PREVENTION, EARLY RECOGNITION, AND INTERVENTION TECHNIQUES FOR INJURIES IN STRING PLAYERS

by

LEAH DUTTON

(Under the Direction of David Starkweather)

ABSTRACT

Over 80% of professional orchestra musicians will experience serious pain and musculoskeletal injuries over the course of their careers. As a result, up to 10% of all musicians will leave the profession due to their injuries, while others continue to play through pain until they are physically unable to perform. At present, there are no systems or strategies at the university or professional level to prevent these injuries from occurring or to support rehabilitating musicians. While the majority of these conditions are preventable or resolve easily if caught early, most musicians avoid medical treatment due to low health awareness, financial constraints, or cultural stigma.

This document explores the causes and consequences of their most prevalent injuries of orchestral string musicians in conjunction with prevention and treatment strategies. It is divided into two sections: the psychosocial and cultural aspects of injury and a physical diagnostic and rehabilitation guide. Chapters I and II explore the history, culture, and economic consequences of injury, while Chapters III and IV provide diagnostic and testing information, sample rehabilitation timelines and strategies, and exercises to increase stamina and improve

performance outcomes. This resource seeks to improve health awareness among string musicians and teachers and provide them with the tools to identify, prevent, and treat their injuries.

INDEX WORDS: Injury, Prevention, Diagnosis, Dissertation, String players, Musician Injuries, Rehabilitation, Orchestra

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CHAPTER I

Introduction

Music is a sport played on a square millimeter. Like elite athletes, musicians require extreme precision, fine motor control, stamina, and perseverance to achieve top performance while under the scrutiny of colleagues, an audience, and media pressure. These small, repetitive movements are performed in sustained and asymmetrical non-physiological postures for between 4 to 6 hours a day; therefore, it is no surprise that musicians have some of the highest injury rates of any profession.[1]

Research into the causes and treatment of musicians' injuries has increased dramatically over the past two decades, but it has had little effect on the number of reported injuries in the field. A study of 408 German professional symphony members in 2014 found that 23.5% of players reported being diagnosed with a musculoskeletal or orthopedic disease, 40% had frequent or permanent pain, and 89.5% had been affected at some point by playing-related musculoskeletal pain.[2] In Australia, a study of 377 professional orchestral musicians in 2012 reported that 84% had experienced playing-related pain, while 50% of participants reported experiencing pain at the time of the survey.[3] The largest study of 2,212 North American symphony musicians in 1988 found that 76% of participants reported a playing-related health

[1] Bosi, Bráulio. "The Reality of Injuries in a Musician's Career." *American Music Teacher* 66, no. 7, 2017.
[2] Steinmetz, A., I. Scheffer, E. Esmer, K. S. Delank, and I. Peroz. "Frequency, Severity and Predictors of Playing-Related Musculoskeletal Pain in Professional Orchestral Musicians in Germany." *Clinical Rheumatology* 34, no. 5 (January 5, 2014): 965–73. https://doi.org/10.1007/s10067-013-2470-5.
[3] Ackerman, Bronwen, Timothy Driscoll, and Dianna Kenny. "Musculoskeletal Pain and Injury in Professional Orchestral Musicians in Australia." *Medical Problems of Performing Artists* 27, no. 4 (December 2012): 181–87. https://doi.org/10.21091/mppa.2012.4034.

problem so severe that it interfered with their ability to perform.[4] These are not trifling injuries easily resolved with a few days of rest; Constant and Hochberg suggested that up to 32% of musicians with hand problems were forced to stop playing, while in over 60% of professional musicians, the musculoskeletal system was injured to the extent that performing was impossible for some period of time.[5]

Surprisingly, it is not only older musicians with a heavy workload who can expect to suffer from pain and injuries. In the aforementioned Steinmetz study, the group of musicians with pain was younger, had played for less time with the orchestra, and indicated a shorter daily and weekly workload than uninjured members.[6] Ioannou and Altenmiller found that 13% of all questioned music students experienced musculoskeletal pain every time they played, while injury rates for childhood learners, tertiary music students, and professional adult musicians were reported at 67, 88, and 84 percent.[7] The Bloemfontein Free State Orchestra is a professional South African symphony with a median age of only 24 years, yet of the 45 members of the 50-person orchestra who participated in the study, 38 (84.4%) reported injuries perceived to be related to playing their instrument.[8]

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[4] Wijsman, Suzanne, and Bronwen J. Ackermann. "Educating Australian Musicians: Are We Playing It Safe?" *Health Promotion International* 34, no. 4 (August 2019): 869–76. https://doi.org/10.1093/heapro/day030.

[5] Constant, Errikos, and F. H. Hochberg. "Hand Difficulties among Musicians." *Plastic and Reconstructive Surgery* 73, no. 3 (1984): 510. https://doi.org/10.1097/00006534-198403000-00075.

[6] Steinmetz, A., I. Scheffer, E. Esmer, K. S. Delank, and I. Peroz. "Frequency, Severity and Predictors of Playing-Related Musculoskeletal Pain in Professional Orchestral Musicians in Germany." *Clinical Rheumatology* 34, no. 5 (January 5, 2014): 965–73. https://doi.org/10.1007/s10067-013-2470-5.

[7] Ioannou, Christos I, Julia Hafer, André Lee, and Eckart Altenmuller. "Epidemiology, Treatment Efficacy, and Anxiety Aspects of Music Students Affected by Playing-Related Pain: A Retrospective Evaluation with Follow-Up." *Medical Problems of Performing Artists* 33, no. 1 (2018): 26–38. https://doi.org/10.21091/mppa.2018.1006.

[8] Barnes, R., H. Attwood, J. Blom, S. Jankielsohn, W. Janse Van Rensburg, T. Smith, L. Van Ede, and M. Nel. "Injury Profile of Musicians in the Bloemfontein-Based Free State Symphony Orchestra: a Short Report." *South African Journal of Physiotherapy* 67, no. 2 (2011): 41–44. https://doi.org/10.4102/sajp.v67i2.45.

However, the consistently high levels of debilitating injury within the profession have not spurred institutional change or educational reform within the music community. When faced with the developing symptoms of playing-related pain, most musicians choose to do nothing due to cultural stigma, financial instability, or unawareness of potentially irreversible damage.[9] Those who seek advice from their colleagues or teachers will find them to be unprepared and ill-equipped to offer useful advice, while those who pursue medical treatment are often frustrated by doctors that fail to understand the performance requirements of elite musicians.

Although more research has recently been published on this topic, it is evident that this information is not reaching its target audience in a meaningful and actionable way. College students graduate with no awareness of injury prevention and only acquire this knowledge after suffering an injury and struggling through the recovery process with little institutional or social support. Music schools do not have rehabilitation and reintegration plans for injured students or a physical therapist on staff to treat the aforementioned 88% of music students that will become injured, or the 13% that experience pain every time they play. University faculty are also unaware of how many hours each student practises on a given day and often actively discourage students from taking steps to care for their bodies when this interferes with rehearsal schedules or performances.

Remarkably, the overwhelming majority of these injuries are avoidable - a physical therapy triage clinic study found that over 94% of injuries sustained by musicians were considered preventable.[10] Despite the near certainty of injury and the importance of early

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[9] Barnes, R., H. Attwood, J. Blom, S. Jankielsohn, W. Janse Van Rensburg, T. Smith, L. Van Ede, and M. Nel. "Injury Profile of Musicians in the Bloemfontein-Based Free State Symphony Orchestra: a Short Report." *South African Journal of Physiotherapy* 67, no. 2 (2011): 41–44. https://doi.org/10.4102/sajp.v67i2.45.

[10] Chan, Cliffton, Tim Driscoll, and Bronwen Ackermann. "The Usefulness of on-Site Physical Therapy-Led Triage Services for Professional Orchestral Musicians – a National Cohort Study." *BMC Musculoskeletal Disorders* 14, no. 1 (2013): 1–9. https://doi.org/10.1186/1471-2474-14-98.

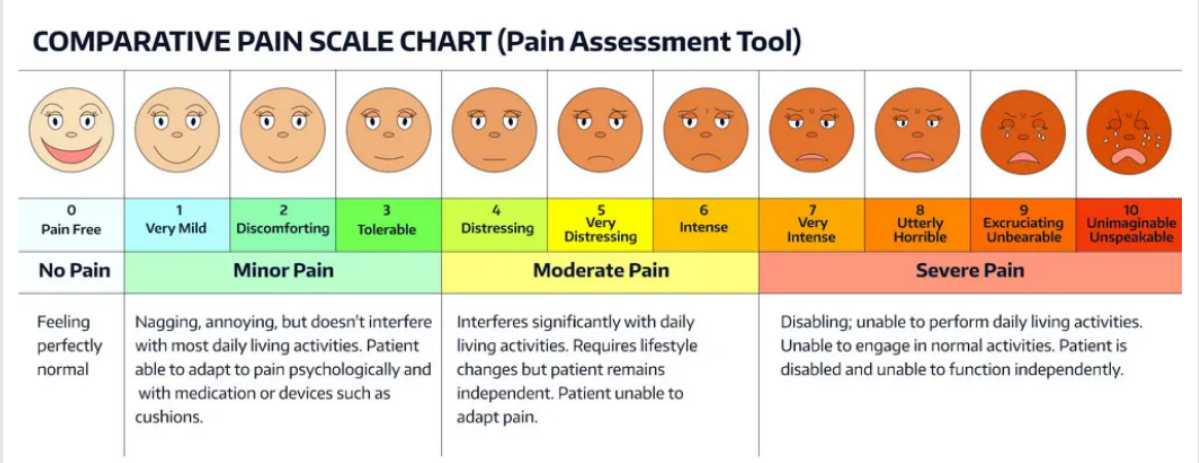
intervention, string faculty, and students do not receive any education on these conditions and as a consequence can only react after severe damage has already occurred. For most, the stress of self-medication and concealment will not resolve their problems, but instead will exacerbate the existing injury and further diminish the chances of recovery. These types of chronic cumulative trauma injuries represent a considerable rehabilitation challenge, and many young performers have been forced to abandon their careers due to irreversible damage caused by preventable conditions.

The objective of this research is to present university string students and educators with techniques of prevention, early recognition, and intervention for the conditions they are most likely to encounter over the course of their careers. This physical therapy and postural approach is presented in the form of a dissertation, which will be adapted into a textbook and comprehensive college course to improve outcomes for future generations of string musicians. This resource will explore the statistics and development of injury, causes of treatment avoidance, and strategies for working with injured musicians. It also provides terminology definitions, specialized anatomy, symptom and testing flow charts, and treatment, prognosis and sample rehabilitation timelines and strategies, along with exercises to increase stamina and improve performance outcomes for string musicians. An early intervention is the most effective treatment for all of these conditions. This research seeks to remove some of the barriers stopping musicians from accessing treatment early in their injury journey with the hope that time, money, and careers can be saved.

Injury Rates of Musicians

Musicians have some of the highest injury rates of any profession.[11] Although symphony orchestra players appear polished and professional on stage, around 40% are in pain at any given time, with a lifetime injury prevalence of around 85%.[12] In Steinmetz's study of 408 professional German musicians, 89.5% had been affected by current or past playing-related musculoskeletal pain, with 62.7% reporting pain in the past three months. While 40% of these musicians reported frequent or permanent pain, only 23.5% of symphony members sought out help and were attended by a physician and diagnosed with musculoskeletal or orthopedic conditions. Remarkably, as these surveys were performed during symphony rehearsal breaks, these high rates of injury were reported by musicians still attending work on a regular basis. When the degree of the participants' pain was measured, pain levels for musicians with frequent pain were ranked at 4.9 out of 10 (very distressing pain), while those with permanent pain averaged 6.1 (intense pain).

Figure 1.1: Comparative Pain Scale Chart



[11] Bosi, Bráulio. "The Reality of Injuries in a Musician's Career." *American Music Teacher* 66, no. 7, 2017.
[12] Steinmetz, A., I. Scheffer, E. Esmer, K. S. Delank, and I. Peroz. "Frequency, Severity and Predictors of Playing-Related Musculoskeletal Pain in Professional Orchestral Musicians in Germany." *Clinical Rheumatology* 34, no. 5 (January 5, 2014): 965–73. https://doi.org/10.1007/s10067-013-2470-5.

According to the Steinmetz study, 40% of full-time musicians experience this level of discomfort either frequently or permanently while playing their instrument. Performing under these conditions in any other profession would be unthinkable, as it would be seen as damaging to not only the employee's current production but also their future output. However, most musicians continue to push themselves to their physical limit, making it nearly impossible to produce music at their highest level or adequately prepare for a performance.

There are several factors that predispose participants to a higher incidence and severity of pain and lead to a greater incidence of musculoskeletal injuries. The association with pain was slightly higher in females, those with stage fright, and violinists.[13] [14] [15] String players are generally the most affected by injuries, with only 9.6% never experiencing any pain, compared to brass players (16.4%), woodwinds (13.1%), and percussionists (15.4%). Although a similar pain intensity was felt by both females and males, females reported more pain regions and were more likely to develop overuse syndrome in all anatomical locations, especially the shoulder, neck, and back.

Remarkably, although research into the causes of musicians' injuries has been widely available for the past 40 years, there has been no institutional effort to prevent these injuries from occurring. Although older musicians do have a slightly lower injury rate than their younger colleagues, this may simply mean that these musicians have learned to manage their pain through the years, while others were forced to abandon their careers when confronted by a debilitating

[13] Steinmetz, A., I. Scheffer, E. Esmer, K. S. Delank, and I. Peroz. "Frequency, Severity and Predictors of Playing-Related Musculoskeletal Pain in Professional Orchestral Musicians in Germany." *Clinical Rheumatology* 34, no. 5 (January 5, 2014): 965–73. https://doi.org/10.1007/s10067-013-2470-5.
[14] Leaver, R., E. C. Harris, and K. T. Palmer. "Musculoskeletal Pain in Elite Professional Musicians from British Symphony Orchestras." *Occupational Medicine* 61, no. 8 (2011): 549–55. https://doi.org/10.1093/occmed/kqr129.
[15] Ackerman, Bronwen, Timothy Driscoll, and Dianna Kenny. "Musculoskeletal Pain and Injury in Professional Orchestral Musicians in Australia." *Medical Problems of Performing Artists* 27, no. 4 (December 2012): 181–87. https://doi.org/10.21091/mppa.2012.4034.

injury. According to the Peabody Institute's Center of Performing Arts Medicine, eight out of ten musicians will encounter a physical disorder that affects their playing. Only two will recover; five will manage chronic symptoms for the rest of their career, while one in ten (10% of all musicians) will leave the music field permanently due to the extent of their injuries.[16]

Although beginner musicians (< 3 years of playing time) had an overall absence of pathologies, studies have found that 13% of all music students experienced musculoskeletal pain every time they played.[17] The incidence of injury rates for childhood learners, tertiary music students, and professional musicians in Australia has been reported at 67%, 88%, and 84% respectively, indicating consistently high levels of injury and a marked increase during college years. It is evident that despite the relative wealth of statistics and information, there is an overall disconnect between the medical professionals performing these studies and their application in classrooms and symphony halls.

History of Injuries

The high rate of recorded injury among musicians has remained constant since the 1800s when the first study on musicians' injuries was published in 1887 by physician George Poore. In his clinical lecture, "Certain Conditions of the Hand and Arm Which Interfere with the Performance of Professional Acts, Especially Piano Playing", Poore cited musicians' limited awareness in the field of occupational medicine as a key factor in the development of injuries.[18]

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[16] Rienzi, Greg. "MUSICIANS GET HURT A LOT: PAGING DR. SERAP BASTEPE-GRAY." *Johns Hopkins Magazine*. Johns Hopkins University, 2016. https://hub.jhu.edu/magazine/2016/fall/peabody-doctor-for-musicians-injuries/.

[17] Ioannou, Christos I, Julia Hafer, André Lee, and Eckart Altenmuller. "Epidemiology, Treatment Efficacy, and Anxiety Aspects of Music Students Affected by Playing-Related Pain: A Retrospective Evaluation with Follow-Up." *Medical Problems of Performing Artists* 33, no. 1 (2018): 26–38. https://doi.org/10.21091/mppa.2018.1006.

[18] Poore, G. V. "Clinical Lecture on Certain Conditions of the Hand and Arm Which Interfere with the Performance of Professional Acts, Especially Piano-Playing." *BMJ* 1, no. 1365 (1887): 441–44. https://doi.org/10.1136/bmj.1.1365.441.

Famous musician couple Robert and Clara Schumann suffered greatly from musculoskeletal injuries, as Robert wrote in 1838:

> "All the music is complete and alive within me, so that I wish to effortlessly breathe it out, but now I can hardly bring it forth; I trip over one finger with the other. This is truly frightening and has already caused me much pain".[19]

This neurological impairment in his right hand, thought to be a combination of focal dystonia and the unfortunate result of a mechanical hand-stretching tool, severely impacted his later career. After attempting to treat his condition through a combination of diet, electrotherapy, and "animal baths" (whereby he would immerse his hand into the abdominal cavity of a freshly slaughtered animal until the warmth subsided), an unsuccessful Schumann abandoned performing in public and instead turned to composition in 1834.[20] Clara Schumann also experienced what would now be called overuse syndrome, which forced her to take nearly two years off from performing. The phenomenal 19th-century Polish pianist Ignacy Paderewski was so intent on impressing American audiences in 1891, that during his impassioned performance of Beethoven's Appassionata Sonata he tore the tendons in his right arm and injured one of his fingers.[21] After this concert, he was in constant pain, and required massages and jolts of electricity before concerts to stimulate any sort of movement in his ring finger. He would never recover the full use of his digits but instead finished out his concert series by teaching himself to play piano with just four fingers of his right hand.

Sometimes, congenital deformities or genetic conditions allowed performers to push the boundaries of what was physically possible on their instruments. Niccol Paganini and Sergei

[19] Betzl, Julia, Ursula Kraneburg, and Kai Megerle. "Overuse Syndrome of the Hand and Wrist in Musicians: a Systematic Review." *Journal of Hand Surgery (European Volume)* 45, no. 6 (July 2020): 636–42. https://doi.org/10.1177/1753193420912644.
[20] Franklin, James L. "Robert Schumann's Hand Injury." *Hektoen International* 13, no. 1 (2021). (https://hekint.org/2020/08/18/robert-schumanns-hand-injury/).
[21] Taylor, David A. "Paderewski's Piano." *Smithsonian Magazine*, March 1999.

Rachmaninoff were suspected of suffering from Marfan Syndrome: a condition that results in increased arm and finger length, as well as flexibility in the joints of the hands and wrist. Although it is unknown whether either of the men were aware they suffered from a genetic abnormality, both Paganini and Rachmaninoff took advantage of their natural physical gifts and composed pieces specifically to show off those abilities. In 1831, Paganini's personal physician wrote,

"Paganini's hand is not larger than normal; but because all its parts are so stretchable, it can double its reach. For example, without changing the position of the hand, he is able to bend the first joints of the left fingers –which touch the strings– sideways, at a right angle to the natural motion of the joint, and he can do it with effortless ease, assurance, and speed. Essentially, Paganini's art is based on physical endowment, increased and developed by ceaseless practicing."[22]

Although violin performance has always required reasonable flexibility, the technical modifications made by Paganini and other composers required such impossible reach for the average musician that young music students sought means to modify their own anatomy to achieve similar results. Dr. William Forbes announced a surgical procedure in 1857 to slice through the hand to "liberate the ring finger" and increase the possible anatomical reach of the performer.[23] Pianists Franz Lizst, Ludwig van Beethoven, Chopin, and Robert Schumann possessed remarkably little webbing between the fingers, leading to rumors that it was removed to better facilitate large spacing. Whether these musicians actually went through with the procedure is unclear; however, by 1885, this operation had been "refined" to the point where the

[22] Nelson, David. "Paganini, How The Great Violinist Was Helped By A Rare Medical Condition." *North Carolina's News and Record*. January 9, 2011.
[23] Forbes, William. "Liberation of the Ring Finger in Musicians." *The Hahnemannian Monthly* 20 (1885): 121–21.

underlying tendons were also cut.[24] When Franz Lizst's student, Johanna Wenzel, asked about his thoughts on the procedure, Liszt responded:

> My dear young lady:
>
> In reply to your friendly lines I earnestly beg of you to think no more of having the barbarous finger operation. Better to play every octave and chord wrong throughout your life than to commit such a mad attack upon your hands.[25]

Although such procedures have fallen out of fashion due to their limited advantages and potentially disastrous consequences, developing child musicians are still expected to perform works by genetically gifted adult composers like Paganini, Rachmaninoff, and Chopin. Although children typically play on smaller instruments, pianists possess no such modifications, and young string virtuosos are often pushed to play on full-size instruments before they are anatomically capable. Also, many cellists would greatly benefit both technically and physically from a ⅞ size professional cello, but unfortunately, the cultural demand for this instrument is still low, making quality specimens difficult to find.

Musicians as Musical Athletes: Contributing Factors to Injury Development

The long hours of daily practice and the complex neuromuscular skills involved in playing an instrument at a professional level are comparable to the training and performance demands of elite athletes.[26] Like athletes, most musicians begin training for their future careers in early childhood and spend hours every day dedicating themselves to their craft. These young students are under enormous pressure to push the boundaries of what is physically possible

[24] Walker, Alan. *Franz Liszt / the Final Years, 1861-1886*. 3. Vol. 3. London: Faber and Faber, 1997.
[25] Ibid.
[26] Guptill, Christine, and Matthew Bruijn Golem. "Case Study: Musicians' Playing-Related Injuries." *Work* 30, no. 3 (2008): 307–10.

through complete dedication, professional coaching, and regular group and personal practice.[27] Musicians and athletes are also prone to overuse injuries due to their highly specific postural requirements and resultant muscle imbalances, but these injuries are typically predictable and fall within similar categories across sports and instrument groups. These careers demand extreme precision, fine motor control, stamina, and perseverance to endure the long hours of practice and training required for top performance, as well as mental fortitude to withstand the psychological stress of constant public performance and achievement.

However, although student-athletes are injured at a similar rate as student-musicians, these injuries are not treated equally by educational institutions.[28] Universities with competitive sports programs generally employ between 5-20 athletic trainers: fully qualified medical professionals specializing in injury prevention and first aid for student-athletes.[29]Athletic trainers create personalized rehabilitation plans in case of injury and guide students through rehabilitation and recovery training while providing regular updates and reports to the coach. Depending on the sport, an additional one or two trainers may be assigned to each team on a full-time basis, in addition to full or part-time physicians, orthopedists, surgeons, chiropractors, and psychiatrists. Student athletes' class schedules are designed for them so they can dedicate their time to "prehab" before practices/competition and recovery work after big games. Universities invest millions of dollars to renovate and upgrade their sports medicine facilities, typically used exclusively by student-athletes, which often include hydrotherapy pools, underwater treadmills,

[27] Steinmetz, A., I. Scheffer, E. Esmer, K. S. Delank, and I. Peroz. "Frequency, Severity and Predictors of Playing-Related Musculoskeletal Pain in Professional Orchestral Musicians in Germany." *Clinical Rheumatology* 34, no. 5 (January 5, 2014): 965–73. https://doi.org/10.1007/s10067-013-2470-5.
[28] Chandran, Avinash, Sarah N. Morris, Jacob R. Powell, Adrian J. Boltz, Hannah J. Robison, and Christy L. Collins. "Epidemiology of Injuries in National Collegiate Athletic Association Men's Football: 2014–2015 through 2018–2019." *Journal of Athletic Training* 56, no. 7 (2021): 643–50. https://doi.org/10.4085/1062-6050-447-20.
[29] Fletcher, David. "Injury Prevention and Medical Care for College Athletes." Web log. *Athletica Demix* (blog), September 21, 2020. https://athleticademix.com/injury-prevention-and-medical-care-for-college-athletes/.

and oxygen tents to monitor athletic performance through premium sports science technology and analytical equipment.[30] Student-athletes also receive this treatment free of charge through their health insurance, and health insurance premiums and deductibles are often covered as part of their scholarship package. If they need a scan or magnetic resonance imaging (MRI), one is arranged right away. If they need to see a specialist, an appointment is made for them. If they feel sore after a difficult game, the athletic training staff is available from dawn until late into the evening to help them and take their health and fitness seriously. The University of Georgia, for example, employs 18 sports medicine professionals, 13 full-time physicians, 10 hospital staff, and 10 athletic training education professionals to care for its 552 student-athletes.[31] As these professionals are full-time staff members, students are encouraged to always use their services and report every symptom to their athletic trainers and coaches.

These athletes have everything they need to quickly return to competition after injury, and for good reason: if a college is investing scholarship funding into one of their athletes, they need them in prime condition to perform as much, and as well, as possible. While only 2% of college athletes will play professionally after graduation, this time and money spent on their health education and wellness is not seen as an exorbitant waste of funding - indeed, the University of Georgia's athletic budget for 2022 was $150,290,994, making the cost of a single preventative trainer pale by comparison.[32] [33] These services are not seen as excessive, but instead essential to the well-being and performance outcomes of the students during and after college.

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[30] Fletcher, David. "Injury Prevention and Medical Care for College Athletes." Web log. *Athletica Demix* (blog), September 21, 2020. https://athleticademix.com/injury-prevention-and-medical-care-for-college-athletes/.
[31] "UGA Sports Medicine - Staff." University of Georgia Athletics. Accessed June 16, 2022. https://georgiadogs.com/sports/2017/6/17/ot-sports-medicine-sports-med-staff-html.aspx.
[32] National Federation of State High School Associations. *NCAA Recruiting Facts*. National Federation of State High School Associations, 2014. https://www.nfhs.org/media/886012/recruiting-fact-sheet-web.pdf.
[33] Shelton, J. C. "UGA Athletics Reveals Huge Budget for 2021." *UGA Wire*. May 28, 2021. https://ugawire.usatoday.com/2021/05/28/georgia-foootball-uga-athletics-reveals-huge-budget-2021/.

In contrast, despite the near certainty of injury within university music schools, music students and teachers have no access to medical resources, training facilities, or injury prevention and treatment plans. This is increasingly frustrating for university students, who often pay up to 10% of their tuition to subsidize university sports teams and facilities, adding thousands of dollars to student loan debt.[34] Of the 230 NCAA Division 1 public universities in the U.S., 80% charge students a fee to finance their sports teams, sometimes up to several thousand dollars. Many of these schools receive over half of the entire athletic department revenue from these student fees, amounting to several million dollars per year.

Despite these and other tuition contributions, there are no designated professionals on staff to treat the 88% of college music students that will become injured.[35] Music students have to design their own treatment plans, make their own appointments, and make medical decisions with no input or advice from a coach or staff member that understands their everyday needs and schedule. Finding a qualified medical professional that is familiar with the injuries and demands of a musician's lifestyle is also prohibitively difficult: most cities in the U.S. have no performing arts specialist clinics, making quality care a costly and time-consuming endeavor.

The most important role of an athletic trainer to a young musician or athlete is that of a representative and advocate. A first-year undergraduate student must not only discover, care for, and follow up with treatment for their condition, but they must also be able to defend their absences to their conductor, refuse to perform until they are fully healed, and stop playing during a rehearsal when pain occurs. There is no one to explain the medical necessity of these interventions and report to the administration about the student's progress and no one to support

[34] Enright, Merritt, Andrew W. Lehren, and Jamie Longoria. "Hidden Figures: College Students May Be Paying Thousands in Athletic Fees and Not Know It." *NBC News*, March 8, 2020. https://www.nbcnews.com/news/education/hidden-figures-college-students-may-be-paying-thousands-athletic-fees-n1145171.

[35] Wijsman, Suzanne, and Bronwen J. Ackermann. "Educating Australian Musicians: Are We Playing It Safe?" *Health Promotion International* 34, no. 4 (August 2019): 869–76. https://doi.org/10.1093/heapro/day030.

them when it is medically necessary, making the power dynamic between these groups difficult to navigate for students who would rather endure pain than be seen as insubordinate, lazy, or weak by their teachers. Private lesson teachers are in a prime position to provide treatment and advice to students, but unlike sports coaches, they never receive any medical education and are unaware of how to prevent and treat injuries specific to their profession.[36] Injured students who do not receive proper care may abandon the musical field altogether, while the students who are able to stay and power through the pain are not equipped to teach their future students healthy habits.

Cultural Influences on Injuries

The source of health problems and treatment avoidance in the music community can be traced to several factors that have remained constant for centuries. First, the majority of musicians are unaware of the warning signs of injury, the length of recovery times, and the risk factors of specific instruments due to the absence of specialized health education. Students who do not know that pain is problematic will likely be equally unaware that there are simple and actionable solutions. Those who do not have enough experience to quantify their pain will have difficulty distinguishing between a passing twinge and the preliminary stages of a serious injury. Temporary discomfort is not uncommon when studying a stringed instrument, but all types of injuries are not considered equal; although a sore muscle can strengthen and heal within a few days, the turnover rate of injured tendon and ligament tissue is between one to three years, making any damage to these structures career-threatening.[37] Surprisingly, resolving injuries,

[36] Rickert, Dale L. L., Margaret S. Barrett, and Bronwen J. Ackermann. "Are Music Students Fit to Play? A Case Study of Health Awareness and Injury Attitudes amongst Tertiary Student Cellists." *International Journal of Music Education* 33, no. 4 (2015): 426–41. https://doi.org/10.1177/0255761415582343.
[37] Dutton, Mark. *Dutton's Orthopedic Survival Guide: Managing Common Conditions*. New York, NY: McGraw-Hill Medical, 2011.

particularly through adaptations to playing technique, is often beneficial not only physically but musically. Several studies report that the degree of ergonomic risk strongly correlates with the extent of the professional performing skill.[38] Therefore, the more elaborate and developed the performer's skills and musical technique, the better the music will sound and the safer it is for their health.[39]

Most U.S. musicians will subsist as freelance performers at some point during their careers, making financial stability and easy access to quality, specialized medical care a near impossibility. Early intervention and access to quality medical care are seen as the most important factors in determining the likelihood of return from injury, but this is often out of reach for gigging musicians without affordable healthcare. Often the choice is between struggling through pain and earning $500 or paying $500 to go to the doctor, to only be prescribed pain medication and rest. Even when health insurance is available, there is a poor fit between generic injury insurance and the highly specific requirements of professional musicians. Standard recovery and return-to-work timelines used by most businesses are based on averages of normal workers performing regular, day-to-day tasks that do not reflect a musician's highly specific and refined requirements. Medical professionals who jump to conclusions about injuries without considering the instrument, practice schedule, and rehearsal demands of the musician will be met with distrust and noncompliance during consultation and rehabilitation.

The final, and most important factor in both the cause and the severity of a musician's injuries involves the cultural and social stigma surrounding injury and recovery. Pain and injuries are taboo topics and are never mentioned inside the classroom or the concert hall. Many

[38] Rietveld, A. B. M. "Dancers' and Musicians' Injuries." *Clinical Rheumatology* 32, no. 4 (April 10, 2013): 425–34. https://doi.org/10.1007/s10067-013-2184-8.
[39] Schramayr, Ernie. "Just like Athletes, Musicians Need Physical Training to Avoid Injury." *The Spectator*. April 12, 2017.

musicians graduate from university thinking that pain is a normal part of performance and spend years guiltily searching for ways to mask the effects of the developing injury instead of treating the underlying cause. In the Bloemfontein Free State Symphony, 63% of the participants continued to play while experiencing symptoms, and 44.7% did nothing to treat their injury once it developed.[40] This denial of symptoms comes from the emotional and psychological trauma of injuries, as they can change the hierarchy in the music school and orchestra, decrease opportunities, and result in guilt from asking to take time off work. Psychosocial pressure to conceal symptoms and pain plays a considerable role in the development of chronic injuries, as it forces musicians to only disclose injuries or seek medical treatment once they are physically unable to play.[41] Although the majority of these conditions are easily resolvable when discovered and treated early, concealment results in chronic, cumulative trauma injuries that become a considerable rehabilitation challenge.

Development of Injuries

Sudden, traumatic injuries in musicians are rare. Most injuries are caused or at least triggered by an imbalance between load and load-bearing capacity, overuse, or misuse.[42] Musician injuries typically develop in the upper extremities, but can also occur in the back and lower extremities due to the long hours spent sitting or standing in stationary (isometric) positions. The leading symptoms are pain, weakness, stiffness, and loss of motor control during

[40] Barnes, R., H. Attwood, J. Blom, S. Jankielsohn, W. Janse Van Rensburg, T. Smith, L. Van Ede, and M. Nel. "Injury Profile of Musicians in the Bloemfontein-Based Free State Symphony Orchestra: a Short Report." *South African Journal of Physiotherapy* 67, no. 2 (2011): 41–44. https://doi.org/10.4102/sajp.v67i2.45.
[41] Rickert, Dale L. L., Margaret S. Barrett, and Bronwen J. Ackermann. "Are Music Students Fit to Play? A Case Study of Health Awareness and Injury Attitudes amongst Tertiary Student Cellists." *International Journal of Music Education* 33, no. 4 (2015): 426–41. https://doi.org/10.1177/0255761415582343.
[42] Rietveld, A. B. M. "Dancers' and Musicians' Injuries." *Clinical Rheumatology* 32, no. 4 (April 10, 2013): 425–34. https://doi.org/10.1007/s10067-013-2184-8.

or shortly after playing or practicing.[43] Pain can also be present at rest or even while sleeping, and may even prevent musicians from performing everyday tasks such as pouring a glass of milk or turning a door handle. Stiffness, tingling, and other abnormal sensations may precede the actual overuse syndrome and appear in close relation to making music. There can also be sensory changes and swelling over the painful area and tenderness as the muscles or joints, while the muscles may move unintentionally, may fatigue more easily, or go into cramps or involuntary spasms during playing.

Any abrupt change in musical habits is a large risk factor and needs to be approached carefully, with a gradual and methodical approach that provides sufficient time for rest and recovery. Injuries can result from a change in:

- Teacher
- Instrument
- Repertoire
- Increased computer use
- Practice or performance habits
- Modification of practice patterns after a vacation or in preparation for a concert, recital, audition, or exam
- Changes to fundamental technique
- Other physical activity or hobby
- Stress levels

Although most people are physically capable of playing and performing for many hours a day, healthy adaptation to major change can take up to a year. Planning ahead and preparing

[43] Betzl, Julia, Ursula Kraneburg, and Kai Megerle. "Overuse Syndrome of the Hand and Wrist in Musicians: a Systematic Review." *Journal of Hand Surgery (European Volume)* 45, no. 6 (July 2020): 636–42. https://doi.org/10.1177/1753193420912644.

students for these transitions will not only prevent the majority of injuries from occurring but will also help alleviate last-minute cram sessions before recitals and performances.

The risk for developing performance-related medical disorders begins in childhood, with the most critical point occurring during university music courses.[44] Students will likely experience diminishing health during this transitional point between childhood participation and professional performance, with an increase in stress, pain, and injuries. Public schools provide a structured and obligatory respite from the instrument, but music majors at university will find that the proportion is reversed, as both their school hours and free time are devoted to practicing and performing. This dramatic increase in practice time, accompanied by low self-responsibility for their own health and poor awareness of the physical and psychological risks they face results in a substantial increase in injuries. The intense focus on balancing recitals, rehearsals, and performances results in stress, increased practice hours, inadequate nutrition and less sleep, creating an optimal environment for injury development. Injury rates increase dramatically while students are in their 20s, but awareness of risk factors is not widely known and only appears after they begin to struggle with injuries as a result of the extra workload.

[44] Rickert, Dale Ll, Margaret S Barrett, and Bronwen J Ackermann. "Injury and the Orchestral Environment: Part III. The Role of Psychosocial Factors in the Experience of Musicians Undertaking Rehabilitation." *Medical Problems of Performing Artists* 29, no. 3 (September 2014): 125–35. https://doi.org/10.21091/mppa.2014.3028.

CHAPTER II

Barriers to Prevention and Treatment

Although there has been a marked increase in published research about musician injuries over the last 30 years, there is comparatively little material that highlights the specific rehabilitation needs of professional musicians.[45] Most studies are designed by musicians with little to no medical background and therefore focus only on the frequency, definitions, and causes of the conditions. For legal or practical reasons, these types of studies generally do not provide any advice on how to prevent or treat these injuries or calls to action directed at the music community. While many treatment and intervention methods have been theorized by musicians and medical professionals, there are no published studies on their efficacy, making it difficult to convince orchestras, educational institutions, and musicians themselves of their importance. Early specialized medical assessment and intervention are essential for positive rehabilitation outcomes, but students who are unaware of the potential dangers and afraid of the cost, time constraints, and social stigma that come with injuries will be wary to seek out help. About 35% of music students affected by playing-related pain do not ask their teachers, colleagues, or doctors for any help but rather employ self-help strategies or their own pain reduction techniques.[46] When young musicians do seek help, it is often from their peers, instructors, or private lesson teachers rather than initially consulting a medical professional. When they do seek professional medical advice, only 28% reported receiving satisfactory treatment.

[45] Rickert, Dale Ll, Margaret S Barrett, and Bronwen J Ackermann. "Injury and the Orchestral Environment: Part III. The Role of Psychosocial Factors in the Experience of Musicians Undertaking Rehabilitation." *Medical Problems of Performing Artists* 29, no. 3 (September 2014): 125–35. https://doi.org/10.21091/mppa.2014.3028.
[46] Ioannou, Christos I, Julia Hafer, André Lee, and Eckart Altenmuller. "Epidemiology, Treatment Efficacy, and Anxiety Aspects of Music Students Affected by Playing-Related Pain: A Retrospective Evaluation with Follow-Up." *Medical Problems of Performing Artists* 33, no. 1 (2018): 26–38. https://doi.org/10.21091/mppa.2018.1006.

Currently, the fields of health and music are still separate entities, with little interdisciplinary collaboration. Until the late 20th century, nearly all published studies were by music teachers or individual physicians attempting to describe and resolve the problem on their own, with little collaboration between the two.[47] Not surprisingly, these attempts were largely unsuccessful, as musicians did not have enough knowledge in the field of anatomy and physiology, while physicians were unable to understand the culture and elite performance requirements of musicians. Medical professionals also often overlooked the influence of the private lesson teacher: a mentor and authority figure who has the unique opportunity and responsibility to work individually with a student for many years. A musician may be referred to a doctor only once for treatment, but their private lesson teacher has constant access and influence over consistency in both positive and negative habits. These teachers, therefore, carry a large proportion of the responsibility for ensuring their student's well-being and monitoring their physical and mental health. As the primary source of injury prevention knowledge of most teachers is based only on their own experiences, this puts them in a compromised position to understand the concerns of their students and mitigate the risks they face.[48] Although some music teachers have created treatment techniques that greatly reduce the incidence of injury, these achievements generally do not receive widespread recognition and circulation, meaning that even the best music schools in the country have little exposure to ergonomic performance training and cannot adequately educate their students on professional health maintenance.

For many musicians in the United States, access to affordable healthcare options is also a major concern. The majority of freelance musicians are unlikely to have health insurance,

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[47] Schramayr, Ernie. "Just like Athletes, Musicians Need Physical Training to Avoid Injury." *The Spectator*. April 12, 2017.

[48] Rickert, Dale Ll, Margaret S Barrett, and Bronwen J Ackermann. "Injury and the Orchestral Environment: Part III. The Role of Psychosocial Factors in the Experience of Musicians Undertaking Rehabilitation." *Medical Problems of Performing Artists* 29, no. 3 (September 2014): 125–35. https://doi.org/10.21091/mppa.2014.3028.

forcing many to rely on advice from their teachers, colleagues, and the internet for their diagnosis and treatment.[49] Specialized clinics are even more scarce and expensive, but at least they are available. Outside of the United States, there are few musician-centered rehabilitation centers or doctors with relevant education and practical experience, forcing many musicians to travel great distances for adequate treatment.[50] However, many are left without a choice, as the average referral to one of these clinics is described as "a long line of previous consultants who have failed to resolve the problem".[51] While this project focuses on western classical musicians, musicians across all styles and genres have a similarly high incidence of health problems, leaving many across the world without treatment regardless of their geographic location or socioeconomic status.[52]

Full-time musicians with healthcare benefits have more options available, but they still vastly under-utilize these resources. Musculoskeletal disorders are the third leading cause of years lived with disability globally among all working populations and account for 70% of workers' compensation claims and 77% of their costs.[53] Some orchestras pay as much as 5% of their annual salary costs on health insurance premiums, which amounted to $10 million for five Australian orchestras between 2005-2015. In Australia's professional orchestras, despite the fact that the 12-month prevalence of symptoms among musicians was 93%, only 3.4% filed claims for worker's compensation during this period. The reasons for this varied; 10% did not file a

[49] Guptill, Christine. "The Lived Experience of Working as a Musician with an Injury." *Work* 40, no. 3 (2011): 269–80. https://doi.org/10.3233/wor-2011-1230.
[50] Schramayr, Ernie. "Just like Athletes, Musicians Need Physical Training to Avoid Injury." *The Spectator*. April 12, 2017.
[51] Guptill, Christine. "The Lived Experience of Working as a Musician with an Injury." *Work* 40, no. 3 (2011): 269–80. https://doi.org/10.3233/wor-2011-1230.
[52] Wijsman, Suzanne, and Bronwen J Ackermann. "Educating Australian Musicians: Are We Playing It Safe?" *Health Promotion International* 34, no. 4 (August 2019): 869–76. https://doi.org/10.1093/heapro/day030.
[53] Stanhope, Jessica, Philip Weinstein, and Dino Pisaniello. "What Can Musicians' Claims Data Reveal about Their Musculoskeletal Conditions?" *Archives of Environmental & Occupational Health* 75, no. 3 (2020): 177–90. https://doi.org/10.1080/19338244.2019.1605968.

claim for fear of demotion, 11% did not want their coworkers to be aware of their injuries, and 6% said there was too much paperwork. Of the filed claims, 60% were for injuries, rather than diseases, which is the opposite of the gradual onset of overuse conditions typically expected in this population. This discrepancy highlights the difficulty of the burden of proof a musician needs to demonstrate to justify that they are injured. Traumatic injuries are easier to identify as legitimate conditions, as they have more obvious symptoms that appear during a basic medical exam. They may also be easier to report, as there is an "incident" where the date and location can easily be cited, in comparison to the chronic exposure leading to musculoskeletal diseases. Contributing factors for these conditions may combine work and non-work-related activities spanning years, making it nearly impossible to pinpoint a causing factor or injury.

Once a patient does receive medical care, they are sent home to continue their recovery and are often thrown back into the hectic routines that originally caused the injury. Adherence to an exercise or rehabilitation program is essential for positive outcomes, but this greatly depends on the patient, their relationship with the organizational structure in which they work, and the physical and psychological demands made on them during this time.[54] The primary barriers to accessible health education are time constraints, inadequate knowledge/information, and the rigidity of organizational structures. However, these barriers can act as discouragers *or* facilitators of health education and awareness. Organizational structures in particular can adjust scheduling, convey the consequences of health issues associated with risk behaviors, and provide assistance in identifying and resolving barriers. Health education within the music education system is only the first step to injury prevention; regardless of whether or not music schools

[54] Ajidahun, Adedayo Tunde, Hellen Myezwa, Witness Mudzi, and Wendy-Ann Wood. "Barriers and Facilitators in Implementing an Exercise-Based Injury Prevention Program for String Players." *Work* 64, no. 4 (2019): 713–20. https://doi.org/10.3233/wor-193033.

present this information to students, it is the individual's workplace that will ultimately determine whether these skills and knowledge are practical and actionable for daily use.

Without institutional support and a setting-based approach to health literacy, the overall uptake of injury prevention exercises and utilization of resources will likely not increase. Office workers who are handed a pamphlet on carpal tunnel syndrome prevention will not instantly be protected from the condition, but offices that prioritize wellness in their day-to-day interactions and activities and offer employees opportunities and incentives to get help will likely see greater success.

Although injury prevention for musicians is usually structured around warm-up exercises, strength training, breaks, and schedule management, these recommendations have never been clinically studied and are based more on subjective views than any scientific validation. Although the causes and development of musicians' injuries have been explored in great detail over the past decades, little research has been done to propose and study concrete, actionable solutions to these problems. Caring for the needs of these students and performers has the potential to enhance performance quality and ensure the sustainability of musicians' contributions to American culture.

Duty of Care in Music Education Systems

Considering the now well-documented incidence of injury in student musicians, educational institutions that continue to ignore this problem must also consider the legal implications and ramifications associated with non-delegable duty-of-care in the same way they apply to sports coaching or physical education. As there is already a legal precedent for the care required by a school to its students, the question is not whether such a duty exists, but the extent

of that duty. As most music students do participate in activities that generate income for the university, the university is responsible, to some degree, for any reasonably foreseeable harm to their bodily welfare during activities held on campus.[55] This is part of the reason why sports teams have so many trainers and doctors on staff, why coaches receive health training and education, and why athletic facilities have the best equipment available. Student-athletes receive these services under the implicit assumption that it will not only help them prevent injuries and lawsuits, but will also allow them to perform competitively at their best.

Considering this special relationship and the high rate of injury among student musicians caused by required activities on the university campus, music education institutions need to reevaluate their legal obligations to the students in their care. Faculty members who encourage students to perform despite their injuries and universities that decline specialist medical care for music students because it is not financially profitable may face legal repercussions in the future. At present, training programs that prepare musicians for the physical and psychological demands of their future careers are minimal, or in most cases, simply do not exist. There are no physical trainers or physical therapists available to immediately assess students, nor outreach to inform them of their resources and educate them about injury risks and treatment. Although music teachers and university faculty recognize that they take some degree of responsibility for their student's performance health, they also acknowledge that they do not have the skills or training to understand their students' concerns and mitigate the risk factors they face. Paradoxically, despite this lack of knowledge, they are often the first people consulted by injured students regarding performance-related problems. This results in potentially unrealistic expectations,

[55] McGirt, Michelle D. "Do Universities Have a Special Duty of Care to Protect Student-Athletes from Injury." *Sports Law Journal* 6, no. 1 (1999). https://digitalcommons.law.villanova.edu/mslj/vol6/iss1/8/?utm_source=digitalcommons.law.villanova.edu%2Fmslj%2Fvol6%2Fiss1%2F8&utm_medium=PDF&utm_campaign=PDFCoverPages.

unnecessary health risks, a higher likelihood of failure in the task itself and poor performance outcomes. As the quantity and quality of activity that musicians can contribute to society is contingent on both their health and the quality of education that they receive, it is necessary to implement a settings-based approach to health literacy that combines the delivery of health education into the delivery of music education.

Recognizing and Addressing Gender Bias in Medicine

In 1913, the Queen's Hall Orchestra in London, England hired six female violinists to perform as tenured section members. As unremarkable as it may seem today, these were the first women in the world hired by a professional orchestra, as they had previously only been allowed to perform in separate "women's only" ensembles. Women began to join American orchestras in 1930, but some orchestras held out remarkably long; it wasn't until 1982 and 1997 that the Berlin and Vienna Philharmonic hired their first women members. That does not mean that women did not perform with these groups; prior to that date, women could be engaged regularly, but were not publicly listed as orchestra members or awarded tenured posts.

Over the past 100 years, the percentage of women in American orchestras has sharply risen, from 5% in 1940, to 25% in 1990, to nearly 40% today. This increase is especially remarkable given the low turnover rate in symphony orchestras, where some positions may only become available once in a generation. The adoption of "blind" auditions in the '70s and '80s greatly reduced sex-based hiring, increasing the likelihood that a female musician would be selected in the final round by 30%.[56] In today's orchestras, most women are found in the string

[56] Goldin, Claudia, and Cecilia Rouse. "Orchestrating Impartiality: The Impact of 'Blind' Auditions on Female Musicians." *American Economic Review* 90, no. 4 (September 2000): 715–41.

section, where 48% of violists and 32% of cellists are female, while women outnumber men in the violin section with 59% of its members. However, this does have a downside; the greatest risk factors for injury in musicians are female gender and playing a stringed instrument - especially the violin.[57]

Just as women face discrimination in the audition process, they also face implicit and explicit discrimination in musical injuries when it comes to medical treatment, disability benefits, and workplace support.[58] Before the 1990s, medical studies only included males as test subjects because they did not have menstrual cycles and could not become pregnant. Unfortunately, unbeknownst to researchers at the time, gender also influences all cell physiology and biology, the manifestation of diseases, and treatment responses.[59] It is now commonly known that the biological and hormonal differences between the sexes greatly influence how diseases, drugs, and other therapies affect patients. While 70% of the people with chronic pain are women, 80% of pain studies are conducted on male mice or human men.[60] This lack of inclusivity has left doctors with a limited understanding of the health of females and intersex members, leading many doctors to blame female patients for exaggerating their symptoms when a drug is not as effective or has more side effects in the female body.

This is a problem, because before pain is taken seriously and included as a symptom of a possible disorder, it first has to be validated by a medical professional. Unfortunately, women are

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https://gap.hks.harvard.edu/orchestrating-impartiality-impact-%E2%80%9Cblind%E2%80%9D-auditions-female-musicians.

[57] Rickert, Dale Ll, Margaret S Barrett, and Bronwen J Ackermann. "Injury and the Orchestral Environment: Part III. The Role of Psychosocial Factors in the Experience of Musicians Undertaking Rehabilitation." *Medical Problems of Performing Artists* 29, no. 3 (September 2014): 125–35. https://doi.org/10.21091/mppa.2014.3028.

[58] Paulsen, Emily. "Recognizing, Addressing Unintended Gender Bias in Patient Care." Duke Health Referring Physicians. Duke University Health System, January 14, 2020. https://physicians.dukehealth.org/articles/recognizing-addressing-unintended-gender-bias-patient-care.

[59] Kiesel, Laura. "Women and Pain: Disparities in Experience and Treatment." Harvard Health, October 9, 2017. https://www.health.harvard.edu/blog/women-and-pain-disparities-in-experience-and-treatment-2017100912562.

[60] Kiesel, Laura. "Women and Pain: Disparities in Experience and Treatment." Harvard Health, October 9, 2017. https://www.health.harvard.edu/blog/women-and-pain-disparities-in-experience-and-treatment-2017100912562.

more likely to be offered sedatives and antidepressants than pain medication, less likely to be referred for further diagnostic investigations, and more likely to have their pain seen as emotional or psychological, rather than biological.[61] Women are seven times more likely than men to be misdiagnosed and discharged in the middle of having a heart attack and are 23% more likely to die as a result.[62]

Even though they are more likely to seek out medical care at an earlier stage, female gender doubles the overall risk and severity of any injury.[63] Besides the aforementioned causes, there are several biological factors that increase this likelihood specifically for female string players.

Table 2.1: Gender Predisposition for Injuries of the Upper Extremities

Condition	**Biological cause**	**Increased risk**
DeQuervain's Syndrome	Women are more likely to have a second tendon compartment, decreasing the space in the canal and increasing friction. Pregnancy results in increased fluid retention, also decreasing available space.	Women make up 80% of cases
Trigger Finger	Fluid retention and hormonal changes during pregnancy and menopause increase the potential for inflammation.	Occurs 2-6 times more frequently in women than men
Carpal Tunnel Syndrome	Smaller wrist canal due to bone size and fluid retention during pregnancy (gestational carpal tunnel).	Occurs 3 times more frequently in women

[61] Cleghorn, Elinor. "The Long History of Gender Bias in Medicine." Time. Time, June 17, 2021. https://time.com/6074224/gender-medicine-history/.
[62] Kiesel, Laura. "Women and Pain: Disparities in Experience and Treatment." Harvard Health, October 9, 2017. https://www.health.harvard.edu/blog/women-and-pain-disparities-in-experience-and-treatment-2017100912562.
[63] Steinmetz, A., I. Scheffer, E. Esmer, K. S. Delank, and I. Peroz. "Frequency, Severity and Predictors of Playing-Related Musculoskeletal Pain in Professional Orchestral Musicians in Germany." *Clinical Rheumatology* 34, no. 5 (January 5, 2014): 965–73. https://doi.org/10.1007/s10067-013-2470-5.

Thoracic Outlet Syndrome	Adult women have lower shoulders and carry heavy burdens that can increase the pressure on these nerves and blood vessels.	Occurs 3 times more frequently in women

Lifestyle factors and activities of daily living also contribute to the additional strain on women's bodies. An American woman with a full-time job still does almost twice as much housework and childcare as a man, spending 2 extra hours every day scrubbing, vacuuming, chopping, and lifting and caring for growing children.[64] When combined with a physically demanding career as a professional musician, these extra hours of repetitive movement tasks can push women over the limit of healthy activity.

Importance of Psychosocial Factors to a Successful Recovery

The greatest barrier to musicians receiving timely and adequate treatment is the organizational structure in which they work or study. This interrelationship between the individual, the workplace, and the psychological and physical demands made on them will influence the frequency and management of injuries as well as the outcome of rehabilitation measures. The physical, psychological, and social effects of injury influence each other and should be considered as a complete whole and not as separate parts. Studies have found that psychosocial factors have a greater magnitude of risk for long-term dysfunction than the nature of the injury itself, as increased stress is known to decrease healing capacity and is closely linked to chronic pain syndromes.[65] Extended rehabilitation periods can result in lasting psychological damage, learned helplessness, and profound withdrawal.

[64] "American Time Use Survey." U.S. Bureau of Labor Statistics. U.S. Bureau of Labor Statistics, January 2020. https://www.bls.gov/tus/.

[65] Rickert, Dale Ll, Margaret S Barrett, and Bronwen J Ackermann. "Injury and the Orchestral Environment: Part III. The Role of Psychosocial Factors in the Experience of Musicians Undertaking Rehabilitation." *Medical Problems of Performing Artists* 29, no. 3 (September 2014): 125–35. https://doi.org/10.21091/mppa.2014.3028.

From a young age, musicians are taught to sacrifice their well-being for the greater good of a performance. Unlike most other jobs, their emotional investment in their future careers starts in early childhood, making their performer and personal identities difficult to separate. Phrases like, “the show must go on” are not just sayings, but a lifestyle that most musicians happily embrace - once you walk on stage, no matter what happens, you do not walk off until your job is done. The variety in musical interpretation and abilities allows an individual to contribute something new and deeply personal to a historic art form, while the interrelated nature of a symphony orchestra means that the absence of one person out of ninety can force the cancellation of an entire performance. Both professional and student musicians tend to measure their self-esteem by how well they perform and judge their value as a person and performer by their performance competence. Anything that limits these abilities can be devastating, and musicians who have to take time off due to injury may face a significant crisis of identity. The long hours spent alone in the practice room are necessary to prepare a musician for their future career, but this can also lead to social isolation and underdeveloped social skills.[66] Losing the emotional and social connections with colleagues and with music causes musicians to feel isolated, voiceless, and socially removed. To many members of this community, music is a means of society and self-expression, and their performing roles within that community are the primary determiner of social contact and status. Injuries that prevent them from expressing themselves and interacting in this way for an extended period are likely to cause depression and identity crises.

Considering this trauma, it is important that musicians also have access to psychological treatment as a main component of extended rehabilitation. Studies have found that psychological

[66] Rickert, Dale Ll, Margaret S Barrett, and Bronwen J Ackermann. “Injury and the Orchestral Environment: Part III. The Role of Psychosocial Factors in the Experience of Musicians Undertaking Rehabilitation.” *Medical Problems of Performing Artists* 29, no. 3 (September 2014): 125–35. https://doi.org/10.21091/mppa.2014.3028.

counseling markedly decreases rehabilitation times among office workers, and in sports medicine, it is seen as essential to creating optimal conditions for a fast return to elite performance.[67] Ignoring this aspect of a musician's mental health can result in non-compliance or dropout from a rehabilitation program, resulting in a lost opportunity to provide complete, quality care for this population.

The amount of perceived social support from colleagues and management also influences recovery times in other working populations, and the negative stigma surrounding a musician's injury can have a profound impact on their recovery rates. Orchestra colleagues need to be aware of their role in creating optimal psychosocial conditions for members to first seek out treatment and follow through with a successful recovery. Important factors include making sure the injured player feels valued and supported, involving rehabilitating players in day-to-day decision-making, and a willingness to explore the shared experience of injuries and recovery.

Challenges When Seeking Help from Medical Professionals

Throughout the late 19th and early 20th centuries, research into the causes and consequences of musician injuries focused primarily on pathology and terminology.[68] By the 1980s, the number of available studies began to steadily increase, but the lack of interdisciplinary collaboration between the medical and musical fields precluded any type of coordinated and holistic effort. The refusal of musicians and music education institutions to acknowledge this problem has resulted in continued low health literacy in the field of injury prevention and occupational health. Musicians' clinics and performing arts medicine organizations have also

[67] Wolff, Aviva L, and Laura Robbins. "Leveraging Implementation Science to Prevent and Reduce Musculoskeletal Overuse Injury in Musicians: A Proposal for the Study of a Conceptual Framework." *Journal of Hand Therapy* 34, no. 2 (2021): 315–22. https://doi.org/10.1016/j.jht.2021.05.008.
[68] Betzl, Julia, Ursula Kraneburg, and Kai Megerle. "Overuse Syndrome of the Hand and Wrist in Musicians: a Systematic Review." *Journal of Hand Surgery (European Volume)* 45, no. 6 (July 2020): 636–42. https://doi.org/10.1177/1753193420912644.

seen growth over the past two decades, but they are often separate from both medical or musical institutions, or only tangentially associated with them. The treatment of musician injuries is still very much a specialist profession, meaning that most primary care physicians do not have the requisite knowledge or experience to adequately treat injured musicians.[69]

The diagnosis of these conditions is challenging due to the differing presentation of injuries, lack of consensus on etiology, and even differences in terminology.[70] For this reason, treatment techniques vary widely and success is variable. A surgeon may be pleased with an 80% recovery of strength and function, but this may be devastating to a musician whot will not be able to return to the occupation that held such meaning in their life. For musicians, music is not only what they do, but who they are. Being able to perform at anything other than their highest level, or even being impeded in their anticipated progress as artists can be emotionally devastating. Standard medical professionals may see this insistence on detail as neurotic and their highly specific concerns as trivial, while musicians tend to distrust professionals who jump to conclusions about injuries without considering the instrument, practice schedule, and rehearsal demands of the artist.[71] Members of the Rickert study in 2014 felt that surgeons underestimated the overall impact on their playing as well as recovery time. For the musicians who underwent surgery, the surgeon expected them to return to work after 6 weeks, when the actual time to safely rebuild playing practices took seven months.

Playing-related injuries often appear gradually over many months, making it difficult to pinpoint a cause or justify a doctor's visit, let alone worker's compensation or disability benefits.

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[69] Guptill, Christine, and Matthew Bruijn Golem. "Case Study: Musicians' Playing-Related Injuries." *Work* 30, no. 3 (2008): 307–10.

[70] Betzl, Julia, Ursula Kraneburg, and Kai Megerle. "Overuse Syndrome of the Hand and Wrist in Musicians: a Systematic Review." *Journal of Hand Surgery (European Volume)* 45, no. 6 (July 2020): 636–42. https://doi.org/10.1177/1753193420912644.

[71] Rickert, Dale Ll, Margaret S Barrett, and Bronwen J Ackermann. "Injury and the Orchestral Environment: Part III. The Role of Psychosocial Factors in the Experience of Musicians Undertaking Rehabilitation." *Medical Problems of Performing Artists* 29, no. 3 (September 2014): 125–35. https://doi.org/10.21091/mppa.2014.3028.

These injuries are difficult to diagnose in the early stages, and many physicians do not believe that small injuries are enough to significantly impair musicians at their work.[72] Standard models for treatment and rehabilitation times are derived from studies on humans doing average, day-to-day things, not populations who frequently push their bodies to the limits of what is physically possible. Reintegration policies, such as task modification and gradual work re-introduction are also not practical given the group rehearsal requirement and instrument-specific skills needed to perform at an elite level in an orchestra.

A musician's ability to perform at a high level requires normal function of the entire upper extremities at a level frequently exceeding population norms, with highly complex, instrument-specific requirements. The difference between full and partial recovery can mean the difference between a long and fruitful career or obscurity.[73] The art of playing a musical instrument requires intensive and focused training from a very young age, and for most performers, this complex and specific skill is not transferable to other occupations, increasing the anxiety surrounding chronic injuries, and prompting musicians to be highly driven to return to work.

Musicians and Rest

One of the most common recommendations heard by injured musicians is to "rest". This advice, often said by well-meaning medical professionals and colleagues, seems innocent enough, but it can be a significant factor in treatment avoidance. Complete rest is a method that is incompatible with the life and career of a professional musician, and recent studies by the

[72] Stanhope, Jessica, Philip Weinstein, and Dino Pisaniello. "What Can Musicians' Claims Data Reveal about Their Musculoskeletal Conditions?" *Archives of Environmental & Occupational Health* 75, no. 3 (2020): 177–90. https://doi.org/10.1080/19338244.2019.1605968.

[73] Rickert, Dale L. L., Margaret S. Barrett, and Bronwen J. Ackermann. "Are Music Students Fit to Play? A Case Study of Health Awareness and Injury Attitudes amongst Tertiary Student Cellists." *International Journal of Music Education* 33, no. 4 (2015): 426–41. https://doi.org/10.1177/0255761415582343.

University of Adelaide and the University of South Carolina have confirmed that complete rest should only be prescribed for the most severe injuries.[74] Although distancing musicians from the workplace ideally gives them the time they need to recover and heal, this period can have a devastating effect on their sense of identity and self-worth. The process of recovery is isolating and difficult and the emotions surrounding a loss of ability are complex. Musicians recognize that every injury could take away an essential aspect of not only what they do, but who they are, deeply impacting their emotional attachment to the injury experience.

Speaking practically, rest as a medical treatment is also a controversial subject because it does little to resolve the underlying cause of pain. Simply taking a break from an activity that caused physical problems does not address its ergonomic and biomechanical causes, making it even more likely that it will reoccur in the future when the activities are resumed.[75] This is the most common pitfall with self-help treatment methods; although rest is the most commonly suggested treatment by teachers and musician colleagues, in most cases, it is only a temporary fix to a more serious problem. Immobilization and extended rest of the muscles involved in music-making can result in muscle wasting and loss of blood flow and nutrients to the injured tissues, further hindering the healing process. Although rest does allow pain to decrease, the swelling to subside, and the healing process to begin, musicians often resume activities too soon when the tissues are still in the repair or remodeling phases (a few days to a few months after injury). Although pain is no longer present, it can take months to years to recover the full strength and function of these tissues. Depending on the severity of the injury, a ligament may

[74] Schramayr, Ernie. "Just like Athletes, Musicians Need Physical Training to Avoid Injury." *The Spectator*. April 12, 2017.
[75] Rickert, Dale Ll, Margaret S Barrett, and Bronwen J Ackermann. "Injury and the Orchestral Environment: Part III. The Role of Psychosocial Factors in the Experience of Musicians Undertaking Rehabilitation." *Medical Problems of Performing Artists* 29, no. 3 (September 2014): 125–35. https://doi.org/10.21091/mppa.2014.3028.

have 50% of its normal strength back by 6 months, 80% after 1 year, and up to 100% only after 1 to 3 years.[76] A wiser approach is the absence of abuse rather than complete rest.

Figure 2.1: Tissue-healing Timeline[77]

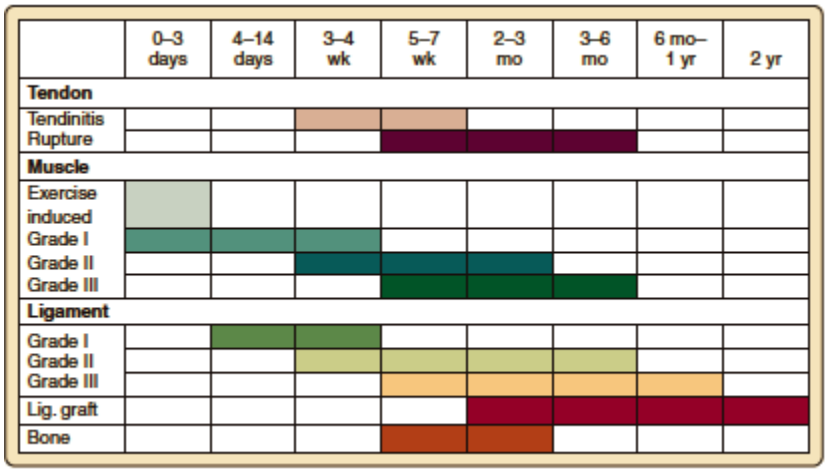

FIGURE 3-1 Tissue-healing time line.

If the musician embraces the same rigorous schedule, using the same technique and practice habits as before, the same symptoms will again become present. However, this time the injury will likely appear sooner, due to the presence of scar tissue, unhealed injuries, and weakened supporting muscles. Understanding the underlying cause of the injury and designing the rehabilitation and reeducation plan around this is a critical step in preventing injury relapse.

How to Improve the Injury Experience

Musicians need to be determined in order to rehabilitate and are not offered a passive recovery. Pain means: stop playing, think, and ask for advice.[78] A musician should not have pain, and playing through the pain will provoke a vicious cycle including muscle compensation,

[76] Pećina Marko M., Krmpotić-Nemanić Jelena, and Andrew D. Markiewitz. *Tunnel Syndromes*. 2nd ed. Boca Raton: CRC Pr., 1991.
[77] Lifecare. "How Long Will This Take? Time Frames of Tissue Healing." Lifecare. LifeCare Kingsway Physiotherapy, December 22, 2017. https://www.lifecare.com.au/blog/how-long-will-this-take-time-frames-of-tissue-healing/.
[78] Rietveld, A. B. M. "Dancers' and Musicians' Injuries." *Clinical Rheumatology* 32, no. 4 (April 10, 2013): 425–34. https://doi.org/10.1007/s10067-013-2184-8.

tension, contracture formation, and inflammation. Musicians have a responsibility to themselves to get medical help as soon as possible when the first signs of injury occur, or to change treatment methods when the condition is not responding to conservative measures.[79] Although medical professionals are experts and want to help, it is important to speak up if concerns arise about the process or the medical practicioner's understanding of the injury. The musucian should ask questions to understand every step of the process, and request copies of all documents, like x-rays and exam results. Christine Guptill provides a list of some characteristics to look for in a reliable medical professional:

- They listen to and respect your story;
- They ask questions about your life or professional to better understand your specific goals and requirements;
- They ask to see you play your instrument;
- They are open and honest about what they do and do not know, and don't make any promises about rehabilitation or recovery timelines that they can't keep;
- They provide realistic hope that the condition will improve;
- They treat the patient's health holistically by understanding the societal and organizational pressure on the patient to return quickly to playing;
- They recognize the deep emotional investment made by musicians and understand that this is far more than "just a job";
- They provide you with informed, understandable information that patients can use to help themselves. [80]

Musicians can expect the best results out of their rehabilitation programs by considering themselves as an active participant of their recovery team. Rehabilitation does not automatically happen; it is a long, difficult journey that will go unnoticed and unrecognized by most colleagues and friends. To work through this process, musicians need to draw upon the same dedication and

[79] Cooper, Cora. "Overcoming Injury: One Musician's Journey and Lessons from Recovery." *American String Teacher* 67, no. 4 (November 2017): 54–56. https://doi.org/10.1177/0003131317734890.
[80] Guptill, Christine. "The Lived Experience of Working as a Musician with an Injury." *Work* 40, no. 3 (2011): 269–80. https://doi.org/10.3233/wor-2011-1230.

discipline they used to become a professional and apply that to their rehabilitation. All exercises need to be performed as prescribed and note-taking and video-watching is encouraged. It can be beneficial to keep a log of progress and limitations to document small successes as the road to recovery is long; it is easy to lose track of progress. Other factors that may be overlooked by medical professionals include practicing with only one hand or modifying the instrument itself - a half-size bow is shorter and lighter and can be helpful for thumb injuries.[81] String musicians can begin practicing on the fingerboard of an unstrung cello or violin to decrease the pressure required to push down strings. Rebuilding practice and playing time should be done slowly, by adding two minutes to a practice period each day. Dr. Donald Weilerstein suggests practicing two days in a row and taking the third day off, adding 2.5 minutes on the first day of each two-day unit, and returning to the previous level on the second day. Dr. Richard Norris, the author of the *Musicians' Survival Manual,* provides this schedule:

Figure 2.2: Sample Rehabilitation Timeline[82]

Levels*	Play	Rest	Play	Rest	Play	Rest	Play	Rest
1	5	60	5					
2	10	50	10					
3	15	40	15	60	5			
4	20	30	20	50	10			
5	30	20	25	40	15	45	5	
6	35	15	35	30	20	35	10	
7	40	10	40	20	25	25	15	50
8	50	10	45	15	30	15	25	40
9	50	10	50	10	40	10	35	30
10	50	10	50	10	50	10	45	20
(Etc.)		*Three to seven days for each level*						

[81] Cooper, Cora. "Overcoming Injury: One Musician's Journey and Lessons from Recovery." *American String Teacher* 67, no. 4 (November 2017): 54–56. https://doi.org/10.1177/0003131317734890.
[82] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

Patients should also ensure that their mental health is being cared for by surrounding themselves with supportive people who create a positive atmosphere. Playing other instruments that do not irritate the condition or even joining a church choir can help maintain the connection to music-making activities and society. The impact of psychological stress and anxiety on injuries is well documented, so instead of spending time dwelling on the injury itself, it is important to look forward and set goals. Believing that a return to playing is possible is essential to a successful recovery.

The greatest health benefits are seen when injury prevention measures address overall work organization and workplace culture.[83] Ideally, medical professionals should work together with orchestra administrations to design new health insurance policies that better reflect their needs. Incentives for early intervention treatment and premium reductions for health initiatives may help to facilitate a cultural change at an individual level. Orchestras are responsible for creating a safe work culture where playing with pain is seen as unacceptable and injury disclosure is seen as normal. Musicians should have, at any time in response to pain, the right and the responsibility to stop playing, take short breaks, stretch, and seek further assistance with the full support of orchestra managers and colleagues. Many of the problems that are present within current orchestral cultures are misconceptions about an injury that stem from the lack of education about these conditions. In other elite performance fields such as dance and sport, these cultures not only accept physical trainers and multidisciplinary medical staff as part of the team but see their roles as vital to performing at the highest level.

[83] Rickert, Dale Ll, Margaret S Barrett, and Bronwen J Ackermann. "Injury and the Orchestral Environment: Part III. The Role of Psychosocial Factors in the Experience of Musicians Undertaking Rehabilitation." *Medical Problems of Performing Artists* 29, no. 3 (September 2014): 125–35. https://doi.org/10.21091/mppa.2014.3028.

Benefits of Injury

Although surprising, there are several benefits that can come from sustaining an injury. Although musicians begin their careers because of a love of music and performance, that initial spark and connection can fade over time. The magic of music-making becomes lost in perpetual rehearsals of new music, demands of tiresome conductors, and strict schedules. The gradual recovery process from injury allows musicians to step back and re-experience their love of music from an audience perspective.[84] The time off lets musicians see concerts, listen to music without associating it with work, and revitalizes the excitement of their profession. This strong attachment to music can be harnessed as a powerful positive factor of rehabilitation and recovery, and can recharge the emotional healing process. Giving injured musicians new roles within the institution and finding ways for them to contribute can redirect their focus from the limitations of their injury to their potential to provide for themselves and their organization in meaningful ways.

[84] Guptill, Christine. "The Lived Experience of Working as a Musician with an Injury." *Work* 40, no. 3 (2011): 269–80. https://doi.org/10.3233/wor-2011-1230.

CHAPTER III

Interventions and Exercises

Despite evidence to the contrary, music performance does not need to be an inherently dangerous occupation. Lifelong participation in music has been shown to positively contribute to healthy aging in terms of improved brain function and cognition, maintenance of communication skills, reduced stress, benefits for the immune system, reduced high blood pressure, and improved physical conditioning.[85] Children exposed to music at a young age benefit from increased IQ, language processing, brain function, spatial-temporal skills, and improved test scores.[86] While 70-80% of professional musicians have injuries associated with playing their instrument, 20-30% of musicians have not reported any pain or injury, despite practicing the same number of hours and having an equal dedication to the profession. While anatomical variations certainly influence injury development for some, the majority of performers can prevent and treat most injuries through awareness of injury development and rehabilitation techniques.[87]

Overview of Physical Therapy Interventions

Although diagnosing these conditions is relatively straightforward, the healing process is more complex. Once an injury sets in, the only option, other than providing optimal conditions

[85] Diaz Abrahan, Veronika, Favio Shifres, and Nadia Justel. "Cognitive Benefits from a Musical Activity in Older Adults." *Frontiers in Psychology* 10 (March 28, 2019). https://doi.org/10.3389/fpsyg.2019.00652.
[86] Brown, Laura Lewis. "The Benefits of Music Education." PBS. Public Broadcasting Service, May 7, 2012. https://www.pbs.org/parents/thrive/the-benefits-of-music-education.
[87] Rickert, Dale Ll, Margaret S Barrett, and Bronwen J Ackermann. "Injury and the Orchestral Environment: Part III. The Role of Psychosocial Factors in the Experience of Musicians Undertaking Rehabilitation." *Medical Problems of Performing Artists* 29, no. 3 (September 2014): 125–35. https://doi.org/10.21091/mppa.2014.3028.

for recovery, is to do almost nothing. Healing can only be inhibited, not accelerated, and this often requires limiting practice time at a critical point in a young musician's career. There are hundreds of preventative stretches and exercises that can strengthen the muscles and tendons while they are healthy, but once these tissues are irritated, there are few options for active rehabilitation, making musicians feel useless both medically and musically. Preventative measures are also incredibly anticlimactic; if they work perfectly, then nothing happens. Convincing musicians to take time to perform these exercises if they have never been injured requires a cultural shift in the way organizational structures approach and emphasize preventative care. Even after a single injury, the musician will have a higher likelihood of relapse due to the potential formation of scar tissue and incomplete modification of practice habits. However, if the muscles and tendons are healthy to begin with due to consistent and specific preventative exercises, the majority of these problems will not occur. Although it is not possible to control all factors that lead to injury, improving body mechanics, preparation, and conditioning allows young musicians to be more resilient to change and bounce back faster from injuries.

Benefits of Strength Training for Musicians

Strength training and stretching are essential components of a musician's life that will not only decrease the probability of injury but will also increase spatial awareness and physical endurance with the instrument. The image of a clumsy bodybuilder is still a common association with weightlifters, but strength training for musicians can increase dexterity, produce greater control of the nervous system, and increase performance endurance. An ideal program works on increasing muscular endurance without adding substantial size to the body and includes

flexibility and range of motion tasks without changing any aspect of fundamental instrument technique.

Maintaining a balanced posture is at the core of technique for all musicians. When the muscles responsible for maintaining posture tire too quickly, other muscles are forced to overcompensate, resulting in earlier fatigue, aches, and pains. The most important component of a strengthening routine is to counteract the repetitive movements that are most frequently performed on the instrument. Below are several important components to safe and productive exercise:

- Perform a dynamic warmup before exercising;
- Focus on compound movements that use multiple joints and muscles;
- Use full range-of-motion exercises whenever possible;
- Prioritize core training and back training;
- Do not train through pain - be sure to perform the exercises correctly and avoid overstraining;
- Prioritize improving endurance, not strength - use light weights with high repetitions.

Musicians have several other considerations to make when developing an exercise routine. Although lifting weights is the most familiar form of strength training, constantly gripping weights and barbells can interfere with the dexterity and flexibility of the hands and fingers. Instead, resistance bands can be looped around the legs or arms and come in different tensile strengths, making them suitable for all stages of strength training. As the resistance of these bands increases at a steady rate throughout the range of motion, this allows the muscles to activate gradually. Their use also recruits the stabilizer muscles that support the larger muscles and joints, reducing the risk of injury and making them a safe and low-impact option.[88] They are

[88] Biddulph, Maddy. "What Are the Benefits of Resistance Bands?" LiveScience. Purch, December 10, 2021. https://www.livescience.com/benefits-of-resistance-bands.

also far more lightweight, portable, and versatile than traditional dumbbells, allowing for easy transport during travel, and can also be used for gentle stretching.

Most Common Muscle Imbalances

Although musicians are frequently clinically diagnosed with nerve and tendon conditions, the most common chronic complaints involve muscle soreness and tension during and after practice. These injuries often develop slowly over several years and are difficult to diagnose and treat, especially by clinicians with little experience with the postural demands of specific instruments. This type of condition is commonly called repetitive strain injury (RSI) or complaints of the arms, neck, and/or shoulders (CANS). These terms are not a diagnosis nor a disease, but a descriptive expression, which can be useful in communicating the condition in occupational medicine.[89]

Like many office and data-entry personnel, musicians tend to have increased forward-positioning of the head over the shoulders, which results in over-stretching the neck and upper back muscles.[90] Every motion of the arms and head of a string player is to the front of the body, from bending forward to read the sheet music and giving cues to other players, to holding up the instrument itself. These types of injuries are especially common in violinists and violists who have to also support the weight of their instruments with the neck and shoulder. Long periods of isometric muscle contractions like these excessively load the smaller muscles, creating a pattern where some muscles are over-tensed while their neighboring muscles are overstretched. The main objective in resolving muscle pain and tension is fixing these imbalances by

[89] Rietveld, A. B. M. "Dancers' and Musicians' Injuries." *Clinical Rheumatology* 32, no. 4 (April 10, 2013): 425–34. https://doi.org/10.1007/s10067-013-2184-8.
[90] Schramayr, Ernie. "Just like Athletes, Musicians Need Physical Training to Avoid Injury." *The Spectator*. April 12, 2017.

strengthening the overstretched and weakened back muscles while stretching the tightened pectoral and neck muscles. This allows the musician to hold their body upright in the proper posture for longer periods of time and better utilize the larger, stronger muscles of the back for the majority of their movement.

Muscle fatigue has been reported to be an important factor in the development of all musculoskeletal conditions, rated as one of the most significant factors by 75% of all Australian orchestra musicians.[91] Muscle fatigue can cause changes in muscle activation patterns, timing, or the redistribution of activity within or between muscles, thus impacting strength, coordination, and body posture. A study of the muscle activation patterns of violinists with and without injuries performed by Moller in 2018 found that overall muscle activity was much higher in the group of injured musicians, with emphasis on the upper shoulder muscles (trapezius) and the forearm. This suggests a strong association between their injuries and overall muscular overuse and tension, which lead to more rapid fatigue and subsequent recruitment of other, smaller muscles to sustain performance.

Student cellists, on the other hand, often display decreased shoulder support and muscular imbalances in the shoulder due to lifting the shoulders while practicing and performing.[92] These conditions leave the back muscles overstretched and weak, limiting their ability to hold the body upright in proper posture.[93] Strength training for the upper back, rear shoulders, rotator cuffs, and lower back, as well as stretching of the chronically tight pectoral muscles, ensures that musicians

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[91] Möller, Dirk, Nikolaus Ballenberger, Bronwen Ackermann, and Christoff Zalpour. "Potential Relevance of Altered Muscle Activity and Fatigue in the Development of Performance-Related Musculoskeletal Injuries in High String Musicians." *Medical Problems of Performing Artists* 33, no. 3 (September 2018): 147–55. https://doi.org/10.21091/mppa.2018.3021.

[92] Ackerman, Bronwen, Timothy Driscoll, and Dianna Kenny. "Musculoskeletal Pain and Injury in Professional Orchestral Musicians in Australia." *Medical Problems of Performing Artists* 27, no. 4 (December 2012): 181–87. https://doi.org/10.21091/mppa.2012.4034.

[93] Schramayr, Ernie. "Just like Athletes, Musicians Need Physical Training to Avoid Injury." *The Spectator*. April 12, 2017.

can hold themselves in proper alignment. The following series of exercises will focus specifically on the common muscular deficits of musicians. In the two diagrams below, the green muscles are those that need to be stretched while the yellow indicates the muscles that should be strengthened. General and specific strengthening and stretching exercises follow.

Figure 3.1: Posterior Muscles

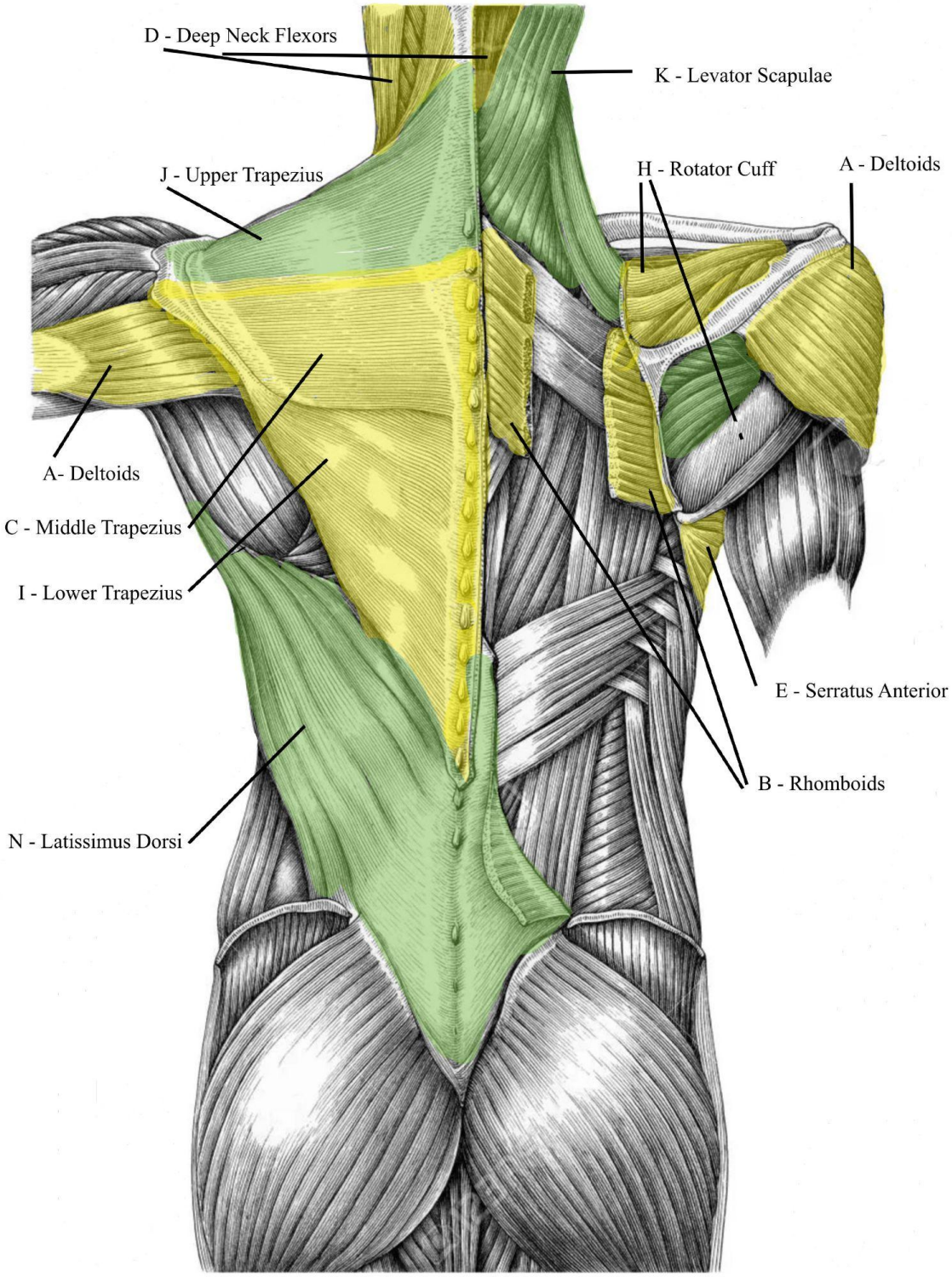
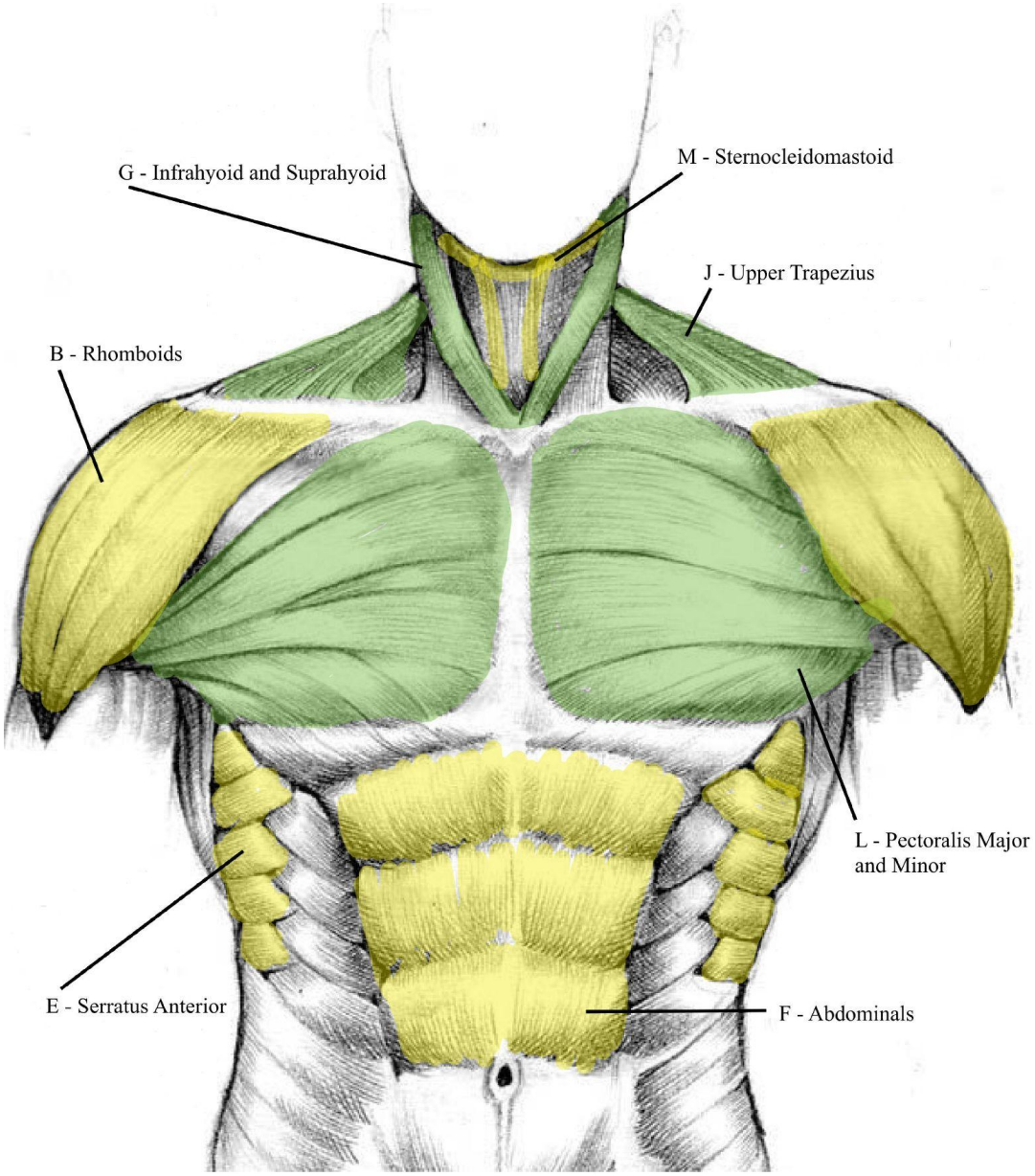


Figure 3.2: Anterior Muscles



Strengthen

A - Deltoids

B - Rhomboids

C - Mid and lower trapezius

D - Deep Neck Flexors (longus colli, longus capitus, rectus capitus, and longus cervicus)

E - Serratus anterior

F - Abdominals

G - Infrahyoid and suprahyoid (front of the neck)

H - Rotator cuff (rear part of the shoulder) includes the subscapularis, teres minor, supraspinatus, and infraspinatus muscles

I - Lower trapezius

Stretch

J - Upper Trapezius

K - Levator scapular

L - Pectoralis minor and major

M - Sternocleidomastoid (side and front of the neck)

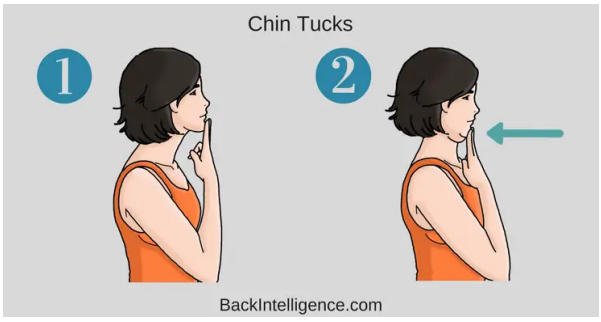
N - Latissimus dorsi (middle to lower back)

Forward Head Posture

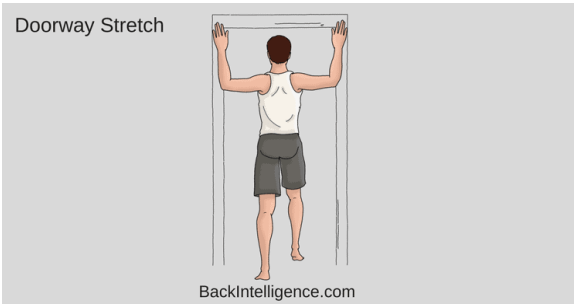
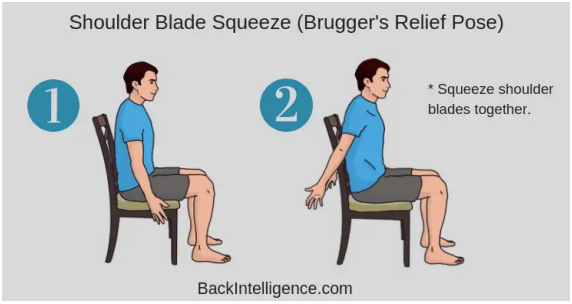
Both office workers and musicians commonly suffer from “forward head posture” (FHP), a condition where the muscles of the neck and joint at the front of the neck become weak, while the muscles in the upper back and shoulders are overtightened during activities such as leaning

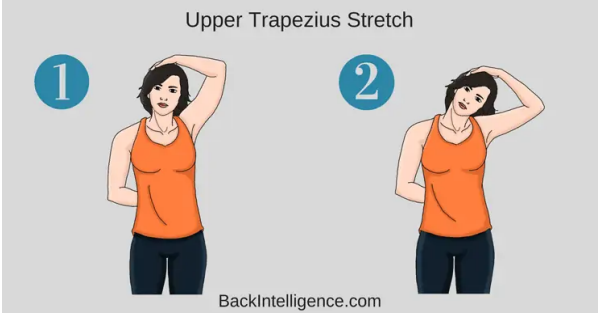
forward and straining to read sheet music, using a cell phone, or reading a computer screen.[94] To test for this condition, stand with your back against a wall with the heels positioned shoulder-width apart. Assume a natural posture and then check to see if the back of the head is touching the wall. For most musicians, the head will be several inches away, and the greater the distance between the head and the wall, the more severe the FHP. For every inch of forward movement of the head, an additional 10 pounds of weight are placed on the neck, leading to potential musculoskeletal and neurologic system dysfunction. This can also create shoulder rounding (thoracic kyphosis), a back "hump", herniated discs, tension headaches, and overuse of the back and shoulder muscles. These and other posture deformities are a main contributing factor to compression syndromes like thoracic outlet syndrome. Below is a five-minute strengthening and stretching routine for forward head posture.

Table 3.1: Exercises for Forward Head Posture

Chin Tucks 	The exercise activates and strengthens the muscles in the front of the neck (deep cervical muscles). ● Place 2 fingers at the bottom of the chin ● Gently tuck the chin in and retract the head and neck backward. Use the fingers to keep the chin tucked in the entire time ● Hold this position for 3 to 5 seconds ● Relax the neck and let the head come forward ● Aim for 2 to 3 sets of 10 repetitions ● The eyes and chin stay level and it should feel like the back of the neck is lengthening and stretching
Neck Flexion Stretch	This stretches the muscles at the back of the neck (suboccipital muscles)

[94] McQuilkie, Dr. Shaina, and Leon Turetsky Turetsky. "How to Fix Forward Head Posture - 5 Exercises and Stretches." Back Intelligence, November 3, 2021. https://backintelligence.com/how-to-fix-forward-head-posture/.

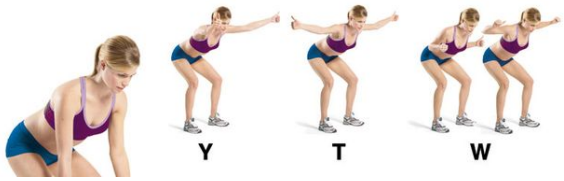
	• Tuck the chin in using 2 fingers of one hand • Place the other hand on the back of the head and apply a gentle force down, pulling the head towards the chest • When you feel a stretch at the back of your neck, hold the position for 20 to 30 seconds • Repeat this stretch 3 times • Keep the chin tucked in for the duration of this stretch
Doorway Stretch 	This stretches the pectorals to open up the chest • Position the elbows and hands in line with a door frame • Step through the door slowly, until you feel a stretch • Hold this end position for 20 to 30 seconds before returning to the starting position. • Repeat this stretch 2-3 times. • Be aware of the lower back and do not arch it as you do this stretch
Shoulder Blade Squeeze 	This exercise will activate and strengthen the lower and middle trapezius muscles. • Sit in a chair and position the feet and knees slightly wider than the hips • Perform a chin tuck from the previous exercises and raise the chest up, allowing the spine to be in a neutral position. • Rest both of your arms down by your sides. • Now bring your arms back and externally rotate them so that your thumbs are pointing backward. • Hold this position for 5-10 seconds and release while breathing normally • Aim for 2-3 sets of 10-15 repetitions
Upper Trapezius Stretch	This exercise stretches the neck and upper back muscles (scalene & upper trapezius)

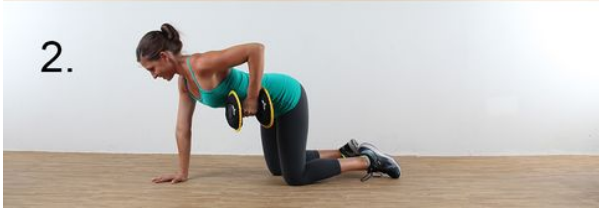
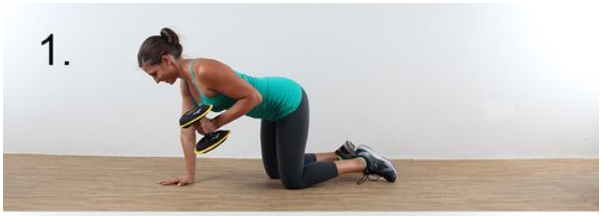
	which can get very tight on individuals with this forward neck syndrome. ● Start either in a standing or seated position. ● Place one of your hands on the opposite side of your head. ● Use the weight of the hand and arm to gently bring the head down towards the shoulder ● Gentle pressure can be used if a deeper stretch is desired ● Hold for 20-30 seconds and do 2-3 sets

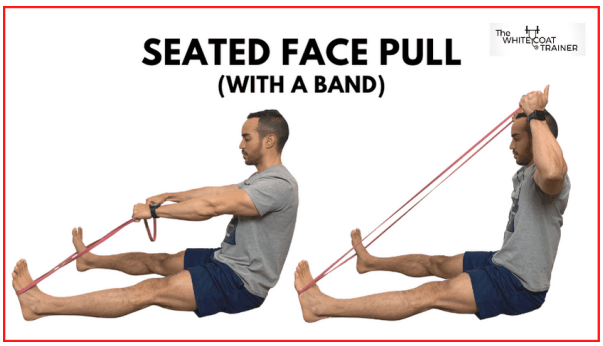
Prevention Techniques and Exercises

When designing a strengthening and stretching routine, consistency in practice and variety in the exercises performed will ensure more complete prevention of these conditions. Below is a table of various strengthening exercises that target the weakened muscles mentioned previously to not only increase physical endurance but also to improve general muscloskeletal aches and pain. Select four of these exercises and perform 3 sets of 10-15 repetitions each at least once a day or up to three times a day. General descriptions are provided, but full tutorials for the proper techniques can be found online. In many cases, these exercises and stretches also function as diagnostic tools to determine the degree of tightness and weakness of the muscles. Pay attention when performing these exercises to whether one side is more difficult than another, or if a greater range of motion can be achieved in one direction but not the other.

Table 3.2: Strengthening Exercises for Musicians

Half-kneeling wall rotation 	One arm is placed horizontally along the wall, while the other rotates out and back. This works to stabilize and strengthen the rotator cuff.
Bent Y, T, and W raises 	This exercise series can be performed laying down, on all fours, or slightly bent over as seen in the photo with one leg in front of the other. This strengthens the lower trapezius and can be increased in difficulty with a resistance band or weights.
Teacup Exercise 	Get a flat weight and move through the range of motion of the shoulder like a serving platter to increase healthy range of motion, flexibility, and adaptive strength in the shoulder stabilizers.
Quadruped high rows/extended rows/ overhead press	Perform a standard row. Row and rotate backward and then forwards. Row, rotate forwards, and extend the arm out in front. This works the posterior deltoids, rotator cuff,

    	and lower trapezius.
Swimmers  	This exercise is performed on a flat surface while simultaneously raising and lowering the opposite arm and leg.
Seated face pull	This exercise strengthens the shoulders and back by providing opposite movement to the typical forward motions performed by

	musicians.
Resistance bands pull apart in various positions  	Strengthens the rotator cuff and shoulder stabilizers.
Heavy-weight shrugs	Pull the shoulders together, not up towards the ears.

