BECOMING A HEALTHIER GUITARIST: UNDERSTANDING AND ADDRESSING INJURIES

A DISSERTATION IN
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DOCTOR OF MUSICAL ARTS

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ABSTRACT

The field of performance arts medicine is supplying musicians with alarming statistics regarding their health. Authors give statistics as high as 93% when discussing the injury rate among instrumentalists. As guitar is one of the instruments listed with the highest incidence of playing-related injuries, this work addresses the types of injuries to which musicians, including guitarists, are prone, as well as their causes and treatment. Musicians often tend to neglect proper treatment for playing related injuries, which leads to the conclusion that investing time in prevention methods is the best choice in regards to injuries. The efficacy of common routines for injury prevention such as warming-up, taking breaks, among others, has proven statistically to be successful. Studies show that warm-up routines and periodic breaks from music practice seem to be effective against playing-related injuries; the benefits of stretching, however, remain controversial. Since some of the injuries investigated are preventable to a large extent through technical adjustments, informed suggestions for guitarists are included. Though the solutions presented are not necessarily the only ones available, they are supported by studies in performing arts medicine.

APPROVAL PAGE

The faculty listed below, appointed by the Dean of the Conservatory of Music and Dance have examined a dissertation titled: “Becoming a Healthier Guitarist: Understanding and Addressing Injuries,” presented by Bráulio Bosi, candidate for the Doctor of Musical Arts degree, and certify that in their opinion it is worthy of acceptance.

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CHAPTER 1

MUSICIANS' INJURIES: AN OVERVIEW

As the field of performing arts medicine evolves, it becomes clear why it should be taken seriously. The statistics shown in multiple studies in this relatively new research area converge to an alarming scenario in which musicians, professionals and amateurs, are exposed to significant risks of injuries of several kinds and degrees that could alter the path of their careers. Musicians need to know that they are at risk, as well as realizing where, how and why injuries can occur. Their consciousness must be raised so they realize the importance of maintaining good physical health.

Though numbers vary and there are different understandings as to what is considered a playing-related injury by the researcher or by the subjects interviewed, some studies estimate that the rate of upper-extremity musculoskeletal disorders among professional musicians ranges from 39% to 87%, and between 34% and 62% among secondary school music students.[1] Other authors acknowledge an even wider range of playing-related injuries among instrumental musicians, with injury rates varying from 26% to 93%.[2]

The Netherlands, a country that is estimated to have 13,000 professional musicians in its population, has a musculoskeletal injury rate of over 60%, in which the musicians were injured to the point where performance was "impossible for some

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[1] Tim Morse et al., "A Pilot Population Study of Musculoskeletal Disorders in Musicians," *Medical Problems of Performing Artists* 15, no. 2 (June 2000): 81.

[2] Christine Guptill and Christine Zaza, "Injury Prevention: What Music Teachers Can Do," *Music Educators Journal* 96, no. 4 (June 2010): 28-9.

time."[3] The numbers in this study led Rietveld to conclude that although acute injuries caused by music making are rare, injuries are often caused by chronic "imbalance between load and load-bearing capacity" and overuse and/or misuse while making music.[4]

A study performed by Morse et al. involving 209 people who stated that they played a musical instrument, professionally or not, concluded that this activity "may be second only to computer use in prevalence as a possible risk factor for cumulative trauma disorder."[5] In this study, 29% of all musicians indicated significant pain, with keyboardists and guitarists leading these statistics, reporting 33% and 30% respectively.[6]

Though the sample sizes of some of these studies might be relatively small, they tend to point towards the same direction and support larger-scale studies. For example, a study done with more than 1,000 musicians found that 36% had muscle fatigue and/or strain as consequences of "poor technique, inadequate supports, bad posture, or overuse/misuse" and that "45% had recognizable structural disorders aggravated or precipitated by technical factors."[7]

Another study indicated that playing-related injuries can affect musicians outside of classical music as well. In a survey performed by Buckley and Ralph, 111 exclusively non-classical musicians were questioned about whether they had ever

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[3] A. B. M. (Boni) Rietveld, "Dancers' and Musicians' Injuries," *Clinical Rheumatology* 32 (April 2013): 430-1.

[4] Ibid., 431.

[5] Tim Morse et al., 81.

[6] Ibid., 84.

[7] John L. Rigg, Randy Marrinan, and Mark A. Thomas, "Playing-Related Injury in Guitarists Playing Popular Music," *Medical Problems of Performing Artists* 18, no. 4 (December 2003): 151-52.

experienced an injury that they felt was attributed to playing a musical instrument. Their results showed significant and disconcerting numbers: 54% (60 participants) reported "having had a playing-related injury at some time," while 19% (21 participants) said that the injury "currently bothers them."[8]

Among conservatory students, different studies from different authors have concluded that 20% of them report a career-altering injury at some point.[9] These studies also show that female musicians are at a higher risk of developing musculoskeletal injury, especially string and keyboard players.[10] This information on female musicians calls for special attention as data shows that the incidence of playing-related musculoskeletal disorders among female musicians can be twice that of their male counterparts,[11] with authors claiming that it may be partially due to "women being smaller in stature and more prone to hypermobility."[12] A survey using a significant sample size of 4,457 musicians (2,345 female and 2,112 male participants) over ten academic years (between 1986 and 1996) published by Cayea and Manchester was consistent with the information presented above.[13] According to their findings, female musicians presented an overall injury rate of 8.9% while male musicians had an injury rate of 5.9%. The authors of this study also acknowledge

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[8] Taylor Buckley and Ralph Manchester, "Overuse Injuries in Non-Classical Recreational Instrumentalists," *Medical Problems of Performing Artists* 21, no. 2 (June 2006): 81-82.

[9] Tim Morse et al., 82.

[10] