissue problems. Snapping hip is a frequent dance-related complaint with two common etiologies, a lateral snapping in which a short IT band becomes irritated, as it moves across the greater trochanter of the femur, and anterior snapping in which the psoas tendon snaps across part of the pelvis or femur. These disorders often begin with an audible sound alone, but as the involved structures become inflamed, they can develop into painful and debilitating injuries. Sciatica-type pain has two common sources in dancers: a tight piriformis, which may be relieved by appropriate stretches, or disc problems in the lumbar spine.¹³⁶ Avulsion injuries are more commonly seen in adolescents when the tendon attachments to bones are vulnerable to the stresses encountered in dance.⁹⁹ Hip acetabular labral tears are often difficult to diagnose and can be career-ending injuries for dancers.

Dancers can experience a number of types of knee injuries, but among the most common are patellofemoral pain syndrome and patellar tendinopathy. Patellofemoral pain syndrome is often caused by mistracking of the patella,¹³⁷ which can often benefit from corrective exercise.¹³⁴ Patellar tendinopathy is an overuse injury that can be treated with rest, then a strength-training program for the muscles that support the knee.¹³⁷ Osgood–Schlatter disease is most often recognized in adolescents. Treatment does not require complete rest from dancing, but movements that irritate the knee, such as grand plié, should be avoided.

The most common ankle and foot injuries in dancers are ankle sprains, ankle impingement syndromes, tendinopathy, and plantar fasciitis.¹³⁸ Most sprains in dancers are inversion sprains that benefit from proprioceptive rehabilitative retraining, using devices such as wobble boards. Both anterior and posterior impingement ankle injuries are bone-related issues, and rest is an essential part of the treatment. Ballet dancers who work en pointe are more likely to have problems with posterior impingement than dancers in other genres. Plantar fasciitis usually has a slow onset, but can become debilitating, and should be treated as early as possible. Many runners and dancers develop Achilles tendinopathy, but in dancers, it is important to look at the patterns of turnout and lower leg alignment that can contribute to the disorder.^{106,139,140,141}

Common back injuries in dancers include spondylolysis and spondylolisthesis, articular facet syndrome, discogenic back pain, strains, and ligament sprains. Adolescent dancers are particularly susceptible to back injuries, especially spondylolysis.¹⁴² Stress fractures of the vertebrae can occur, particularly among young dancers, due to insufficient core, lumbar mobility or hypermobility with poor stabilization. To prevent these back issues, care should be taken to avoid excessive lifts and repetitions of ballistic movements, such as grand battement (high kick) in a backward direction.¹⁴³

Dancers often work to develop extreme ranges of motion in the shoulder complex, which can add to difficulties with stabilization and can predispose them to injuries.^{144,145} Healthcare providers evaluating dancers should evaluate range of motion and recent changes in lifts, routines, and styles of choreography.

A number of other modifiable risk factors for injury in ballet have been identified, including poor alignment, lack of warm-up exercises, repetitive jumping, and environmental factors such as hard floors and poorly fitting shoes.^{3,146} Other biomechanical factors that have been identified include certain foot types, tight Achilles' tendons, and a number of technique-related issues including foot "sickling" (non-weight bearing) and "rolling in" (weight bearing), with excessive foot supination or pronation. Technique-related and environmental issues in dance can often be addressed, but some risk factors, such as hypermobility, may be manageable with good training, but cannot be modified. Clinical evaluation of all of these issues requires examination of the dancer in both static and dynamic settings.

As in many workplaces, fatigue and overuse can contribute to the incidence of injuries.^{3,147} Prevention efforts, especially with young dancers, should include limits on practice. This can help prevent the fatigue and burnout that can lead to injury and increased psychological problems. Children and adolescent dancers should also be discouraged from extreme stretching, such as over-splits and long static stretches before dancing. While muscles can be stretched over time to increase ranges of motion, extreme stretching can harm ligaments and other stabilizing structures. Developing a relationship and good communication with a dancer's teachers can be of great benefit when addressing extreme stretching and other dance-related issues (Fig. 3).

Pointe work should not be attempted until the dancer is at least 12 years old, has participated in three dance classes per week for a minimum of 2 years, and has demonstrated lower extremity

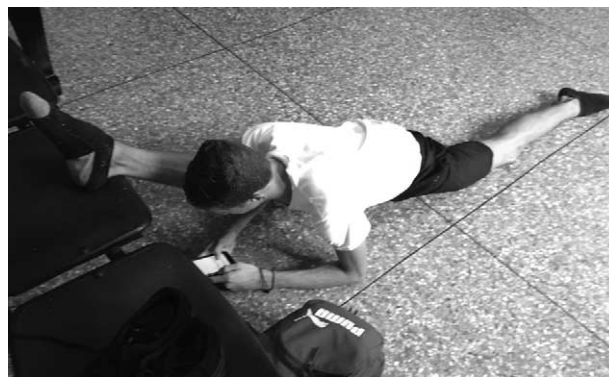


FIGURE 3. Dancer demonstrating extreme stretching.

strength, core support, and good alignment.¹⁴⁸ Other issues in young dancers include growth spurts that can create a number of problems: tight musculature can result from bone growth preceding muscle growth and proprioception can be disrupted with temporary loss of some hard-won dance coordination. Dancers and their teachers need to be aware of growth patterns and how to modify dance activity to avoid injuries during these temporary phases.⁹⁹

Good lighting, reasonable temperatures, and appropriately "sprung" floors can help to prevent dance injuries. Sprung floors already have been discussed, but lighting is also critical for both balance and spatial orientation, especially while learning dances. Temperatures that are too cold in dance studios can irritate some repetitively used muscles, and when the environment is too hot, dancers can become dehydrated.

Good nutrition and hydration are essential for dancers and it is important that they understand the special dietary needs for dance performance. Protein and carbohydrate requirements may be high for dancers, especially among adolescents.¹⁴⁹ Dance is primarily an anaerobic activity, and carbohydrates are essential as energy sources, but this is something dancers may not understand in their attempts to avoid weight gain.¹⁵⁰ In the ballet environment, dancers may receive encouragement rather than concern after losing large amounts of weight.^{151,152} A meta-analysis found that eating disorders, menstrual disturbances, and low bone mineral density are important health issues for dancers.¹⁵³ Eating disorders of all varieties affect dancers,¹⁵⁴ and medical professionals who specialize in eating disorders, especially those who have experience with dancers, can be crucial in these settings.¹⁵⁵

Performance anxiety, stress, and other psychological issues can profoundly impact dancer performance and increase injury rates.^{156,157} Sleeplessness, loss of appetite, and diminished energy can be clues to these disorders. Coping strategies, support systems, and fitness training can help reduce the effects of these disorders, but individuals may need personalized care.^{158–160} Fortunately, the field of dance psychology is expanding, and this specialized care is becoming more available.

In general, dancers have more problems finding appropriate health care than their counterparts in sports.¹⁶ Moreover, when they do approach the healthcare professions, they often perceive the responses they receive as unconstructive or even discouraging.¹⁶ Two organizations were founded with performing artists' needs at the center of their mission statements. The PAMA and the IADMS organizations can both provide referrals to experienced practitioners for dancers. In addition, these organizations can help healthcare practitioners find other treatment providers who work with dancers in a variety of locations and can provide diagnostic, treatment, and prevention guidance.

MUSIC

Instrumental musicians perform in orchestras, ensembles, and bands, as soloists and accompanists, and in these settings, they often work as self-employed freelancers.¹⁶¹ The U.S. Bureau of Labor Statistics (BLS) data for 2014 documented approximately 255,400 musicians, singers, music directors, and composers,¹⁶² but other estimates are much larger. Membership in organizations of composers and songwriters alone exceed 900,000 in the United States¹⁶³ and estimates of recreational or nonprofessional musicians in the United States range as high as 62 million.¹⁶⁴

Musical involvement often begins in childhood; the average starting age among surveyed professionals in orchestras was 10 years.² One inclusive U.S. study reported that 41% of 12th graders participate in music or other performing arts programs,¹⁶⁵ and thousands of young musicians attend more than 650 accredited college-level music programs.¹⁶⁶ Participation in instrumental music can last for decades and a number of professionals have played into their 80s.¹⁶⁷

In order to excel, musicians need specialized skills¹⁶⁸ that usually include

- Small-muscle athletic skills with endurance for multiple, fast, repetitive motions;
- Critical hearing for intonation and balance within an ensemble;
- A precise sense of timing;
- Prolonged ability to concentrate despite multiple sensory distractions;
- Coping skills for the stress of travel, health problems, and other issues.

The physical demands of certain musical pieces can be surprising. Musical passages have been documented that include 38 notes in 3 seconds; 740 arm movements on the cello in 2 minutes; and 5144 arm movements on the snare drum in 14 minutes.¹⁶⁹ The hands and upper extremities must be capable of executing extremely precise and rapid movements for performances such as those requiring 5595 notes in 4 minutes and 3 seconds, or up to 72 finger joint movements per second.¹⁷⁰ During the first movement of Tchaikovsky's Violin Concerto, the violinist's right arm has to progress from 50 cycles per minute of back-and-forth bowing to 300 cycles per minute by the end of the piece.¹⁷¹

For this level of performance, every component of the anatomical systems involved must be functioning flawlessly and abnormalities that might be clinically insignificant in the general population can be catastrophic for instrumentalists. Unfortunately, it can be difficult to assess minor losses at this extraordinary level of functioning¹⁷² and some artists have expressed concern about the knowledge levels and attitudes of health care providers who evaluate their playing-related complaints.¹⁷³ The perception of a lack of understanding from providers can prevent musicians from seeking medical care early. One group of health care specialists who treat musicians regularly noted how common it is for musicians to delay seeking medical care, as they suffer through long periods of disability, even when the condition is easily correctable.¹⁷⁰

The specialty of medicine focused on musicians is a relatively recent development¹⁷⁴ with a limited bibliography¹⁷⁵ but with several excellent basic textbooks.^{176–179} Published, peer-reviewed studies include surveys of symphony musicians, opera musicians, younger students, collegians, and military groups.^{2,29,180–187} The primary designs of these original publications have been cross-sectional surveys,^{2,167} specialty patient case series,^{188–192} and case reports,^{193,194} but few controlled studies.

Studies of instrumental musicians have examined subjects including

- Playing-related musculoskeletal disorders related to overuse in practice and performance^{185,195};
- Faulty technical factors,¹⁹⁶ for example, poor posture, excessive playing force, physical mismatch between musician and instrument;
- Physical factors, for example, hypermobility; fitness, health conditions, hand and body size;
- Environmental factors, for example, poor seating, loud sound levels, and lighting issues;
- Nonplaying related injuries, for example, carrying instruments, moving equipment, and podiums.¹⁹⁶

In 1713, when Bernardino Ramazzini wrote about musicians and repetitive activities, he noted, "There is no exercise, though never so healthful and innocent, but what may produce great disorders, if it [is] used with intemperance."¹ Repetitive music-related activities are still associated with serious disorders, as well as high rates of musculoskeletal pain complaints among professionals, students, and amateur musicians. As a result, playing-related disorders of the musculoskeletal system have dominated the medical literature concerning instrumental musicians. A landmark survey of 2212 musicians from 47 symphony orchestras in the United States documented that 82% of musicians surveyed had experienced a medical problem and 76% listed the disorder as severe in terms of its effects on performance.² The most commonly cited performance-related factors that contribute to these musculoskeletal problems were the playing loads, which included practice and performance time and intensity.¹⁹⁷

Studies of other orchestra musicians have found comparable results. In a study of 377 participants in Australian orchestras, 84% had experienced pain or injuries that had interfered with either practicing on their instrument or participating in normal orchestral rehearsals and performances. Approximately 50% of responding musicians had playing-related pain or injury at the time of the survey. The most commonly affected sites were the trunk (primarily the back), right upper limb, left upper limb, and neck, and the percentages varied by instrument. Of those musicians who reported at least one episode of pain or injury in the past, less than 50% reported that they had completely recovered. Sleep disturbances related to these complaints were reported in half of the professional musicians responding, a finding that is consistent with other studies.^{197–199}

Playing-related pain conditions include musculoskeletal syndromes of overuse, myofascial pain, and nerve entrapment,^{200–203} but there is little current evidence that osteoarthritis is a result of playing.¹⁷⁴ More of these problems occur in string and keyboard musicians than in other instrumentalists.^{2,188} The lowest number of reported musculoskeletal complaints are usually seen in brass instrumentalists,^{2,197,204} but even this group showed a 32% prevalence of severe musculoskeletal problems.^{2,29} High rates of playing-related disorders were not only found in professional instrumentalists but also in young musicians during their training years.^{182,183}

Common risk factors for playing-related overuse disorders included playing time, technique, demanding repertoire, posture at the instrument, larger instrument size, gender, and age.^{174,182,183,205} The highest injury rates have been reported to occur approximately mid-career, and it has been postulated that this is a result of peak family and financial responsibilities.¹⁷² No reviews of survivor bias or other research design factors were found, but a study of retired orchestra musicians did not indicate that retirement was caused by physical problems.¹⁷²

Sites of musculoskeletal disorders in musicians are often instrument-specific, and posture plays a role.^{2,206,207} Classical cello and bass players who have to reach around their instruments can develop difficulties in the upper and lower spine,² and standing electric bass players who support their instruments with a shoulder strap may be at more risk of injury than upright bass players.¹⁷² The

left hand is nearly twice as often involved in violinists and violists as the right. In percussionists, the shoulders and wrists are most often at risk,^{190,208} but in guitarists, the varieties of playing styles have confused the issues of anatomical site-specific pain problems related to this instrument.^{172,209}

Some modifications of posture, extremity position, and instrument design have been shown to be helpful in reducing these issues.²¹⁰ Instruments that require an asymmetrical approach, such as the violin, viola, and flute, are more likely to cause postural disorders.^{211–213} For violin and viola, elevations of the arm and muscular fatigue are important issues and can be somewhat reduced with appropriate, individualized adjustment of the chin and shoulder rests.^{214,215} The piano keyboard height is fixed, so seating height adjustment is needed to get the hands and wrists into positions that are close to neutral, with arms and shoulders relaxed. Slight wrist flexion helps keyboardists engage the flexors of the three long fingers and avoid using only the lumbrical muscles to provide downward pressure.¹⁷² Back support is likely to be as important during long periods of practice as it is during long periods of office work. The size of an instrument and the playing position should be individualized as much as possible, and in certain situations, ergonomic adaptations of instruments have been designed and used.^{216–218}

Musicians who march in military bands, drum corps, college bands, and other, similar groups report health problems related to the outdoor environment, loud sounds, and marching while carrying their instruments.²¹⁹ Research has suggested that the physical demands of participating in marching band are similar to athletics.²²⁰

Other health issues have also been reported among musicians. Allergies to cane reeds, instrument woods, nickel-containing mouthpieces, and rosins have been reported.¹⁷² Respiratory issues, including unusual cases of respiratory disorders that are likely to be related to inadequate instrument hygiene, have also been reported.^{221,222} A common skin lesion known as “fiddler’s neck” can occur in violinists where the chin rest contacts the skin.²²³ Partial resolution can often be accomplished with moisture reduction and pressure point reduction techniques.

An occupational history of a musician’s playing activities is crucial to an accurate diagnosis and appropriate treatment. Successful assessment can depend upon an appreciation of the mechanics of playing a particular instrument, along with an appreciation of the risks of being a musician, including lifestyle issues.²²⁴ Guides to obtaining detailed occupational health histories from musicians are available.^{225,226} Details of musical life, performance schedule, practice regimen, length of rest breaks, and any rapid increases in playing load should be reviewed. Nonmusic activities should also be noted to assess whether musicians are doing other repetitive tasks during breaks, such as computer work or other tasks.

As in many occupational health evaluations, it can be important to directly observe the work activities of a performing arts patient. Observing a musician patient while playing can be very helpful when attempting to assess the physical demands of the work. This kind of review may reveal postural abnormalities,²²⁷ evidence of excessive playing force,²²⁸ or even finger or lip incoordination that is characteristic of focal dystonia.¹⁷⁶ Physical examination findings rarely provide overt pathological signs as seen in some sports injuries, and a musician’s subtle musculoskeletal problems can leave uninitiated providers frustrated by the difficulty of identifying a diagnosis.¹⁷²

When treating overuse syndromes, resting the affected part is mandatory, usually until pain subsides.¹⁹⁶ Unfortunately, health care workers who advise musicians or other performing artists to temporarily give up playing completely will often risk not seeing that patient again. Instead, it is often desirable to recommend some continued movement and function of the involved parts, which will also avoid disuse issues, especially of the small hand muscles and joints. The model of “work hardening” may be useful. Affected

musicians should gradually begin to perform prescribed playing tasks, but should start out at greatly reduced levels of time and intensity. Visualizing, or doing the mental work of playing, can be especially useful for instrumentalists who need strict rest of an anatomical structure. Nonresisted motions of the affected parts can also help in a gradual return. A program for gradual return to playing music should take into account duration, tempo, technical difficulty of chosen pieces, and the specific instrument.²²⁹ Minor setbacks are to be expected, but can be discouraging, and patients should be advised from the start that this is a normal part of the process. Rehabilitation techniques that are appropriate for soft tissue disorders in other work settings, such as massage, therapeutic exercises, and trigger point releases, are applicable to these injuries.

Prevention remains the gold standard for playing-related disorders.¹⁹⁶ Activities such as warm-up routines and exercise have been effective in reducing performance-related musculoskeletal disorders in musicians.²³⁰ Recognizing and modifying risk factors in music practice, playing technique, and the environment may be most effective when conductors, teachers, and coaches are involved. Some important aspects of these issues are noted as follows:

- Music practice modifications include
 - Warm-up should probably begin within 30 minutes of playing and involve general exercise and specific movements throughout the general ranges of motion and the specific motions of the activity to be undertaken.²²⁹
 - Playing time and intensity should be controlled; playing 25 minutes of every half hour is a good beginning, with rest for both body and brain during breaks. Breaks should not be used for computer work or other repetitive tasks.
 - Some repertoire may be damaging for unprepared students and playing should only be appropriate for the musician’s skill level.
 - Minimize stressful repetition of difficult passages.
 - Reduce fatigue, which can cause bad posture at the instrument and lead to musculoskeletal strain.
 - Avoid prolonged practice sessions by scheduling practice long before performances.²³¹
- Technique modifications: There is no single correct playing technique,¹⁷² but general guidelines include
 - Assessment of posture and extremities for deviations from neutral position;
 - Evaluate inefficient playing and consider instrument modification or support;
 - Using only needed muscle groups to accomplish the musical task with preference for large muscle use for force and smaller muscles for fine movements;
 - Avoiding co-contractions of opposition muscle groups;
 - Minimizing mental tension.
- Environmental modifications apply to seating, lighting, and hearing.²³²
 - Seating, lighting, and loudness may not be controllable during rehearsals and performances, but they can be personalized during individual practice.

The National Associations of Schools of Music (NASM) and PAMA have developed recommendations for health promotion in schools of music and have made it part of the accreditation standards.²³³ Accredited schools of music should provide safety and health information that reflects “attention to injury prevention and to the relationships among musicians’ health, the fitness and safety of equipment and technology, and the acoustics and other health-related conditions in practice, rehearsal, and performance facilities.”²³⁴ Cautious optimism may now be warranted for improvements in recognition and early intervention of musicians’ disorders.^{233,235}

VOICE

Singers rely on their abilities to alter volume, pitch, and other characteristics of their voices to compete for work and to perform. Even small changes to the conditions of the physical apparatus and control mechanisms of the voice can have career-altering effects on a singer. In addition, the psychological toll on singers who fear losing their vocal attributes should not be underestimated.²³⁶

Effective evaluations and treatment of singers depend upon an understanding of the anatomy and physiology of voice production. Sound is created by the vibration of the specialized mucosa of the true vocal fold or cord over a thin area of loose connective tissues, the superficial lamina propria, or Reinke space. These tissues overlie the muscles of the vocal fold that provide shape, tension, and movement of the vocal folds. Phonation is created using the articulating structures of the vocal tract such as the tongue, palate, teeth, and lips.