	
Kettlebell to hip halos	Similar to the teacup exercise, but now using both hands together on a kettlebell in a circle in range of motion around the head and upper body.

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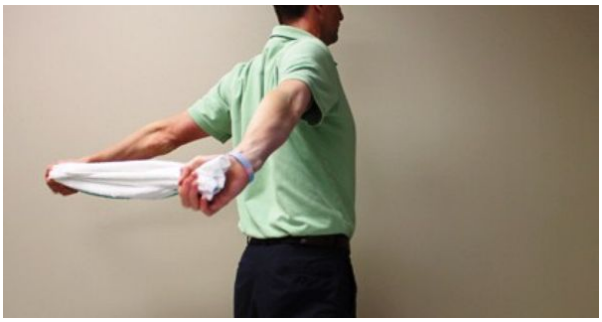
The next table contains stretches that can be performed before or after a long practice day, or as a warm-up before a performance. Resistance bands can be added to some of these stretches to allow them to also function as strengthening exercises.

Table 3.3: Stretches for Musicians

Thoracic Rotations 	Thread one arm under the other, then rotate back to neutral and reach up as close to straight up as possible.

	
Step-back stretch  	Put straight arms on a wall or chair and then slowly step backward, keeping the arms straight. Modifications of these stretches can be seen in the second image, where the elbows are bent, bringing the chest close to the wall.
Wall Angels	Keep the head and shoulders in constant

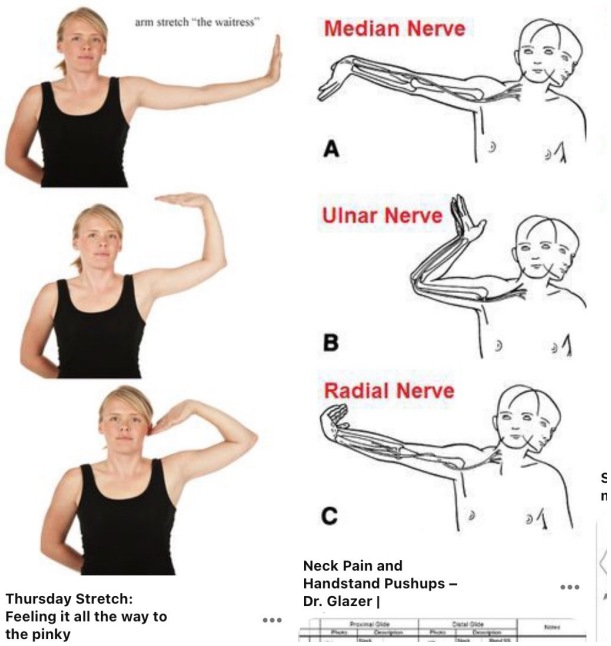
	contact with the wall. This exercise is helpful for forward head posture.
Cobra pose 	Stretch for the back and chest.
Child's Pose  	Hip rotation and shoulder relaxation.
Towel Rotation 	This works on the range of motion of the shoulders, counteracting the constant forward motion of music performance.

Seated Windmills 	Sit with feet far apart. Bend over and place hands on the floor, then walk both hands over to one side. Open up the upper arm vertically.
Levator Scapulae Stretch 	For violinists who have consistently tight levator scapulae due to the isometric contraction of the neck and shoulder - sit on one palm, then put the other arm gently on the head and pull in the opposite direction.
Side-lying sweeps	Start with palms together and move the upper arm in a circle above the head while keeping the knees on the ground. This exercise is helpful for resolving pain between the shoulder blade and the spine.

	
Thoracic rotation reach 	Check for thoracic rotation mobility with elbow-to-ceiling reaches while being aware of any large difference between mobility between sides. This mobility test also functions as an exercise to treat the condition.

Nerve flossing exercises serve to stretch the nerves of the wrist, shoulders, and elbow. These stretches should be performed when the nerve is already warmed up through physical movement. If these exercises have never been performed before, most musicians will easily feel the stretch of the tendons and nerves in these positions.

Figure 3.3: Nerve Flossing Techniques



Treatment Modalities

There are as many methods for treatment as there are variations of the human body. Medical establishments generally tend to recommend treatments backed by scientific research and studies, but many of the available modalities have not been rigorously tested or have presented mixed results during studies. Although the majority of conditions covered in this research have tested and proven treatment strategies, there are no syndromes with a 100% cure rate, and the same procedure or set of exercises that worked for one patient are not guaranteed to have the same result on another. In his book *Musician's Survival Manual*, Dr. Richard Norris offers an overview of some of the most commonly prescribed treatment methods for musculoskeletal conditions.[95]

[95] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

Table 3.5: Treatment Methods

Relative Rest	● The first and most important treatment option; ● This is not a complete removal from the activities that caused the injury but involves avoiding pain-producing activities; ● Like sports medicine, the goal of performing arts medicine is to try to keep patients playing to the extent possible; ● Research has shown that it is often not necessary to cease playing, but to simply reduce and modify the playing schedule; ● The musician should be instructed to avoid playing to the extent that aggravates the injury - this threshold may vary from a few minutes to a few hours per day; ○ If every amount of playing causes pain or aggravation of symptoms, then the rest should be as complete as possible; ○ Once the pain has abated, it is imperative that the return to playing be gradual.
Immobilization	● In its most extreme form, rest may include immobilization, which is not a benign treatment without consequences, as muscles need to contract and relax periodically to remain healthy and support blood flow, while joints depend on motion for cartilage nourishment; ● Immobilization may be indicated if there is pain with hand use during any daily activities, especially when the patient seems unable to stop using an injured hand in activities of daily living; ● A full-length resting splint (from the tips of the fingers to the mid-forearm) is usually required; ● The splint should be removed several times a day to perform gentle, pain-free, range-of-motion exercises to prevent stiffness and worsening of symptoms.
Gradual Return to Playing	● Returning too rapidly to prior levels of practice and performance is one of the most common pitfalls of the rehabilitation process; ○ Sudden increases in playing time must be avoided;

	○ A written, individualized training schedule is very helpful in giving the performer guidelines to follow; ○ In the initial stages, practice periods should be brief and rest periods long; ○ As the injury heals, practice periods can grow progressively longer and rest periods shorter, and the patient can go from playing slow tempo and easy material to faster tempos and harder material.
Modification of activities of daily living (ADLs)	● Modification of ADLs, sometimes using adaptive equipment, is of the utmost importance in treating overuse injuries; ○ ADLs are often overlooked by both the physician and patient as a source of continued aggravation to the injury and failure to improve, despite a seemingly adequate therapy program; ○ ADLs can include computer and phone use, writing, childcare, cooking, and driving.
Modification of posture and technique	● The role that posture, body mechanics, and faulty musical technique play in causing and perpetuating an injury must be assessed by the physician and therapist together with a music teacher; ● Posture away from the instrument, while working at a desk for instance, may also contribute to strain; ● Modification to the instrument itself is sometimes necessary for both prevention and treatment of injuries.
Medications	● Most commonly used medications are nonsteroidal anti-inflammatory agents (NSAIDs); ● Anti-inflammatory medications tend to be more useful in acute rather than chronic situations, and should not be used for more than three or four weeks at a time; ● Should rarely be used as the sole treatment, but may be helpful in conjunction with other modalities; ● Patients with a history of ulcers or bleeding disorders must be cautious when using these medications, which should only be taken after a full meal to avoid these symptoms.
Injections	● Injections are usually done with a solution of steroid and anesthetic;

	● De Quervain's syndrome, carpal tunnel syndrome, and lateral epicondylitis often respond well to steroid injection; ● Trigger finger also occasionally improves with steroid injection, if combined with specialized splinting and an exercise program.
Orthotics	● An orthotic is a medical device, such as a splint or strap, applied to or around a body part to improve a physical impairment or disability; ● They can also be applied to an instrument to help stabilize it and lessen the amount of hand force required for control.
Thermotherapy	● The application of either heat or cold; ● Heat is commonly applied as either a hot pack for surface injuries or as an ultrasound, which has much deeper penetration.; ● This can also include contrast baths between hot and cold fluids to decrease swelling.
Electrical Stimulation	● Electrical stimulation (E-stim) is often beneficial when there is swelling, as the current can help polarize and drive the free fluid between cells back into the vascular system when combined with compression and elevation; ● E-stim often induces gentle, rhythmic muscle contractions in sore areas, relieving discomfort by removing excess fluid and increasing blood flow to the muscles; ● E-stim can also be used with active muscle contraction to strengthen weak or atrophied muscles; ● Caution must be used with patients who have pacemakers and those with very sensitive skin, which can be irritated by the electrodes.
Massage	● Massage is useful in stimulating blood flow, reducing swelling, and breaking up localized areas of muscle spasm known as trigger points; ● Also helpful for general relaxation and reduction of overall stress and tension.
Feedback Techniques	● Video feedback can be quite useful in treatment by allowing patients more insight into technical errors. The video monitor is placed in front of the musicians while the

	camera is placed to the side or rear. This allows the musician to see themselves from previously unseen angles and react in the moment; ● Biofeedback and stress management programs can be extremely useful in the treatment of upper extremity disorders by bringing about an overall decrease in stress and muscle tension.
● Therapeutic Exercise	● Useful in both prevention and treatment; ● Therapeutic exercise is necessary after a period of injury and rest to restore muscle strength and endurance; ● Preventative strengthening of the wrist and finger extensors has not yet been researched but may prove useful; ● Hand exercises must be undertaken with caution and supervision because of the risk of overdoing the exercises and thereby worsening the condition; ● A good exercise program should address not only strength and endurance but also flexibility and dexterity since these are the characteristics of fine players with a high degree of coordination and efficiency of movement.

Before an injury actually occurs, there are several risk factors that musicians can take active steps to mitigate. These include:

- Always warming up - if a physical warmup is not possible, begin practice with scales and slow practice, not the hardest concerto;
- Using only the minimum force necessary to push down the strings;
- Use the weight of the body and gravity to your advantage - cellists shifting to higher positions should allow gravity to do most of the work;
- For cellists and bassists, minimize to the extent possible the amount of time in extended positions;
- Reorganize practice schedules to incorporate more structured time away from the instrument;
- Use a timer while practicing to increase concentration and as a reminder to take breaks (10-15 minutes every hour);

- Gentle movement and changing positions while playing or at rest ensures that muscles do not become locked in position and allows other muscles to share the load;
- Get input from teachers to make technique more streamlined and efficient;
- Practice the music mentally without the instrument;
- Get glasses if constant straining is pushing the head and neck forward;
- Ensure that jewelry, watches, or hair ties are not constricting the wrist;
- Make sure chin rests, endpins, chairs, and stools are all at an appropriate height ;
- Do not go straight to a phone or computer during a practice break - it only counts as a break if you are actually resting;
- When in “rest” position while playing, do not hold the bow vertically on the knee - instead let it fall forward so the hand can remain in a more neutral position;
- Also allow the arms to relax and elbows to straighten to the extent possible during long measures of rest;
- Know your schedule, and know your limits - listen to your body and react immediately to any warning signs;
- Keep looking for ways to further relax the body during practice and performance. Always ask yourself, “Could I play this easier?”;
- Find ways to decrease arm strain during all daily activities, especially when performing freelance work.

These and other strategies are small modifications that can have a large impact on muscle and tendon health when compounded over years of practice and performance.

Although musicians' injuries are incredibly prevalent, the good news is that the vast majority of them will respond well to conservative, non-surgical treatment. However, non-surgical treatment is not always the best option. There are many conditions that may resolve with months of rehabilitation and exercises but will respond quickly and reliably to surgical or medical procedures. When the musician has been suffering from prolonged pain and inability to

work, nonsurgical procedures should not be pursued indefinitely if surgery would provide a solution to the problem and allow the performer a rapid return to playing.[96]

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[96] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

CHAPTER IV

Etiology and Treatment of Common Injuries

This chapter contains an overview of the most common injuries sustained by musicians throughout their careers. Although all of the information has been acquired from medical sources, these proposed testing, exercise, and rehabilitation programs do not constitute medical advice and should only be performed under the advice and supervision of a medical professional. An early medical intervention is the most effective treatment for all of these conditions, and the information provided here is meant to provide clarification on the medical process and encourage early action at the first sign of these injuries.

Medical Definitions and Terminology

Table 4.1: Anatomical Terminology

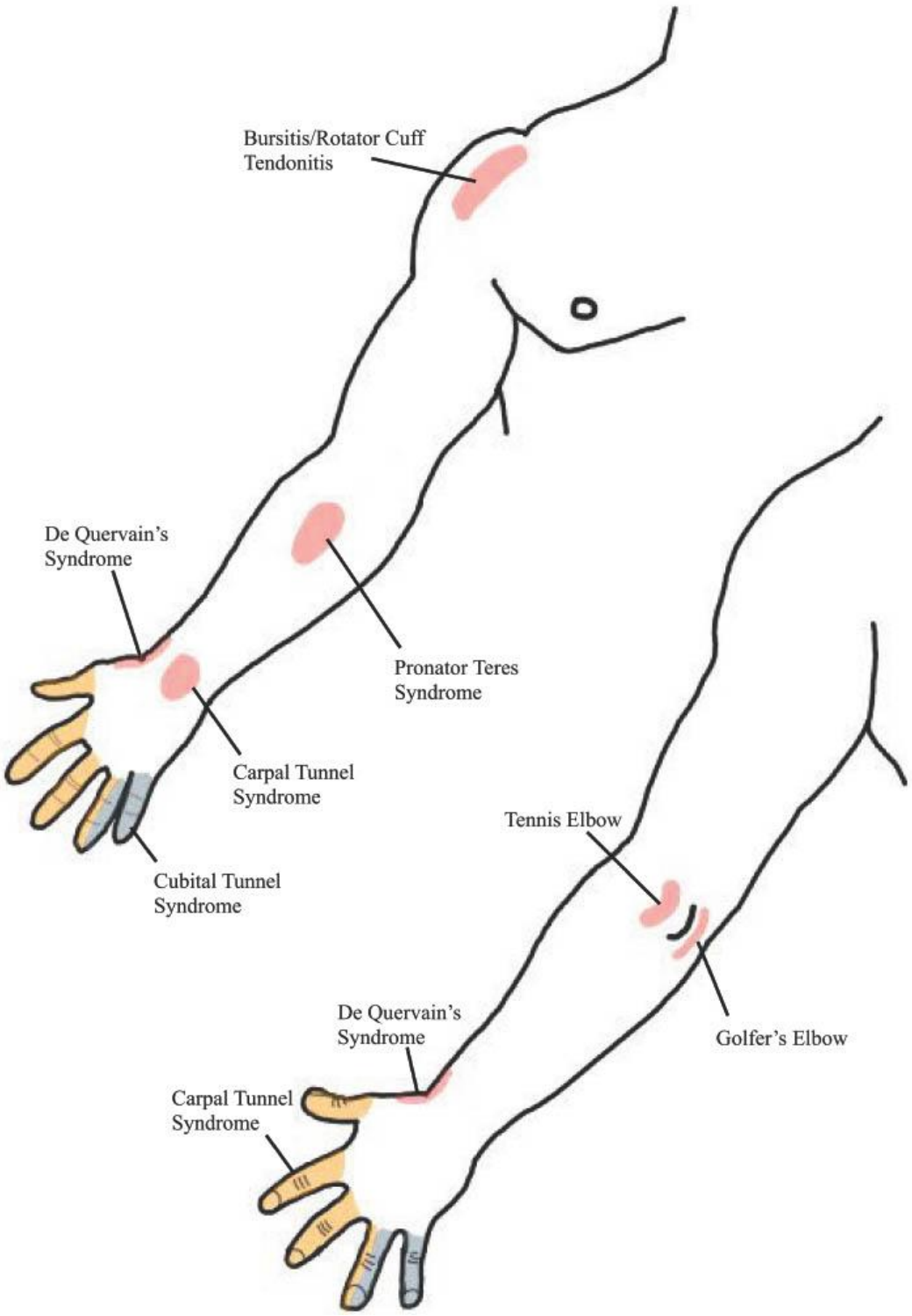
Muscles	Muscles are the only biological tissue capable of actively generating tension. This enables human skeletal muscle to perform the important functions of maintaining upright body posture, moving body parts, or absorbing shock.
Bones	The function of bones is to provide support, enhance leverage, protect vital structures, provide attachments for both tendons and ligaments, and store minerals, particularly calcium.
Ligaments	Ligaments are dense connective tissue structures consisting of high tensile strength collagen. These tissues contribute to the stability of joint function by preventing excess motion, acting as guides to direct motion, and

	providing tactile information for joint function. Due to their function as supporting cables, ligaments are fairly inextensible.
Fascia	Fascia are connective tissues that provide support and protection to the joint, and act as a connection between tendons, ligaments, nerves, and the intrinsic components of muscle.
Tendons	Tendons are cord-like structures that attach muscle to bone and transmit the forces generated by muscles to bone to achieve movement or stability of the body. The thickness of each tendon varies, and is proportional to the size of the muscle from where they originate.
Joints	Joints are bone regions that are capped and surrounded by connective tissues that hold the bones together and determine the type and amount of movement between them.

General Overview of Common Conditions

Musicians need a practical prevention guide that explores the diagnosis and causes of injury together with treatment explanations and prevention plans. This list is by no means exhaustive, but it does cover the majority of conditions musicians can expect to encounter over their careers as performers and educators. Each condition has a short explanation, and further detail for some of these conditions listed can be found later in Chapter 4. Figure 4.1 shows the most common location of pain or abnormal sensation for each of these conditions. Pain is shown in pink, while tingling, numbness, and pricking sensations are shown in yellow and blue.

Figure 4.1: Site of Injury for Common Conditions



Wrist

a. De Quervain's Syndrome (Stenosing Tenosynovitis)
    i. Diagnosis: Dull ache and swelling near the base of the thumb and thumb side of the wrist that can travel up the forearm. Worse when the hand is in use and when grasping or manipulating objects. Positive Finkelstein test.
    ii. Cause: Inflammation of the tendons that attach to the thumb. Overuse of the wrist, especially ulnar deviation in the right hand while playing near the frog (turning the wrist to the pinky side of the hand), lifting heavy objects, pregnancy
    iii. Treatment: Self-rest, anti-inflammatory medication, thumb splint, massage of activator muscles.
    Medical - Steroid injections or surgery to release the tight tunnel, physical therapy, or surgery to release the
    iv. Training: Prognosis is usually good with this condition, and nearly all patients respond well to steroid injections. Avoid spending too much time near the frog of the bow or above seventh position in the left hand for violin and viola players.

b. Cubital Tunnel Syndrome
    i. Diagnosis: Numbness and tingling in the ring and little fingers, pain in the forearm and/or weakness in the hand. Tapping Tinel's sign in the elbow or the elbow flexion test can reproduce this sensation.
    ii. Cause: Compression of the ulnar nerve in the elbow due to excessive time spent with the elbows bent, pressure on the elbow, or repetitive bending. Occurs most frequently in the left elbow of violinists and violists, but appears in all string players (up to 9% of all musician injuries). Excessive computer or desk use, or extra muscles in the elbow.
    iii. Treatment: Self - Splinting to keep the elbows straight at night, and the elbow should be kept relaxed and straight during daily activities. Ice, anti-inflammatory medication, or creams.
    Medical - Surgery is sometimes necessary due to anatomical variations, but if recognized and treated early, it usually responds well to conservative measures.

iv. Training: Cellists should avoid excessive tension in lower positions, while violinists need to be relaxed especially in seventh position and above. Avoid compression of the nerve when leaning on elbows, and avoid prolonged driving, cell phone, computer use, or any other activity that requires elbow bending and tension.

c. Carpal Tunnel
    i. Diagnosis: Pain, numbness, or tingling in the palm, thumb, index and middle fingers, sometimes in the wrist, forearm and upper arm. Often the pain and numbness can wake you up at night. Tapping the wrist on the palm side may reproduce shooting pain or tingling in the hand. Phalen tests can reproduce symptoms.
    ii. Cause: Compression of the median nerve as it passes through the wrist from overuse and extremes in wrist position, especially in the right hand of violinists and violists; pregnancy
    iii. Treatment: self - There are few really effective treatments for CTS. Ice, elevation, splinting (especially at night), anti-inflammatory medication, absence from abuse. Medical - Cortisone injections, ultrasound treatments, surgery
    iv. Training: Nerve gliding exercises, vitamin B6 (?)

d. Tendinopathy (commonly referred to as tendinitis/tendonitis)
    i. Diagnosis: Stiffness, pain, or popping sensations when performing certain movements. Swelling around the wrist or at the base of the fingers, and wrist pain along the side of the wrist near the thumb or pinkie finger
    ii. Cause: Repetitive stress on the wrist tendons, causing inflammation of the layer of lubricated tissue surrounding the tendons (synovial sheath). This irritation and enlargement of the sheath causes compression on the tendon and makes wrist and finger movements painful
    iii. Treatment: Self: RICE - Rest, ice, compression, elevation. Apply ice in a towel to the wrist for 20 minutes every 2 hours while keeping it elevated above the level of the heart. Splinting. Medical: Surgery

iv. Training: Stretch before physical activity. Tendon injuries often occur due to tight muscles that stretch out the tendons at their attachment points. Ensure to provide sufficient rest during practice sessions.

Finger

e. Trigger Finger - Stenosing Tenosynovitis

i. Diagnosis: Stiffness, clicking or "locking" of the finger, sometimes with pain or discomfort in the palm or base of the affected finger. Lumps in the fingers and palms may also be present.

ii. Cause: A size discrepancy between the tendon and the channel the tendon passes through. The tendon can become too large through frequent, repetitive motion or forceful use of the fingers and thumb. Also appears as a complication of carpal tunnel surgery, and is six times more common in women than men.

iii. Treatment: Self-splints, anti-inflammatory medication.
Medical: corticosteroid injection combined with night splinting for symptom relief, and a physical therapy program to prevent reoccurrence. Surgery can be performed in recurrent cases

iv. Training: Avoid excess tension in the hand and overuse of the hand and fingers.

f. Contusion

i. Diagnosis: Sharp pain in a specific point at the tip of the fingers of the left hand. Different from the dull pain associated with callus development

ii. Cause: A minor bone bruise, damaged nerve, or damaged muscle tissue from using too much pressure and/or extended use.

iii. Treatment: Self - Rest. Alternate heat and cold to soothe the pain.
Medical - Typically not necessary.

iv. Training: Avoid excessive force in the left hand or "hammering" of the fingers without a proper warmup. Ensure that calluses are providing sufficient protection to the fingertips

g. Finger Split
    i. Diagnosis: Break in the skin
    ii. Cause: Excessive practice hours on metal strings can cause the skin on the fingertip to break open
    iii. Treatment: Self - Limit practice and give the injury time to heal. Keep the injury clean and apply an antibacterial ointment. Medical-grade glue can be used to bring skin edges together.
    Medical - Usually not necessary unless the injury becomes infected or is not healing.
    iv. Training: Allow time for sufficient callus buildup. Wait 30 minutes after prolonged water immersion to allow the skin to harden

h. Lumps
    i. Diagnosis: Rigid or rubbery lumps, usually at the joints of the fingers and wrists. Nearly all (95%) are synovial cysts.
    ii. Cause: Weak lining of joint bulges
    iii. Treatment: Self - Leave alone. Medical - Pressure, drain with a needle, surgical removal.

i. Thumb Arthritis
    i. Diagnosis: Swelling, stiffness, or tenderness at the base of the thumb. Decreased strength, range of motion, and enlarged or bony appearance of the joint at the base of the thumb. The Grind test of the thumb produces pain or a gritty feeling.
    ii. Cause: Aging or previous injury to the joint can cause deterioration of the cartilage that covers the ends of bones. This causes the bones to rub against each other, resulting in friction and joint damage.
    iii. Treatment: Self - Rest, splint, ice/heat, instrument modifications, topical medications, pain relief.
    Medical - Steroid injections, prescription pain relief, or surgery to fuse, reposition, remove, or replace a component of the joint.

iv. Training: Seek treatment early to limit cartilage deterioration and protect the remaining tissues and bone.

j. Flexor Tenosynovitis
   i. Diagnosis: Uniform swelling of the finger, tenderness of the finger, burning pain, redness in the finger, finger stays slightly bent and cannot be straightened without pain
   ii. Cause: Infection of the tendon sheath by bacteria, sometimes introduced by a traumatic event or puncture wound
   iii. Treatment: Self - Seek medical treatment. Can cause loss of hand function or limb if treatment is delayed.
   Medical - IV antibiotics, elevation, splinting in early stages. Steroid injections, surgical drainage of the tendon sheath, and slow rehabilitation consisting of range-of-motion exercises.
   iv. Training: Early medical treatment is necessary to reduce the likelihood of surgery or loss of finger function. Prevention is difficult, as it is often the result of a minor injury that the patient doesn't remember.

Elbow

a. Pronator teres syndrome
   i. Diagnosis: Tenderness in the elbow and aching pain in the forearm, sensory disturbances in the palm of the hand, and tingling and weakness in the thumb, index, and middle fingers. Symptoms are similar to carpal tunnel syndrome, but occur in both the hand and forearm.
   ii. Cause: Compression of the median nerve in the elbow. Usually by swollen and inflamed structures around the elbow. Occurs often with prolonged pronation of the hand (turning the palm towards the floor) while tightly grasping with the fingers. The right hand of string musicians is most often at risk.
   iii. Treatment: Self - Rest, splinting, exercises and massage therapy, and antiinflammatory medications.

Medical - Hand therapy, steroid injections, or surgery to decompress the median nerve.

iv. Training: Avoid tension if the bow arm when practicing and avoid positions where the elbow is bent for long periods of time

b. Golfers Elbow - Medial epicondylitis -
   i. Diagnosis: Pain from the elbow to the wrist on the palm side of the forearm. Pain can be felt in this part of the elbow when bending the wrist towards the palm against resistance, or when squeezing a rubber ball.
   ii. Cause: Inflammation of the tendons that bend the wrist towards the palm from use of excessive force.
   iii. Treatment: Self - Ice, splinting, massage and stretching, antiinflammatory medication.
   Medical - Steroid injections or surgery.
   iv. Training: Can occur in electric and upright bassists who rest their forearms on the instrument. When the muscles in the forearm become shortened, this leads to greater tension on the tendons and disturbs the nerves in this area. Prayer stretch before and after playing

c. Tennis Elbow - Lateral Epicondylitis - upper notch - can sometimes happen together with Golfer's elbow due to overcompensation and delayed treatment of one or the other
   i. Diagnosis: Pain on the outer part of the elbow when performing activities that require resistance with a straight wrist, such as pouring a gallon of milk, turning a door knob, or shaking hands. Grip strength may also decrease when the elbow is straight. Pain and tenderness over the lateral epicondyle in the elbow.
   ii. Cause: Inflammation of the tendons that join the forearm muscles to the outside of the elbow. When the ECRB muscle is weakened from overuse, small tears form where it attaches to the bones of the elbow. As the elbow bends and straightens, this muscle also rubs against the bony bumps of the elbow, causing gradual wear and tear.

iii. Treatment: Self - Rest, anti-inflammatory medication, forearm support band, stretches, and light exercise of the muscles.
Medical - Platelet-rich plasma injection, physical therapy, ultrasound, surgery.

iv. Training: Ensure proper warmup and cooldown exercises are performed. Let your shoulder and back muscles create most of the power, avoid sharp, jerky movements, and consider a lighter bow.

Shoulder

a. Thoracic Outlet Syndrome

i. Diagnosis: Fatigue or numbness of the hand or arm with use. Slow onset. Non-specific aching of the limbs, or vascular changes causing coldness or discoloration of the hands. Symptoms are caused and relieved by positioning. The elevated arm stress test will likely be positive.

ii. Cause: The thoracic outlet is an area where nerves and blood vessels are subject to compression from the muscles of the neck, chest, collarbones, and ribs. Anatomical variations can contribute greatly to this condition, as well as bad shoulder posture and tight pectorals, often seen in cellists or other performers where the arms are held in front and wrapped around the instrument. This pinches off the blood supply or stretches the nerves, so the muscles lack blood supply, resulting in pain, numbness, tingling, and coldness.

iii. Treatment: Self - Depends on the diagnosis. If caused by tight muscles, heat application, and stretching. Strengthening the muscles of the shoulder and ensuring proper posture are also often necessary. Avoid lifting the shoulders when playing difficult passages, and work with a video camera or teacher to eliminate excess tension and forward head posture.
Medical - Physical therapy and specialized stretching methods. Surgery.

iv. Training: Maintain good posture at work and at rest and try to avoid becoming locked into a single position. Modifications to the chair or seat cushions can be considered, as well as modifications to heavy cases, or those with a strap that goes over the shoulder.

b. Bursitis
    i. Diagnosis: Pain, swelling, excessive warmth at the site, fever if the bursa becomes infected.
    ii. Cause: Inflammation of a bursa (a sac-like structure a few cells thick located in places of friction, like between tendons and bones). Too much friction in these locations can irritate and inflame the bursa, changing its texture from thin like tissue paper to thick and lumpy like corrugated cardboard. If bacteria enters, the bursa can become infected.
    iii. Treatment: Self - If an infection is present, seek medical care. Reduce aggravating activities, splinting, anti-inflammatory medications, ice application 2-3 times a day for 20-30 minutes. No heat.
    Medical - Depends on the type. Treatment may include steroid injections, physical therapy, antibiotics, removing some fluid with a needle, compression and padding, and surgery.
    iv. Training: Swelling often takes several weeks to disappear. Bursitis in musicians is most common in the shoulder (where it is referred to as rotator cuff tendinitis, shoulder impingement, or biceps tendinitis)
c. Rotator Cuff Tendinitis
    i. Diagnosis: Pain and swelling of the bursa. Shoulder weakness and/or limited range of motion based on the severity of the tear
    ii. Cause: Irritation to the area over a long period of time. Lifting overhead, calcium in the tendons, or sudden injury to the shoulder can also cause problems.
    iii. Treatment: Self - Ice and anti-inflammatory medication. Rest until pain and swelling subside. Avoid movements above shoulder level, but stay active in a comfortable range of motion to avoid a frozen shoulder.
    Medical - Physical therapy, steroid injections, surgery.
    iv. Training: Focus on shoulder stabilization exercises while healthy and ensure that the shoulders are relaxed, especially when nervous in front of an audience.

Variability in the Healing Process

Muscles, tendons, and ligaments all respond to injury and stressors in different ways. Small muscle injuries, like those sustained through exercise, repair themselves with muscle tissue, allowing muscles to increase in size and strength, while large muscle injuries repair with scar tissue.[97] The most common form of tendon injury is overuse, which results from excessive repetitive motion or repetitive overload at a rate that exceeds the tendon's ability to repair itself. Ligaments, however, are damaged through excessive stretching of the ligament after the associated joint has been moved beyond its normal range of motion.

There are three phases of the healing process: Phase I - Inflammatory (0-14 days); Phase II - Reparative (0 to 21 days); Phase III - Remodeling (21-360 days). Although most injuries will feel and appear healed three to four weeks after injury, the tensile strength of the injury is only 25% of its normal value. Several months later, only 70-80% of the strength may be restored, meaning that the remodeling process may last many months or even years, making it extremely important to continue applying controlled stresses to the tissue long after healing appears to have been completed.

A number of factors can have an impact on healing, including:

- Local factors:
  - The degree of tissue damage
  - The type and size of wound
  - The type of tissue involved
  - The presence of swelling
  - The presence of infection
  - Stress or hormonal influences
  - The blood supply to the injured site
  - The amount of stress applied to tissue
  - The degree of wound stabilization

[97] Dutton, Mark. *Dutton's Orthopedic Survival Guide: Managing Common Conditions*. New York, NY: McGraw-Hill Medical, 2011.

- Systemic factors:
  - Age
  - Comorbidities
  - Nutritional state
  - Obesity
- Extrinsic factors:
  - Medications
  - Temperature
  - Humidity

The most important factor in the healing timeline is sufficient blood flow. Low-impact exercise like walking or jogging that does not impact the injured areas is especially beneficial during this time, as it provides injured tissues with the necessary nutrients to facilitate repairs, support proper posture, and decreases exposure to stressors. Continuous immobilization of healthy muscle tissues can also result in undesirable consequences, including weakness or atrophy (muscle wasting). Disuse atrophy of muscles begins within four hours of the start of bed rest, resulting in eventual decreases in muscle mass, muscle cell diameter, and the number of muscle fibers. Prolonged immobilization of the wrists and hands with splints or slings should also be avoided, as the application of controlled stresses to the new scar tissue must occur during recovery to help prevent it from healing in a shortened position.[98] If the new tissues are kept immobile, the repair is weak and inflexible, like a frozen rubber band, making it difficult to achieve full strength and range of motion, and leaving the injured area vulnerable to future injuries and strains.

The promotion and progression of tissue repair involves a delicate balance between the protection and the application of controlled functional stresses to the damaged structure. Range-of-motion exercises should be started as soon as possible once swelling and tenderness

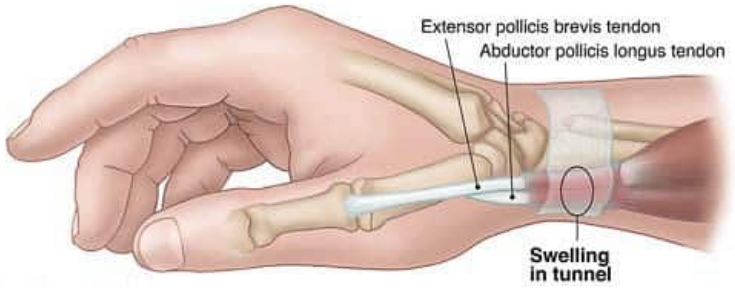
[98] Dutton, Mark. *Dutton's Orthopedic Survival Guide: Managing Common Conditions*. New York, NY: McGraw-Hill Medical, 2011.

have subsided and the exercises are not unreasonably painful. Allow pain to be the guide when working through rehabilitation exercises. Although physical therapy cannot accelerate the healing process, it can ensure that it is not delayed or disrupted and that it occurs in an optimal environment. When undergoing rehabilitation, goals and measurable objectives should be established that are realistic and that the clinical and patient believe can be achieved within a specific timeframe. If these goals have not been met after the determined time frame, the treatment method and potentially the diagnosis need to be reexamined and the goals modified, or the patient needs to be referred to another practitioner.

De Quervain's Tenosynovitis

Anatomy

Figure 4.2: Anatomy of De Quervain's Tenosynovitis[99]



De Quervain's tenosynovitis (also known as De Quervain's tendinopathy or De Quervain's tendinitis) is the inflammation of the tendons that run through the wrist and connect to the thumb bones. The specific tendons affected by De Quervain's are the abductor pollicis longus (APL) and extensor pollicis brevis (EPL), part of a group of extensor tendons located in

[99] Daniel, Gaffney. *Description of De Quervain's Tenosynovitis*. 2022. *MD West One*. https://mdwestone.com/dequervains/.

the wrist that facilitate movement and stabilization of the wrist and thumb.[100] The APL and EPL are particularly susceptible to friction and irritation as they must pass through a tight compartment in the wrist formed by dense bands of connective tissue and bone. One of the forearm bones (the radius) flares out near the base of the thumb where this tunnel is located, creating additional mechanical stress on the tendons when the wrist bends towards the pinky side of the hand (ulnar deviation; see fig. 4.4). Repetitive movements involving the thumb or wrist, such as texting, typing, or playing a stringed instrument can lead to the thickening of the tendon sheath and overlying connective tissue, resulting in increased friction and irritation to these structures. Prompt identification of this painful condition is important, because injured tendons often develop scar tissue during the healing process, leading to chronic problems.

Symptoms

De Quervain's tenosynovitis begins as a gradual onset of a dull ache and swelling near the base of the thumb and thumb side of the wrist. This pain, like most types of nerve irritation, is characterized as burning, electric, tingling, or numbness.[101] The pain can be triggered by activities that use the thumb and wrist or require a gripping motion, such as turning door knobs, forming a fist, or lifting something to the front with the thumbs pointed to the ceiling (e.g., lifting a child). This pain begins in the wrist and can travel up the forearm, and is usually worse when the hand and thumb are in use. A grating or "sticking" sensation can be felt as the tendons move through the tunnel (extensor sheath), and there may be a noticeable swelling of the wrist or a fluid-filled cyst.

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[100] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.
[101] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

Tests for De Quervain’s Syndrome

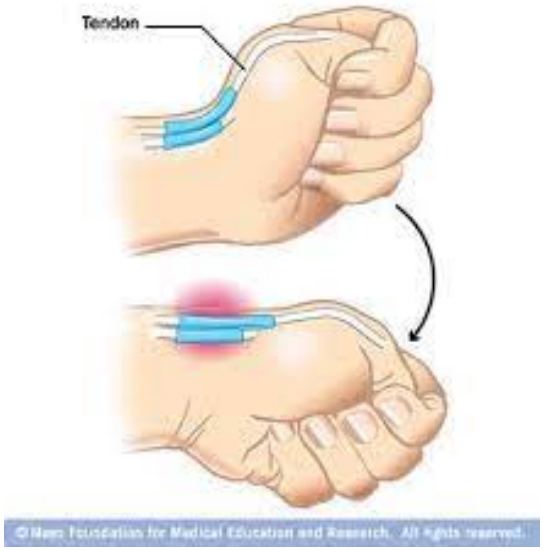
Osteoarthritis and entrapment of the superficial branch of the radial nerve are two conditions that are often confused with De Quervain's, but can usually be distinguished by a physical exam. Osteoarthritis at the base of the thumb is common in the general population, and it is often one of the first joints to be affected, so many patients are unaware that they have the condition. In osteoarthritis, the pain will occur in the same location as in De Quervain's, but can usually be differentiated by gently compressing the long bone of the thumb towards the wrist bones and gently rotating the base of the thumb in a circle while maintaining the compression. This maneuver (the grind test) does not usually cause pain and grinding with De Quervain’s but will cause discomfort with arthritis.[102]

Figure 4.3: The Grind Test

The Finklestein test consists of making a fist by wrapping the fingers around the thumb, which is tucked into the palm, and then causing ulnar deviation by bending the fist toward the pinky. Pain with this maneuver indicates a positive response, indicating either De Quervain's tendinopathy or entrapment of the radial nerve; the response is usually negative with arthritis.[103]

[102] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.
[103] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.

Figure 4.4: Finkelstein Test[104]



As this test may also be positive in several other conditions, it is important to see a doctor to complete a full medical examination. Affected musicians include string players playing upbow near the frog and pianists playing passages where the thumb must pass under the hand, like arpeggios. Tight watch bands, bracelets, or hair ties worn on the wrist can also aggravate the condition. In fact, this specific nerve compression is sometimes described in medical textbooks as “handcuff neuropathy” due to the detrimental influence even a short stay in tight handcuffs can have on these tendons.[105]

Positional Factors

4.5: Example of Ulnar Deviation

[104] McClellan, Thomas. *Finkelstein Test*. *Hand 411*. McClellan Plastic Surgery. Accessed March 27, 2022. https://hand411.com/category/finkelstein-test/.
[105] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

The tendons involved in De Quervain's tendinopathy become compressed and aggravated by certain characteristic movements, especially ulnar deviation (turning the hand and wrist toward the pinky side). Strain on these tendons increases when the thumb is brought under the hand towards the little finger when holding the bow or playing arpeggios on the piano.[106] There is additional strain when returning to the frog during an up-bow, which brings the wrist into a position of extreme ulnar deviation. The acute bend of the left wrist that occurs during large shifts or in the highest positions on the violin and viola can also pull the tendons around a sharp angle, rubbing them against bone and connective tissue.

4.6: Violinist Demonstrating Positions Requiring Ulnar Deviation

[106] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

Other causes

De Quervain's tendinopathy is known by many different names among the general population, including designer's thumb, gamer's thumb, mommy thumb, and texter's thumb. Women are far more susceptible to this condition than men, making up 80% of all cases.[107] This is caused in part by the hormone "relaxin", produced during pregnancy, that normally aids in relaxing a woman's muscles and ligaments for a baby's delivery. However, as these ligaments loosen, the muscles must work harder to keep bones in place, putting additional strain on the muscles. Once the baby is born, the physical demands on the arms and wrists greatly increase from all the holding, feeding, and changing of the new family member, further increasing the possibility of injury. Anatomical variations can play a role as well, as multiple compartments or extra tendons are often present, increasing the volume and therefore friction within the canal. Women are more likely to have a second compartment, or one for each APL and EPL tendon. Anatomical variation is very important for the surgeon to keep in mind, as one common cause of surgical failure is inadequate decompression or release of the entrapped tendons.

Adults of both genders are prone to develop this condition from frequently lifting the baby with the two thumbs pointing up. The baby's weight forces the wrists down into ulnar deviation, stressing the first compartment tendons as they try to resist the increasing weight of the child as it grows.

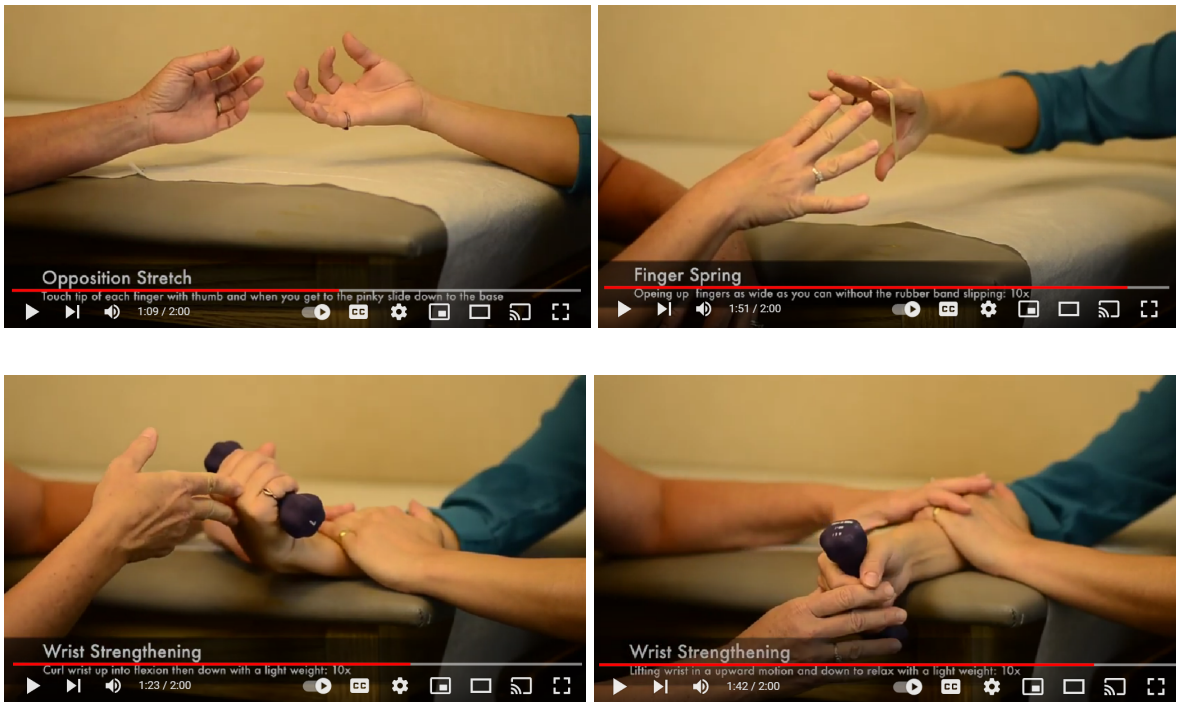
Prevention Exercises

This five-minute exercise series can be performed before the onset of De Quervain's to increase tendon health and muscle strength. Begin slowly with low repetitions; the goal is not to increase

[107] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.

the weight, but the number of repetitions performed, as the objective for musicians is endurance, not overall strength.

Figure 4.7: Exercise Series to Prevent De Quervain's Tenosynovitis[108]



Treatment

Treatment for De Quervain's tendinopathy can be conservative or surgical. Conservative intervention usually includes rest, relative modification of activities, splinting, cortisone injections, and anti-inflammatory medication. In some studies, wrist splints and pain relief medication (NSAIDs) were found to be effective only in patients with minimal symptoms and no restrictions in daily activities.[109] If splinting is appropriate, the treatment consists primarily of adequate immobilization of the thumb in a splint that goes from the tip of the thumb to about

[108] *De Quervain's Tenosynovitis: Information & Exercises For Hand & Wrist Pain*. *YouTube*. YouTube, 2016. https://www.youtube.com/watch?v=QphqT63MqiY&ab_channel=OrlandoHandSurgeryAssociates.
[109] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.

halfway up the forearm. If a splint cannot be tolerated or complied with, a padded fiberglass cast can be used for a week or two, but will cause more stiffness than a removable splint. Both the splint and the cast should be "bubbled out" directly over the tendons to avoid direct, mechanical irritation. The splint should be removed every thirty to sixty minutes for a few minutes of pain-free, range-of-motion exercises, as prolonged, uninterrupted use of the splint can result in stiffness and increased symptoms. The typical course of treatment is 4-6 weeks of splint usage while receiving cortisone injections, but this has problems with adherence due to the long time requirement. Following the removal of the splint, range-of-motion exercises are prescribed, with a gradual progression from stretching to strengthening.

While some weakness can occur as a result of splinting and only allowing gentle, controlled movements, in most healthy people, strength will return in a relatively short time upon the resumption of normal daily and musical activities.[110] A far greater concern is aggravating the injury by prematurely starting strengthening exercises with therapy putty or weights prior to the decrease of pain. If pain persists during splinting and daily activities, one or two cortisone injections can be helpful and provide rapid relief in most cases. If the condition becomes chronic or symptoms persist after six to eight weeks of treatment, then a relatively simple surgical procedure may be indicated to release the tight tunnel and free the tendons. The performer can anticipate returning to practice and start to rebuild practice time within two to three weeks after surgery.

[110] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

The site of injury should never be massaged, and the wrist should not be stretched, as this will increase the compression and friction that caused the injury, but there are some massages that can be performed that focus on relaxing the activator muscles of these two tendons. Tight muscles pull on the tendons, increasing their tension and contact with the hard surfaces of the tunnel, creating an increase in friction.

Table 4.2: Massage Exercises for De Quervain's

Point of Massage	Technique
	Massage this point forward and backward for 30 seconds, and then press and hold while slowly moving the thumb in and out and back and forth within the pain-free range.[111]
	Massage all through the thumb muscle in the palm, and then pinch and pull the muscle from the back of the hand.
	Massage all through the thumb muscle in the palm, and then pinch and pull the muscle from the back of the hand.

[111] *Thumb Wrist Pain Relief: How to Fix De Quervain's Tenosynovitis*. *Youtube*, 2020. https://www.youtube.com/watch?v=Dvdko_emB4M&ab_channel=Mr.Physio%ED%98%B8%EC%A3%BC%EB%AC%BC%EB%A6%AC%EC%B9%98%EB%A3%8C%EC%82%AC.

	Massage the point in Figure 4.6.4 in a circular motion to relax the muscle.

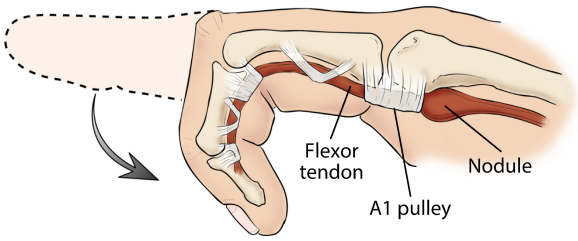
Trigger Finger

(Stenosing Tendonopathy/Tenosynovitis)

Anatomy

Trigger finger is one of the most common upper limb problems encountered in orthopedic practice and is also one of the most common causes of hand pain and disability.[112] It is an inflammatory condition involving the protective covering (synovial sheath) of the flexor tendons of the fingers and the numerous bands of fascia (retinacula) that hold the tendons in place.

Figure 4.8: Anatomy of Trigger Finger



[112] Satishchandra , Kale. “Trigger Finger.” Practice Essentials, Background, Anatomy. Medscape, July 12, 2021. https://emedicine.medscape.com/article/1244693-overview#a5.

Trigger finger occurs when the affected finger's tendon synovial sheath becomes irritated and swollen, and a hard bump (nodule) develops on the tendon adjacent to where the tendon must slip through a structure called a retinaculum (seen in white in Figure 4.7). Although these retinacula usually serve to keep the tendon in place as it travels down the finger, they can also become thickened, contributing or possibly causing friction that results in a nodule. This nodule gets caught on the edge of the retinaculum and the finger is unable to straighten until the pressure allows the nodule to pop through and move to the other side. It is this sudden popping movement, like pulling a trigger, which gives the condition its name.