The force required to create sound is not by itself traumatic to the vocal tissues, but as with other soft tissues, excessively repetitive use at a normal intensity, or extreme intensity, can cause inflammation and potential injury. Microinjury to the vocal fold mucosa can be demonstrated histologically in these cases even before changes in the voice become audible.²³⁷ People who talk a great deal probably provoke minor vocal microinjury, which is clinically insignificant. Continuous speaking or singing for a few hours will often cause hoarseness from vocal fold edema, even in trained professionals. Clinically significant injury can be produced by use of excessive vocal force, by extended rehearsals and performances, or by performing with an underlying upper respiratory infection or other problem.

For performing artists who can be called upon for consecutive days of performance, the resulting vocal injury is a “phonotrauma.” (Sufferers often find the term “vocal abuse” inappropriately pejorative.) When phonotrauma is suspected, a comprehensive history may reveal the cause of voice dysfunction even before the physical examination is initiated.²³⁸ Guides to the comprehensive medical history for singers are available.^{238,239}

The most common causes of voice problems are also the common causes of respiratory problems such as infections, allergies, and irritant exposures. Inflammatory changes in the mucosa, with swelling, increased secretions, and other effects increase the vulnerability of these tissues to injury. Coughing and throat clearing, as a result of increased secretions or attempts to get back the normal voice sound, can cause phonotrauma.

Respiratory dysfunction can affect the voice if air movement or volumes are decreased in obstructive or restrictive lung disorders. Pulmonary function testing may be valuable in revealing occult asthma, restrictive defects, or other respiratory concerns.^{240,241} Other issues such as aging, fitness level, hormonal changes, weight changes, systemic disorders, foods, and medicines can all affect the voice.

Sex hormones can have a profound influence upon voice. For males, the most important change occurs with puberty, and most experts agree that singing exercises that strain the voice should be minimized during puberty for both sexes.²³⁸ Premenstrual voice changes in women can include loss of highest notes, along with vocal inefficiency and fatigue. In addition, submucosal hemorrhages are reportedly more common at those times.²⁴² Birth control pills may help, but can have their own harmful effects on range.²³⁸

A number of other materials and exposures can influence vocal health. Caffeine, highly spiced dishes, and other foods can aggravate gastric reflux, and a heavy meal can interfere with abdominal support for the voice. Exposure to environmental irritants such as smoke or stage fogs can cause local irritation or provoke asthmatic responses.

Vocal dryness affects the voice and can occur when performers stop drinking anything before going on stage so that they can

avoid having to urinate during the performance. Common medicines that cause vocal dryness include antihistamines and decongestants as well as anticholinergics, sleeping medications, antiemetics, diuretics, alcohol, some antidepressants, and other psychiatric medications. Some medications predispose to vocal hemorrhage such as blood thinners, niacin, vitamin E, alcohol, and some ginkgo preparations. Anti-inflammatories can also mask the vocal pain that warns of impending vocal fold hemorrhage or other damage.

Difficulty speaking due to a vocal disorder is known as dysphonia. Common etiologies include phonotraumatic lesions, reflux, neurological disorders, age-related changes, and infection.²⁴³

Phonotraumatic lesions are caused by repeated and/or excessive force at or adjacent to the contact point of the vocal folds. Vocal performers with dysphonia are more likely to have phonotrauma findings on examination such as nodules, polyps, cysts, varix, or hemorrhage, whereas nonperformers are more likely to have vocal fold paresis, muscle tension dysphonia, or age-related changes.²⁴⁴ Polyps, nodules, cysts, and varices may require surgical excision, using the technique of microlaryngoscopy. After surgery, voice rest and rehabilitation are critical for good healing and eventual return to performance.

Vocal nodules, polyps, cysts, vocal fold varix can all affect the voice in singers. Varices can be caused by or enlarged by phonotrauma. An important concern with varices is the potential increased risk of intracordal vocal fold hemorrhage.

Vocal fold hemorrhage is one of few conditions where strict voice rest and performance cancellation may be indicated. Hemorrhage usually presents as a sudden voice change associated with intense vocal use, often during performance, yelling, or coughing,²⁴⁵ and it will usually resolve.