Symptoms

This can be a career-threatening injury for musicians.[113] Although it is sometimes a pain-free condition, it often begins as discomfort in the palm or base of the affected finger, where a bump or nodule may be felt. The finger can be stiff in the morning after periods of inactivity, and can become caught or locked in a bent position, which suddenly "pops" straight. In the later stages of this condition, the finger may become locked in this claw-like bent position, with thickening and puckering of the skin of the palm.

Testing

In general, diagnosing trigger finger is straightforward and no pathology or lab tests are needed. Radiography is rarely necessary, but may be performed if there is concern other conditions may also be involved. The clinician will look for tenderness over the flexor tendon

[113] Rietveld, A. B. M. "Dancers' and Musicians' Injuries." *Clinical Rheumatology* 32, no. 4 (April 10, 2013): 425–34. https://doi.org/10.1007/s10067-013-2184-8.

sheath in the palm of the hand and any observable lumps on the fingers or palms. This lump will move as the finger moves causing triggering when bending or straightening the finger.

Positional Factors

The exact cause of this condition is unknown, but there are situations where it is associated with frequent, repetitive motion.[114] It can also occur after forceful use of the fingers and thumb, particularly pinching and grabbing activities. Occupation and hobbies that involve repetitive hand use, bending of the wrist towards the little finger side and prolonged gripping may increase the risk.

Other Causes

People who have diabetes, metabolic issues, or rheumatoid arthritis are at a higher risk. Trigger finger is more common in women, with 2.8 cases per 1000 versus 0.6 cases per 1000 men.[115] Pregnancy, cell phone use, and some breast cancer medications are all risk factors that can potentially contribute to its development. It can also be a complication associated with carpal tunnel, as over 60% of trigger finger patients also present with some median nerve compression at the wrist.[116]

Treatment

The prognosis is very good; typical treatment strategies include other-the-counter pain medications, steroid injections, or surgery in more severe cases. Although pain medications may

[114] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.
[115] Vuillemin, V., H. Guerini, H. Bard, and G. Morvan. "Stenosing Tenosynovitis." *Journal of Ultrasound* 15, no. 1 (2012): 20–28. https://doi.org/10.1016/j.jus.2012.02.002.
[116] Adams, Julie E., and Rohan Habbu. "Tendinopathies of the Hand and Wrist." *Journal of the American Academy of Orthopaedic Surgeons* 23, no. 12 (December 2015): 741–50. https://doi.org/10.5435/jaaos-d-14-00216.

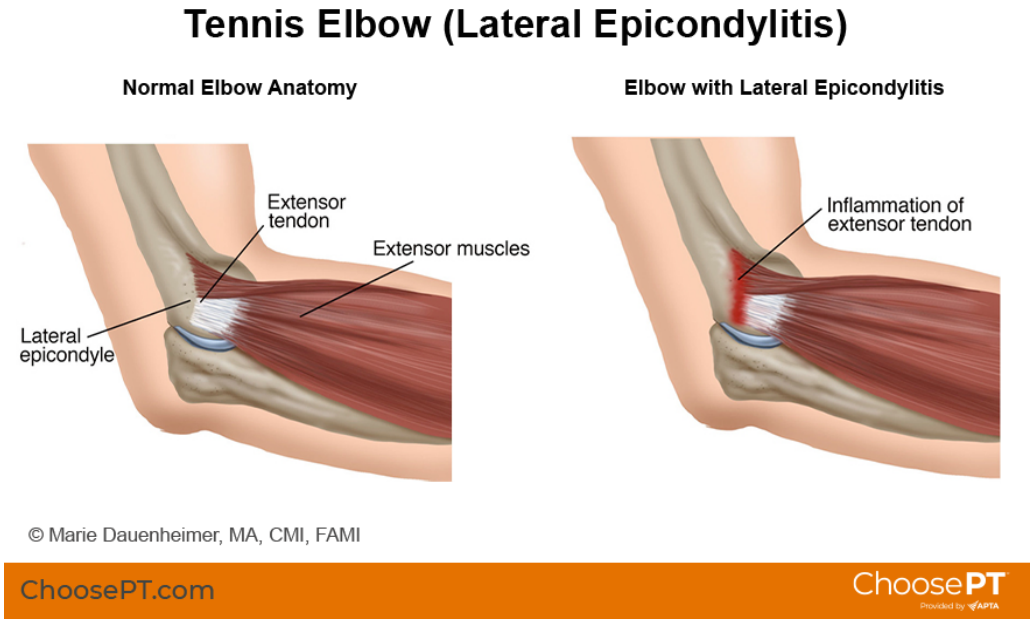
relieve symptoms, they are unlikely to relieve the swelling constricting the tendon sheath or trapping the tendon. In the past, trigger finger was treated by splinting the fingers in extension, which caused stiffness and, consequently, loss of finger mobility. In an uncomplicated case of trigger finger, the first-choice therapy is still generally agreed to be corticosteroid injection into the area of tendon sheath thickening combined with night splinting.[117] This fast-acting treatment reduces inflammation and allows the tendon to move freely, and can last for a year or more. For musicians, however, surgery may be indicated at an earlier stage due to the higher degree of demands made on their hands. Trigger digits that fail to respond to two injections usually require surgical treatment, in the form of surgical release of the A1 pulley, under local anesthesia. Physical therapy is generally not required for patients with TF. For cases of chronic TF, however, treatment may include a trial of heating modalities followed by slow stretching of the flexor tendon, as well as soft-tissue mobilization of the A1 pulley. After injection or surgery, a home exercise and stretching program may be one component of treatment.

[117] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

Tennis Elbow

(Lateral Elbow Tendinopathy)

Figure 4.9: Anatomy of Tennis Elbow



Anatomy

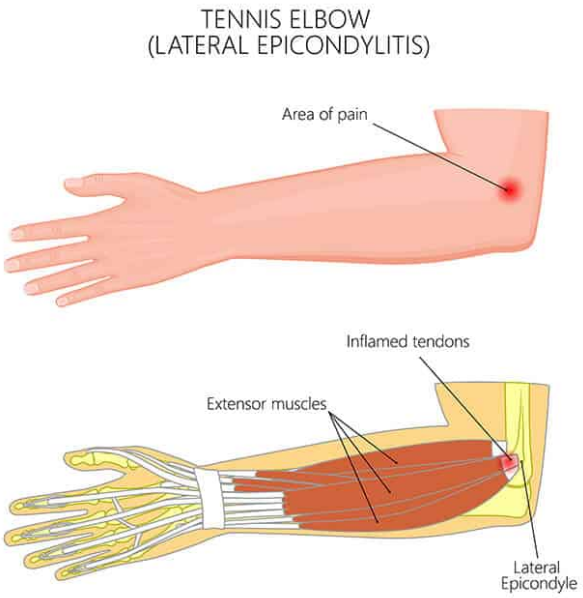
The cause of tennis elbow is multidimensional and, although it usually results from overuse, it can also be caused by a traumatic injury.[118] Although it is commonly caused by playing tennis and other racquet sports, tennis elbow also affects many people who perform repetitive activities involving the elbow. It is a common condition involving the muscles and tendons of the outer forearm, the extensor carpi radialis brevis (ECRB). This tendon attaches the muscles of the forearm to the elbow bone (lateral epicondyle) and is responsible for stabilizing the wrist and elbow. This muscle also rubs against bony bumps as the elbow bends and straightens, causing gradual wear and tear of the muscle over time. Overuse can occur with

[118] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.

repetitive arm and wrist movements, involved in painting, playing a musical instrument, using hand tools, or using a computer mouse. Repeated wrist extension (pulling the hand back as in the signal to stop traffic) and gripping and twisting movements can also lead to inflammation and tiny tears in the tendon that cause pain at the elbow.

Symptoms

4.10: Pain Location in Tennis Elbow



The symptoms of tennis elbow develop gradually. Pain is the primary symptom, and it is usually related to activities that involve straining to keep the wrist straight or grasping an object tightly, such as pouring a gallon of milk, turning a wrench, or shaking hands. In most cases, the pain begins as a mild burning or ache on the outer part of the elbow and slowly worsens over weeks and months.[119] The pain may spread down to the wrist, even at rest, and the site of the tendon's attachment to the elbow is often painful to the touch, which is found just below the

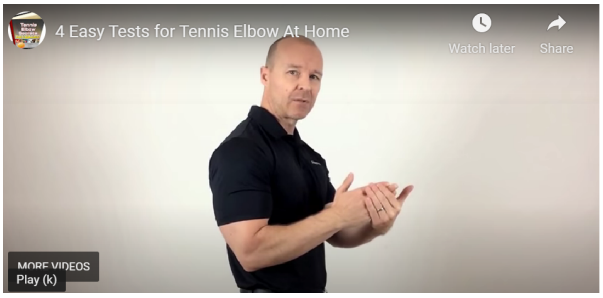
[119] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.

bony bump on the outside of the arm. General achiness and morning stiffness are also common complaints. Occasionally the pain may be experienced at night, and the patient may report dropping objects frequently, especially if they are carried with the palm facing down.

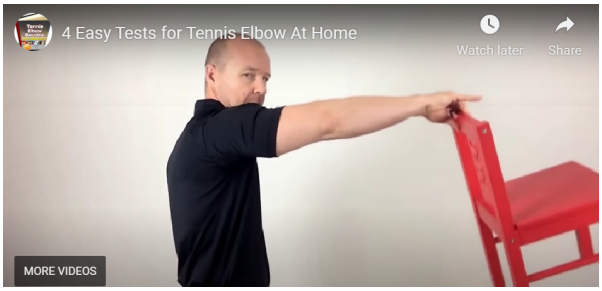
Testing

A number of simple tests exist that test for pain and functional grip loss for tennis elbow. [120] [121]

Table 4.3: Tests for Tennis Elbow

Test Demonstration	
	The area around the bony bump on the outside of the elbow is typically painful to the touch
	Hold the affected elbow out in front and try to move it away from the body while applying opposing pressure from the uninjured hand

[120] *4 Easy Tests for Tennis Elbow At Home*. *YouTube*. YouTube, 2015. https://www.youtube.com/watch?v=dfx2eo_qdCw&ab_channel=TennisElbowSecretsRevealed.
[121] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.

	Maudsley Test: Put the injured arm up and apply resistance with the other hand to the middle finger. Press away from the middle finger
	Chair test: The patient is positioned in front of a chair and is asked to lift the chair while keeping the elbows straight. A positive test is the reproduction of elbow pain.

Pain-free grip strength is the most commonly affected motor impairment, and is a reliable, valid, and sensitive measure of physical impairment in tennis elbow. A dynamometer is used to measure the grip force applied to the point of onset of pain. A 2007 cohort study by Dorf found that with the elbow straight, the affected side had 50% grip strength when compared to the unaffected side.[122]

If the diagnosis of tennis elbow is clear following the history and physical examination, diagnostic imaging is not indicated. However, imaging and diagnostic tests may be used, as there are several other conditions that can mimic the symptoms of tennis elbow, including supinator syndrome, arthritis of the elbow or neck, herniated disks, nerve compression, or other syndromes.

[122] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.

Other Causes

Tennis elbow particularly affects those who smoke, manual workers, and those with professions that require repetitive and/or forceful/heavy tasks, and non-neutral wrist postures.

Treatment

A thorough but focused history and physical examination are critical to a timely and accurate diagnosis. Analysis of posture and movement as the patient performs the activities that caused the condition is recommended to identify potential risk factors that may be modifiable through rehabilitation or posture awareness. To date, there is no consensus on the optimal treatment approach for tennis elbow, which is in large part due to its unclear underlying cause and development.[123] Thus, there are numerous interventions cited for this condition, both medical and surgical. In fact, more than 40 treatments have been suggested, indicating that the ideal remedy has yet to be found, although there is agreement that the initial management should be conservative. However, approximately 80-95% of patients have success with non-surgical treatment. The goals during the acute phase are to decrease inflammation/pain, promote tissue healing, increase flexibility, and slow muscle atrophy. This is accomplished through resting the arm to decrease swelling and inflammation, taking NSAID medications to reduce pain and swelling, avoidance of painful movements, and stretching and light exercise of the injured muscles. As the condition heals, strengthening exercises can be introduced to prevent reoccurrence.

Several new treatment modalities have been explored in the past few decades, with many demonstrating promising results in studies.

[123] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.

Table 4.4: Treatment Methods for Tennis Elbow

Treatment Method	Results
Injection of platelet-rich plasma from blood into the affected area	Platelets are known for their high concentration of growth factors, which can be injected into the affected area. This procedure has been shown to reduce the number of interstitial tears and decrease neovascularity. A study by Edwards and Calandruccio in 2003 reported that 22 patients in whom nonsurgical modalities had failed were completely relieved of pain even during strenuous activity after receiving this treatment.[124]
Forearm Support Band	This band relieves between 13-15% of the load placed on the affected muscles during use, reducing irritation in mild cases of tennis elbow.
Extracorporeal shock wave therapy	These sound waves create microtrauma which stimulates the body's natural healing processes.
Physical manipulation of the wrist	A recent randomized pilot study by Struijs of 31 patients diagnosed with tennis elbow found that manipulation of the wrist was more effective at a follow-up of 3–6 weeks than ultrasound, friction massage, and muscle stretching and strengthening exercises. These exercises were repeated 15 times, two times a week, with a maximum of nine intervention sessions.
Spinal Manipulation Techniques[125]	A retrospective study by Cleland et al. demonstrated that patients receiving manual therapy techniques directed at the cervical spine achieved similar success rates as a group who received treatment solely directed at the elbow, but that they achieved this

[124] Flatt, Adrian. "Tennis Elbow." Proceedings (Baylor University. Medical Center). Baylor Health Care System, October 2008. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2566914.
[125] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.

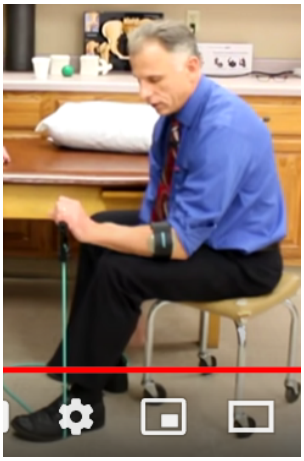
	success in significantly fewer visits. Another clinical trial by Cleland et al., which compared the outcomes of 10 patients with lateral epicondylosis, who were randomly assigned to receive localized treatment or localized treatment plus manual therapy to the cervicothoracic spine, found that the latter group demonstrated greater improvement in all outcome measures as compared to the treatment group receiving the localized management.
Physical Therapy	In a randomized trial by Bisset et al. that investigated the efficacy of physical therapy for LET versus corticosteroid injections over a 52-week period concluded that the physical therapy intervention had a superior benefit to cortisone injections after 6 weeks.

Listed below are some rehabilitation exercises that can be performed on a 10-repetition maximum, morning and night. Gradually, the weight is increased so that the 10-repetition maximum is always maintained. The pain may increase for the first week or two or three, but by the fifth or sixth week, the elbow pain will be better. An ice pack or heating pad can be used during the painful period.

Table 4.5: Exercises to Treat Tennis Elbow

Exercise	Method
	Every hour, place the forearm on a flat surface, lift your wrist, and squeeze. The pain should be dull but not sharp. This exercise is performed 10 times, 4-5 times a day.[126]
	Massage the muscle below the bony protrusion to break up the scar tissue and promote healthy and strong muscle regrowth. This should be performed for 5 minutes. It will initially be painful, but it should decrease within a minute or two. If the pain increases instead, then it is too soon and rest and ice should be resumed.
	"Drop" technique to increase elbow range of motion - lift up wrist like a bicep curl and then drop the wrist down until the arm is straight - 10 times. It should feel better with every repetition.

[126] Schrupp, Bob, and Brad Heineck. *Tennis Elbow? Absolute Best Self-Treatment, Exercises, & Stretches. YouTube*. YouTube, 2017. https://www.youtube.com/watch?v=NExFfXSe2Mc&ab_channel=Bob%26Brad.

	Rotation stretch - bring the wrist up like a bicep curl and then turn the wrist a little further outwards or inwards 10 times. Stick with the one that feels better with repetition.
	Once the pain has gone away, the next goal is to increase muscle strength. In this exercise,a theraband or weight can be used. The uninjured hand helps lift the weight up, releasing at the top. The injured hand then slowly lowers the weight down. As the injury improves, it may not need the help of the uninjured hand.

If symptoms don't resolve after 6 to 12 months of non-surgical treatments, surgery is recommended. This involves removing the diseased muscle and reattaching the healthy muscle back to the bone. Physical activity can usually be resumed 4 to 6 months after surgery. Tennis elbow surgery is considered successful in 80 to 90% of patients, but it is not a desirable option for musicians as it is not uncommon to see a loss of strength as a side effect.

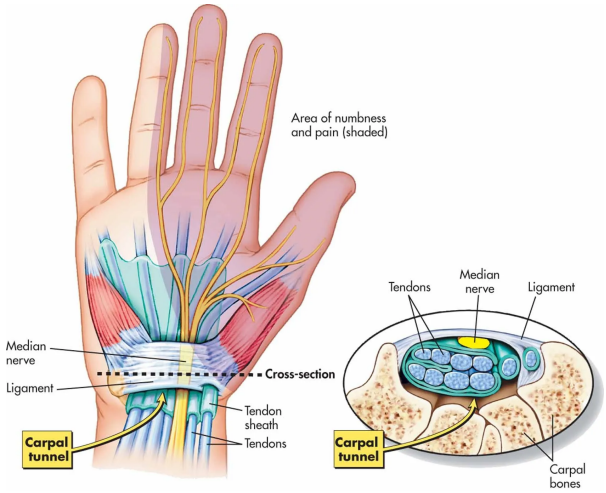
Carpal Tunnel Syndrome

Carpal tunnel is a common condition that causes pain, numbness, and tingling in the hand and arm. The condition occurs when the median nerve (one of the major nerves of the hand) is squeezed or compressed as it travels through the wrist. Although it is common among data entry

and assembly line professionals, musicians are also at high risk for developing this common syndrome.

Anatomy

Figure 4.11: Anatomy of the Carpal Tunnel



The carpal tunnel is a narrow passageway on the palm side of the wrist, about an inch across. As seen above, the floor and sides of this tunnel are formed by small wrist bones called carpal bones, while the roof is formed by a strong band of connective tissue (transverse carpal ligament/flexor retinaculum), which transforms the carpal arch into a tunnel. Because the tunnel is formed by these solid boundaries, the carpal tunnel has little capacity to stretch or increase in size. The nine tendons that bend the fingers and thumb (flexor tendons) and the median nerve all thread through the carpal tunnel. As the median nerve lies between these tendons and ligaments, it is very susceptible to compression by these structures.[127]

The median nerve originates as several nerve roots in the neck that come together to form a single nerve in the arm. This nerve goes down the arm and forearm, passes through the carpal tunnel at the wrist on its way to the hand. It carries motor impulses to the hand as well as sensory

[127] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.

impulses from the skin for the thumb, index, middle, and inside half of the ring fingers and controls the muscles around the base of the thumb.

Carpal tunnel syndrome occurs when the tunnel becomes narrowed or when the tissues surrounding the tendons (synovial sheaths) swell, putting pressure on the median nerve. Synovial sheaths can be thought of as long narrow balloons filled with synovial fluid, which wrap around a tendon so that one part of the balloon wall is directly on the tendon, while the other part of the balloon wall is separate. During wrist motions, the sheaths move with the tendons to reduce friction. When the sheath becomes irritated and swells, it cannot move the rigid walls of the carpal tunnel and instead takes the path of least resistance on the softer nerves and tendons, putting pressure on the median nerve. This added pressure and friction restricts healthy blood flow and causes further irritation, resulting in nerve swelling. This further decreases the available space and results in pain, numbness, tingling, and weakness in the hand. Some people are born with a smaller tunnel than the average population, which predisposes them to this condition.

Symptoms

Carpal tunnel syndrome refers to the symptoms of median nerve compression. These are typically numbness, tingling, burning, and pain, localized in the thumb, index, and middle fingers, and the half of the ring finger closest to the middle finger. Occasional shock-like sensations can also be felt that radiate into these fingers. This pain or tingling may travel up the forearm toward the shoulder, making the fingers feel useless and swollen, even though little or no swelling is apparent. Weakness or clumsiness in the hand and especially the thumb makes it difficult to perform small muscle activities like buttoning clothes or handling small objects. Other symptoms include dropping things due to finger weakness, numbness, or loss of awareness

ofwhere the hand is in space. For musicians, this loss of dexterity becomes noticeable much earlier than in the general population due to the demands of their profession.

These symptoms may disappear and reappear in the early, milder stages of the syndrome, but as the condition worsens they occur more frequently or persist for longer periods of time. Symptoms often first appear or persist at night, or early in the morning, causing the patient to wake up with numb or painful hands, feeling the need to "shake out" the hand or wrist. Night-time symptoms are very common, due to the fact that many people sleep with their wrists bent. During the day, symptoms may occur when the wrist is bent forward or backward for a long period of time, such as using a phone, driving, or reading a book. Moving or shaking the hands helps relieve symptoms. As the median nerve is present all throughout the arm and even into the neck, the pain can also radiate to these areas, but carpal tunnel syndrome is only treatable at the wrist. As the condition progresses, some people with very severe CTS cannot determine hot or cold by touch and may burn their fingertips without noticing. The muscles of the thumb may also noticeably waste away.

Testing

The diagnosis of CTS is primarily by physical examination, although other tests such as nerve conduction velocity studies can be useful for confirmation and clarification. Patient symptoms and history are usually sufficient to clearly determine the cause to be carpal tunnel syndrome. Tingling and/or decreased sensation in the thumb, index, middle, and half of the ring finger is typical with this condition.

Tinel's Sign for CTS

The doctor can provoke the symptoms of carpal tunnel by tapping or pressing on the median nerve. Variations of this test exist in regards to the location and number of taps, and in some studies, the test is performed by tapping the median nerve with the wrist bent slightly back, while others tap on the path of the nerve up until where it enters the carpal tunnel. Generally, though, the median nerve is gently tapped 4-6 times at its location on the wrist, and if pain, tingling, or electric shock sensations are felt, then the test is positive for CTS.[128]

Figure 4.12: Tinel's Sign at the Wrist

[128] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.

Phalen Test

In the Phalen test, the patient bends the elbows and places the back of the hands together for 45 seconds. The test is positive if tingling or numbness are felt around the median nerve, and in some patients, an aching sensation of the hand and wrist is felt.

Figure 4.13: Phalen Test

Reverse Phalen Test for CTS

A reverse Phalen position is the same as the Phalen except the palms are placed together in the “prayer pose”. The patient is asked to keep both hands with the wrists completely bent for 60 seconds. The test is positive if the carpal tunnel symptoms are replicated while performing this test. An indicator of the severity of the condition is how quickly the symptoms appear while testing for Phalen's sign and how long they take to disappear once the wrists are released.

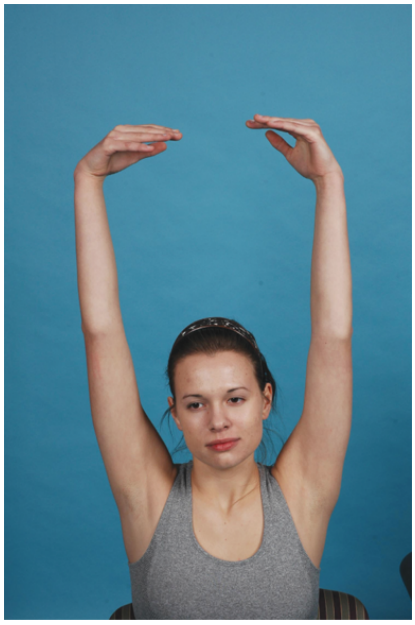
Figure 4.14: Reverse Phalen Test

Hand Elevation Test for CTS

A more sensitive and specific test for carpal tunnel involves simple hand elevation. The patient is seated or standing and is asked to elevate both arms above the head with the wrists bent inwards and hold them in this position until tingling or numbness occurs. A positive test is the reproduction of carpal tunnel symptoms after raising the arms for no longer than 2 minutes. This test was found to be more specific than Phalen or Tinel tests, but it can also be positive in patients with thoracic outlet syndrome.[129]

[129] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.

Figure 4.15: Hand Elevation Test



Wrist Flexion and Median Nerve Compression Test

The patient holds their arm straight with the palm facing up and flexes the wrist 60 degrees. The clinician then applies constant and even pressure over the median nerve at the carpal tunnel with their thumb. This test is positive for carpal tunnel if the symptoms are reproduced along the median nerve within 30 seconds.