These conditions reinforce the need for good warm-up, appropriate posture, breathing, relaxation, staying within limits of volume and range, staying hydrated, not performing when ill, and not using accessory or external muscles or posture to push a note. Minor, self-limited problems, such as vocal fold edema, can be resolved without becoming more serious as long as the singer does not continue to “push through” the problem and uses appropriate voice rest after performance.

Age-related vocal changes include atrophy and muscle weakness often resulting in voice weakness and pitch elevation in men. Thickening of the laryngeal tissues with pitch deepening can also be seen in women. Other causes of voice problems include metabolic conditions such as thyroid disease, hearing loss, neurologic conditions, stress, and psychiatric disorders, and these should always be part of the evaluation.²⁴⁰

The gold standard for examination of the larynx is the fiberoptic videostroboscopic examination. This technology uses a stroboscopic light firing at a frequency slightly different from the vocalizing frequency (detected with a microphone), making the vibratory mucosal wave visible at a much slower rate than could be seen with the naked eye or by simple fiberoptic examination. The slowing enables careful evaluation of the critical vibration: whether it is present, its relative speed, symmetry with the opposite vocal fold, etc.

It should be noted that sophisticated stroboscopic laryngeal examination can demonstrate abnormal findings even in asymptomatic patients with normal voice production. A study of laryngeal findings in 72 healthy singing teachers²⁴⁶ found that most subjects had visible abnormalities. And in a study of healthy singing students, more than 60% were found to have abnormalities such as erythema, asymmetry, reduced mucosal wave, and edema.²⁴⁷ Clinicians must use the patient’s history and the examination findings to make the appropriate diagnosis.

Phonotraumatic lesions often resolve or improve significantly with voice rest, behavior modification, and rehabilitation. During rehabilitation, it is important to monitor for recurrent phonotrauma

and to begin prevention modalities such as behavioral modifications.²⁴⁵ For performing artists, the involvement of a multidisciplinary team including a laryngologist, singing teacher, speech-language pathologist skilled in the voice user's particular area of performance, and others can be very important.²⁴⁸

Voice rest is commonly prescribed, and most providers recommend about 7 days of rest, with about half favoring complete voice rest and the other half favoring relative rest.²⁴⁹ One study found that only about one-third of patients actually complied with the recommended voice rest and noted a significant negative impact on their quality of life.²⁵⁰ Voice rest appears to be helpful, but questions remain about its actual efficacy and the optimal recommendations.

Regardless of the singing style, excessive voice force, vocal strain, singing outside the natural range, and prolonged performance can all cause vocal injuries. Some rock, pop, and blues singing styles include a style of purposeful roughness and glottal fry, or a "growling" character. This technique can cause excessive contact force, but has not been studied extensively in the peer-reviewed literature. Good voice teachers can help any style of a singer protect and expand the voice range without changing voice quality. Singing, like athletic activities, benefits from exercise, warm-up, and good coaching.²⁴² Some recent high-profile cases of pop and rock singers who developed vocal lesions and with coaching went on to have successful recoveries have certainly raised awareness of this issue.²⁵¹

Good vocal health habits should begin in childhood, especially for youngsters interested in singing, acting, or other voice use activities.²⁴² Voice overuse, including yelling or excessive practice or performance, should be discouraged. Good teachers will prepare students for progressively challenging pieces and will not prematurely encourage repertoire that could cause phonotrauma. The body and the voice change throughout life and vocal changes occur even in the most successful singers. With conditioning, these problems are largely correctable, including many changes that are age-related. Cooperation among health care providers, a speech-language pathologist, and a performing arts teacher can help to provide the best setting for voice protection, healthy habits, and recovery.

HEARING LOSS

Hearing loss is a special issue in the performing arts. Performing artists, behind-the-scenes workers, and audiences are at a significant risk of hearing loss if the sounds of a performance are too loud.²⁵² Loud sound exposures have been reported among classical²⁵³ and jazz musicians,²⁵⁴ marching band members,²⁵⁵ musical theater performers,²⁵⁶ and even music students.²⁵⁷ For performing artists, the onset of any type of hearing loss, even at frequencies well above those required for speech, can be catastrophic and career-affecting events.²⁵⁸ Vocal and instrumental musicians, in particular, require high levels of hearing accuracy in order to monitor sound quality, pitch, and volume and to make subtle adjustments during performance.

There have been limited audiometric findings of hearing loss caused purely by music exposure, but loud music exposures have been associated with asymmetrical hearing loss on the left side in violinists and in the ear facing drums among rock musicians.²⁵⁹ Tinnitus, vertigo, and pain can accompany this hearing loss, though other causes must be ruled out. There continue to be controversies over protective sound-level standards for performing artists,^{260,261} so in the meantime, the NIOSH standards have been recommended as good guidelines.^{262,263}

Most cases of hearing loss caused by loud sounds, heredity, or aging cannot be cured, making prevention essential. Reducing sound-level exposures at work can be a complex matter for musicians whose work product is sound.²⁶⁴ The risk of hearing loss is associated with the level of exposure as well as the duration, so

reduction of loud sound exposures outside of the performance workplace, during leisure activities or other work, can be very important. Exposures to loud music listening devices, loud tools, and loud machinery can all be important nonperformance risks. Although the issue can be complex in the performing arts, the general sound reduction methods and the principles of hearing protection that are familiar to occupational health professionals can be of great value to these workers.

Personal hearing protectors used in industrial applications are usually inappropriate for music applications because they attenuate the high frequencies too much.²⁶⁵ Newer sound-reducing earplugs for musicians have been designed to reduce sound pressures more equally throughout the range of frequencies.²⁴⁹ Whether generic or custom made, these earplugs allow musicians to hear a more accurate version of the music at a reduced volume. Active, noise-cancelling earplugs have also been found to provide effective new options for hearing protection.²⁶⁶

In-ear monitors are custom-fitted devices that act as hearing protectors, isolating users from ambient sound, while sending the music to the ears at lower volumes. These are more expensive but are especially useful for musicians, sound engineers, and others working in large performance venues because they can reduce the need for some on-stage amplification. As with all personal protective equipment (PPE), users need to understand the proper application of these devices and the potential consequences of misuse.²⁶⁷

A program for hearing protection for those in the performing arts with loud sound exposures should include the following^{263,265}:

- Sound pressure measurements in rehearsal and performance settings. Inexpensive digital sound pressure meters are available to screen these environments.
- Comprehensive baseline and periodic audiometric examinations. Testing the frequencies from 125 to 12,000 Hz is recommended.
- Education regarding work-related and nonwork-related causes of hearing loss.
- Sound exposure reduction measures including engineering and administrative controls.
- Use of sound-reducing PPE during exposures to loud sounds.

CONCLUSION

Performing arts work and workplaces have recognized occupational hazards. Specialized groups of physicians, therapists, teachers, and performing artists have created interest groups that are dedicated to the care of performing artists. These specialists have developed clinical expertise and research findings that have advanced the understanding of performing artists' health issues and inform the current clinical approach to these problems.

Occupational health professionals share the goals of these dedicated practitioners to reduce work-related health issues in the performing arts. They understand that a comprehensive occupational health approach could contribute to these efforts.²⁶⁸ This approach recognizes the wide scope of at-risk workers in the performing arts sector, and could help implement, monitor, and validate appropriate clinical and preventive measures.

The hazards faced by performing arts participants are usually familiar to occupational health professionals from their training and experience in other work sectors. Preventive approaches developed in other industries can often be useful in the performing arts given sufficient understanding of the specific challenges faced by these workers. Worksite visits, occupational histories, and work task evaluations can help occupational health practitioners understand the issues facing participants in the performing arts.

The occupational health history is essential to these efforts. An occupational history that explores the patient's activities both on and off the job can be particularly valuable. Occupational health

providers should also keep in mind the extreme demands of performance and the pressures to perform and succeed that their performing arts patients may experience. Performing art workers, like athletes and others, often exhibit a strong determination to quickly get back into the activity that initially caused their problem and this can be detrimental to their healing. It is important to adjust the approach to recovery to prevent overuse and premature return to activity.

Excellent resources are available for further investigations of the health issues encountered in the performing arts, including texts by physicians and other clinical specialists,¹⁷⁷ texts by safety and industrial hygiene specialists,^{55,269} and an extensive publication bibliography.¹⁷⁵

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