Figure 4.16 Wrist Flexion and Median Nerve Compression Test

In severe cases, the muscles around the base of the thumb will atrophy and appear visibly smaller. Obvious signs of wasting or weakness of the thumb muscles indicate severe or long-standing disease and the need for a surgical consultation. The doctor can also test sensitivity in the fingertips and hands by touching them with a special instrument while the patient has their eyes closed. There are several other conditions that mimic carpal tunnel syndrome, and these should be ruled out before progressing further with treatment.

Other tests include electrophysiological tests that measure nerve function and degree of compression and also help determine whether another nerve condition or type of compression is contributing to symptoms. Electrodiagnostic testing can be useful in confirming a diagnosis, especially if surgery is a potential option. Testing is also useful because the median nerve can be compressed in locations other than the wrist, such as the forearm or the neck, producing symptoms very similar to carpal tunnel syndrome. Electrodiagnosis is often extremely useful in assessing both the site of the entrapment and the severity and prognosis.

Electrophysiological tests may include:

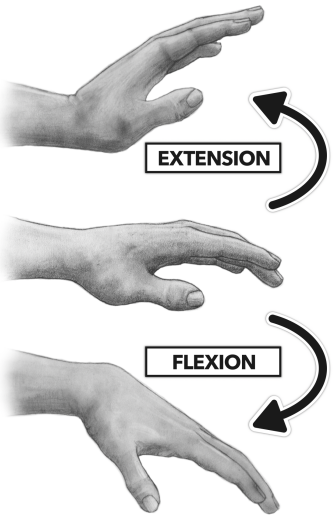
- Nerve conduction velocity (NCV) studies: In a NCV study, the nerve is electrically stimulated at a certain point. A surface electrode placed on the skin over the nerve at a different location registers the length of time the impulse takes to travel between the two points. This allows the clinician to calculate the velocity of the impulse and determine the health of the nerve, as nerve transmission is slowed across a compressed or damaged segment. These results are used to determine the degree of damage to the nerve and decide on future treatment plans.
- Electromyography (EMG) tests: In an EMG test, a thin, Teflon-covered probe, similar to an acupuncture needle, is inserted into a muscle and the electrical activity is observed on a screen. Compression or damage to the nerve that stimulates that muscle produces a recognizable pattern of electrical activity.

About five to ten percent of people with CTS will have a normal EMG/NCV, so the test results must always be correlated with the patient's history and other clinical findings.[130] Conversely, many asymptomatic people have a borderline slowing of the NCV across the wrist, and this should not be considered a sign of injury. Other types of tests include ultrasounds to measure the diameter of the nerve, x-rays, and MRIs to exclude other causes for the symptoms, such as arthritis, fracture, or scarring.

[130] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

Positional Factors

Figure 4.17: Wrist Flexion and Extension



The most common cause of carpal tunnel syndrome in musicians is sustained or repetitive wrist flexion (bringing the palm towards the arm). A study performed in 1981 by Gelberman showed that the pressure in the carpal tunnel increased dramatically as the wrist approached 90° of flexion or 90° of extension.[131] Repetitive flexion and extension of the wrist also resulted in a sustained increase of pressure within the carpal tunnel, causing inflammation of the flexor tendons. The subsequent swelling of the tendons can then cause the median nerve to be further compressed against the rigid walls of the carpal tunnel.

These extremes in wrist position are often seen in people playing in the higher positions on the violin and viola. The viola, with its wider body, tends to cause an even greater degree of wrist flexion in high positions. Some string players also allow the right wrist to flex excessively on the up-bow as the frog approaches the bridge and extend when approaching the tip. The key

[131] Gelberman, R H, P T Hergenroeder, A R Hargens, G N Lundborg, and W H Akeson. "The Carpal Tunnel Syndrome. A Study of Carpal Canal Pressures." *The Journal of Bone & Joint Surgery* 63, no. 3 (1981): 380–83. https://doi.org/10.2106/00004623-198163030-00009.

factor here is repetitive or sustained extremes of wrist position combined with muscle tension. To minimize carpal tunnel pressure, string players should strive for a neutral wrist position when playing, or at least avoid positions that require sustained or repetitive flexion or extension of the wrist. If that is not possible, then the practice should be performed in very brief segments for the passages that require extreme flexion, interspersing them with the practice of less stressful passages.

Other Causes

Carpal tunnel can be caused by any number or combination of factors. Anatomical differences that decrease the space in the carpal tunnel can cause a faster onset of symptoms. Women are three times more likely than men to develop carpal tunnel, partly due to smaller tunnel sizes and fluid retention during pregnancy.[132] This condition, called gestational carpal tunnel syndrome, can increase the pressure within the tunnel, causing nerve compression, but it typically resolves itself after the birth of the child. Hormonal changes during pregnancy and menopause can also cause fluid retention, and conditions like diabetes, rheumatoid arthritis, and thyroid gland imbalances are all associated with carpal tunnel syndrome. Although CTS usually occurs gradually, it can also be caused by a trauma or injury to the wrist that results in swelling, such as a sprain or fracture. Modern technology is also a main contributing factor to the development of carpal tunnel syndrome, as cell phone, computer, and game console use contribute to nerve irritation. CTS is beginning to affect younger patients than ever before due to the unnatural wrist positions needed to text and take photos.[133] Even reality TV star Kim

[132] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.
[133] White, Debbie. "Growing Number of Millennials Need Surgery for 'Selfie Wrist' Due to Phone Use after Kim Kardashian Suffered Condition." *The U.S. Sun*, December 15, 2019. https://www.the-sun.com/news/158104/growing-number-of-millennials-need-surgery-for-selfie-wrist-due-to-phone-use-after-kim-kardashian-suffered-condition/.

Kardashian was diagnosed with carpal tunnel in 2018 as a result of taking 6,000 photos on a Mexican vacation. The use of vibrating hand tools, assembly line work and data entry positions, and cell phone and computer use are all risk factors that need to be taken into consideration.

Treatment

There aren't many, if any, treatment techniques for carpal tunnel syndrome.[134] Most treatments are aimed at prevention, splinting, or post-surgical protocols, with the mainstay of conservative treatment being splinting and avoiding offending activities. Early on, symptoms can often be relieved by simple measures like wearing a wrist splint or decreasing certain activities. If the pressure on the nerve continues, however, it can lead to nerve damage and worsening symptoms.

Nonsurgical treatments may include bracing or splinting. These devices leave the fingers free but stabilize the wrist, preventing flexion or extension over 5 degrees. They are commonly used at night for mild cases, as many people sleep with their fists curled up and wrists flexed. If the symptoms do not subside within a week or two, the splints should be used during the day as well. They should be removed every hour or two for five to ten minutes of gentle exercise and stretching to prevent wrist stiffness. The splints may be removed for instrumental practice, assuming that the practice does not provoke the rapid or severe onset of symptoms, and positions of increased wrist flexion must be avoided during practice.[135] Sometimes splinting is only partially successful. Although it keeps the wrist neutral, some splints allow grasping and opening

[134] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.
[135] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

of the fingers, permitting the flexor tendons to still move and rub against the inflamed median nerve.[136] A full-length splint that immobilizes the fingers will prevent this.

Figure 4.18: Full-Length Wrist and Finger Splint

In addition to splinting, other treatment methods that are often helpful are the moderate use (five minutes) of ice massage to reduce inflammation, low-dose ultrasound treatments, and anti-inflammatory medications to relieve pain and inflammation. For musicians, postural or instrument changes can help slow or stop the progression of the disease.

After immobilization, some patients may benefit from nerve gliding exercises that help the median nerve move more freely within the carpal tunnel. Steroid injections are a powerful anti-inflammatory agent that can be mixed with local anesthetic and injected into the carpal tunnel. Although these injections often relieve painful symptoms or help to calm a flare-up of symptoms, their effect is sometimes only temporary. Vitamin B6 supplements are often used as a conservative and adjunct therapy in the treatment of CTS. Although their effectiveness is controversial, in a retrospective review of 994 CTS patient charts, Kasdan and Janes found that, in the 494 patients whose treatment included vitamin B6 (100 mg twice daily), the rate of

[136] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

symptom alleviation was much higher (68%) than among patients who did not receive vitamin B6 (14.3%).[137] This and other studies present evidence to suggest that vitamin B either increases pain tolerance or helps treat an underlying nerve condition, but is so far inconclusive. However, this method is still recommended as a complementary treatment to postpone hand surgery.

If conservative treatment is unsuccessful after a period of 6 to 8 weeks, and electromyography shows signs of muscle denervation, surgery is usually recommended. This decision is based on the severity and length of symptoms to prevent irreversible damage.

Surgical Procedure

Surgery for any condition should not be thought of as a quick fix, and should only be considered when every other alternative conservative measure has failed. However, if there is evidence of muscle wasting or if the pain, numbness, or tingling are so severe and persistent that they become disabling to one's musical career or daily activities, then a surgical intervention would likely benefit the patient. Surgery for CTS has a fairly high success rate for relieving symptoms by alleviating pressure on the median nerve by cutting the ligament that forms the roof of the tunnel. This increases the size of the tunnel and decreases pressure on the median nerve. After surgery, the ligament may gradually grow back together, but there will be more space in the carpal tunnel and less pressure on the median nerve. Recovery, however, may be gradual, and complete recovery may take up to a year, depending on the type of surgery performed. Grip and pinch strength usually return by about 2 to 3 months after surgery, but if the condition of the median nerve was poor before surgery, it may not improve for 6 to 12 months. In long-standing cases of carpal tunnel syndrome with severe loss of feeling and/or muscle wasting

[137] Ryan-Harshman, Milly, and Walid Aldoori. "Carpal Tunnel Syndrome and Vitamin B6." *Canadian Family Physician* 53, no. 7 (July 2007): 1161–62.

around the base of the thumb, recovery will also be slower. For these patients, a complete recovery may not be possible. A new, micro-invasive surgery can be performed in less than 10 minutes and claims to return patients to work within 4 days, but this procedure is still being studied for effectiveness.

Cubital Tunnel Syndrome

(Ulnar Nerve Entrapment)

Nerve entrapment at the elbow is common among musicians. Unlike tendonitis or muscle strain, irritated nerve tissue does not respond quickly to physical therapy or medications. Rest and early recognition of the syndrome are of the utmost importance in preventing more severe nerve damage and its consequences.

Anatomy

Figure 4.19: Affected Regions of Cubital Tunnel

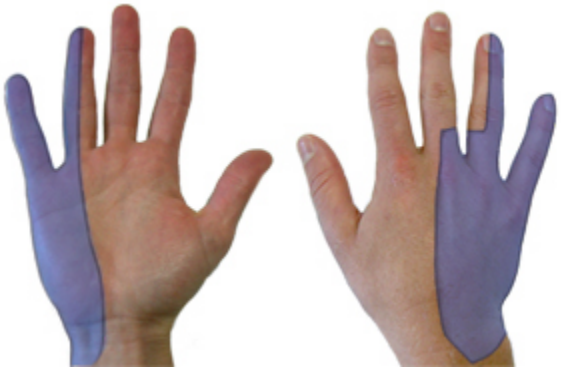
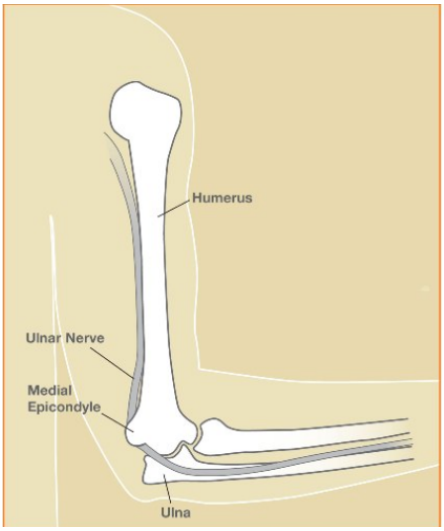


Figure 4.20: Anatomy of the Cubital Tunnel



Cubital Tunnel Syndrome is a condition that involves compression or irritation of the ulnar nerve (the “funny bone” nerve), which can cause numbness or tingling in the ring and little fingers, pain in the forearm, and/or weakness in the hand. The ulnar nerve is the most commonly affected nerve around the elbow, and the second most common compression neuropathy in the upper limb, after carpal tunnel syndrome.

The ulnar nerve is one of three main nerves in the arm, responsible for giving feeling to the little finger and half of the ring finger. It controls most of the smaller fine movement muscles in the hand and some of the bigger muscles in the forearm that provide a strong grip. As it travels from the neck all the way down into the hand, it can be constricted in several places, such as the collarbone, elbow, and wrist. Ulnar nerve compression at the elbow is called cubital tunnel syndrome. Although the ulnar nerve is fairly well protected in the arm, it is in a more vulnerable position at the elbow, and can be compressed or entrapped in and around this point. The ulnar nerve passes between a tunnel, called the cubital tunnel, created by the two heads of the flexor carpi ulnaris muscle. When the elbow is bent, space decreases in the tunnel, causing increased

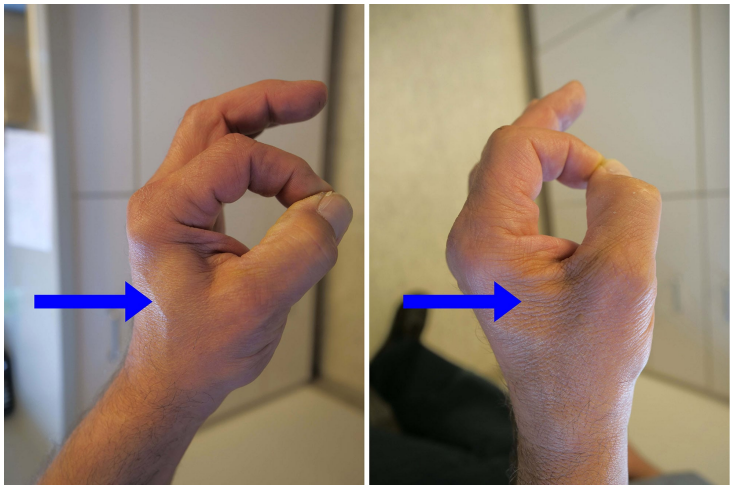
compression on the ulnar nerve. The anatomy of the ulnar region means that certain instrumentalists are predisposed to develop cubital tunnel syndrome. Violinists and violists are especially prone to this condition due to the degree of bending and twisting of their left elbow when playing, but this injury is common among all string players.

Due to the location of the ulnar nerve near the skin's surface, repetitive motion, prolonged elbow flexion, or medial elbow instability may initiate a cycle of inflammation and swelling that inhibits the normal flexibility of the nerve. Injury can also occur through physical force applied to the elbow, such as resting it on a chair arm, or table, causing additional compressive force on the internal structures of the cubital tunnel. The severity of nerve injury will be dependent on the strength, duration, and type of the applied forces.

Symptoms

The most common symptoms of cubital tunnel syndrome include numbness and a tingling "pins and needles" sensation in the ring and little finger. It may feel like these fingers are "falling asleep" and occurs more frequently when the elbow is bent, such as when performing, driving, typing, or holding a cell phone. Some people will wake up at night with numb fingers or pain that extends out from the elbow, and in some cases, it may be harder to move the fingers or manipulate objects. As the symptoms worsen, grip weakness, decreased sensation, and difficulty with finger coordination when playing an instrument or typing on a keyboard may occur, along with a progressive inability to separate the fingers. If the nerve is very compressed or has been compressed for a long time, muscle wasting in the hand can occur, with the ring and little finger locked in a claw-like shape.

Figure 4.21: Thumb Muscle Wasting



Testing

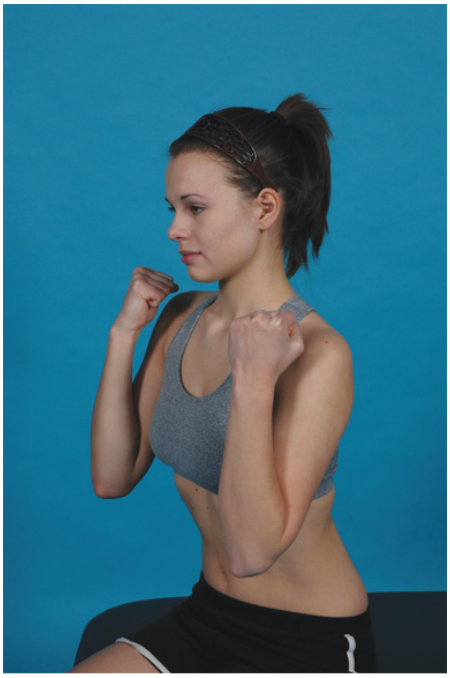
Cubital tunnel syndrome is diagnosed through a combination of medical history as well as observable data and test results.

Table 4.6: Tests for Cubital Tunnel Syndrome

Tinel's Sign	The primary test requires the clinician to tap four to six times over the "funny bone" nerve at the elbow. If the nerve is irritated, this can send a shock into the ring and little fingers. However, as anyone who bumps their elbow can attest, this sensation can also be felt with a healthy nerve.

Source: Mark Dutton: Dutton's Orthopaedic Examination, Evaluation, and Intervention, Fifth Edition

Elbow Flexion Test



Source: Mark Dutton: Dutton's Orthopaedic Examination, Evaluation, and Intervention, Fifth Edition

The elbow flexion test checks to see if the elbow is the main location of nerve compression. The elbows are bent as far as possible up to the shoulders, similar to a bicep curl, but with the shoulders low and relaxed. The patient stays in this position for 3-5 minutes and is then asked to describe any symptoms. Tingling and numbness in the forearm and hand indicate a positive test.

Wartenberg's Sign	The clinical moves all five fingers on the affected hand so they are spread out and the patient is asked to pull them together again. A positive test result is if the patient is unable to pull the little finger in with the rest of the fingers.
Froment's Sign	The patient is asked to make a fist and grip a piece of paper with the thumb and hold as the clinician attempts to pull it away. A positive sign is if the paper can be easily taken away, or if the patient has to bend the thumb to grip the paper.

Although cubital tunnel syndrome can be diagnosed clinically, definitive diagnosis is made by two types of electrodiagnostic testing: nerve conduction velocity studies (NCV) and electromyography (EMG).[138] Nerve conduction velocity studies test the speed at which the nerve conducts an electrical impulse. When a nerve is entrapped, irritated, or partially damaged, the nerve impulses are slowed across the damaged segment. Therefore, by stimulating the nerve and measuring the velocity in several different areas, the clinician can discover the exact location of compression and damage. An EMG focuses on testing the muscles to determine whether the nerve compression is also causing muscle damage. This consists of probing the muscles to look for electrical patterns characteristic of nerve damage. Indication of muscle damage is a more serious finding than damage to the sensory portion of the nerve itself and may warrant earlier and more aggressive treatment, like surgery.

A clinician might also perform x-rays to ascertain if other factors are contributing to nerve compression. As x-rays provide detailed pictures of dense structures, like bone, the most

[138] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

common causes of ulnar nerve compression cannot be seen on an x-ray. However, x-rays can help rule out bone spurs, arthritis, and other places where a bone may be compressing the nerve.

Positional Factors

Cubital tunnel syndrome is surprisingly frequent in musicians (up to 9% of all musicians' injuries). The ulnar nerve is used intensely in music-making, because it is responsible for almost all fine motor muscles of the hand. In the left arm in the cello and double bass, there is a prolonged, significant bend of the elbow, especially in the lower positions, which stretches and compresses the ulnar nerve in the cubital tunnel. In the double bass, the ulnar nerve is also subject to local pressure when the elbow is placed on the body of the instrument in higher positions. Although a violinist's left arm never bends at as severe an angle as a cellist's, the left arm is twisted, which stretches and puts additional strain on the nerve. The flexor carpi ulnaris muscles, which form the sides of the tunnel and surround the ulnar nerve, are used in playing in the seventh position and above on the violin, and contraction of these muscles contributes to additional nerve compression. When a string musician plays with excessive tension in the left hand, these muscles remain constantly flexed, which can lead to problems such as cubital tunnel syndrome and tendonitis.

Other Causes

Direct pressure, like leaning the elbow on an armrest, can put pressure on the nerve, as well as keeping the elbow bent for long periods of time. Sometimes the ulnar nerve does not stay in place and snaps back and forth over a bony bump as the elbow bends and straightens. This type of repetitive snapping can irritate the nerve, especially if soft tissues over the nerve become thicker or there is an extra muscle over the nerve that prevents it from working correctly. The

anconeus, an extra elbow muscle, has also been reported as a cause of cubital tunnel syndrome and has been found to occur in 3–28% of human anatomic specimen elbows, and in as many as 13% of patients undergoing surgical treatment for cubital tunnel syndrome.[139] Musicians who have to spend long hours driving between freelancing gigs may not realize that driving with their elbows bent, especially without power steering, can also contribute to this condition.

- Outside Factors/influences
    - Computer/cell phone use
    - Weight lifting/physical exercise
    - Stress and anxiety

Treatment

The treatment of cubital tunnel syndrome depends heavily on early recognition, when the problem is easier to cure. Avoiding extreme and prolonged bending of the elbow is very important and may require the use of a splint, especially at night when the elbows are usually bent. Treatment for cubital tunnel syndrome consists of splinting the elbow in extension, although not necessarily with a rigid splint: a hinged splint that allows not more than 90 degrees of elbow flexion is best.[140] In severe cases, the splint is worn during the day, or the elbow is cast at about 45 degrees. The splint should be worn all night and for as many hours per day as possible for ten to twelve weeks, or until the tingling and numbness subside. As the symptoms lessen, the hinge is adjusted to allow more and more elbow movement. When over 100 degrees of flexion is attained and sustained without provoking symptoms, the splint may be gradually

[139] Dutton, Mark. *Dutton's Orthopaedic Examination, Evaluation, and Intervention*. New York, NY: McGraw Hill Education, 2020.
[140] Norris, Richard. *The Musician's Survival Manual: A Guide for Preventing and Treating Injuries in Instrumentalists*. United States: M M B MUSIC INC (MO), 1993.

discontinued and normal activities resumed. Gentle strengthening exercises may be helpful if the arm has become somewhat weakened from disuse, but of greater importance is a gradual return to playing. Exercises must not reproduce the nerve symptoms and may, therefore, initially need to be performed in limited arcs of motion.

Cellists should begin practicing in thumb position and gradually work towards first position. During recovery, musicians should work to minimize left-hand tension during forte passages and analyze their music to determine passages where repetitive practice could be detrimental to their health. For example, a violinist could more safely play in the first and second positions and avoid playing in the higher positions, if possible. The goal with any nerve compression syndrome is to get the pressure off of the nerve. Although it is not possible to directly manipulate the nerve to speed healing, the goal is to remove the factors that increase nerve compression and irritation.

Table 4.7: Treatment Methods for Cubital Tunnel Syndrome

Elbow Pad	Used to avoid direct compression of the nerve when leaning on the elbows
Cold Packs	Applied for ten minutes, two to three times per day
Oral anti-inflammatory medications	NSAIDs
Aspercreme	Salicylate-based creams contain anti-inflammatory medication that can penetrate through the skin into the affected area
Gabapentin	A prescription anti-convulsant, has a low incident of side effects, other than drowsiness, and can be extremely helpful. It should be started at a low dosage and slowly increased as tolerated.

For those patients who fail to respond to conservative management after 3–4 months, and who have muscle atrophy, persistent sensory changes, or persistent symptoms, surgical decompression or an anterior transposition of the ulnar nerve is available. Sometimes, surgery is needed to relieve the pressure on the nerve, especially in the case of anatomical variations. There are several types of surgical procedures, which can involve releasing the nerve, moving it to the front of the elbow, and/or removing part of the bone. Numbness and tingling may improve quickly or slowly, and it may take many months to recover after surgery. The symptoms of cubital tunnel may never go away, even after surgery, especially if the symptoms are severe. However, if cubital tunnel syndrome is recognized and treated early enough, it often resolves fairly quickly and well without surgery.

CONCLUSION

One of the great benefits of living in the modern age is the degree of accessibility of all of the information included in this research. Not only are studies into the causes and treatment of musicians' injuries more numerous than ever, but prominent members of the musical community are finally comfortable enough to speak out about their pain and injuries to a wider audience. There is an overall desire to access this information and high motivation from teachers and professors to communicate accurate information to their students about these conditions, making it an ideal time to incorporate injury prevention as an essential component of music education. Although it will take many years before the cultural, social, and institutional stigma surrounding these conditions fades away, over the course of this project I was happy to encounter many motivated individuals working to improve the professional musical environment for the next generation of musicians. It is my hope that this work continues, and injury prevention for musicians becomes an essential component of string pedagogy and future achievement in music performance.

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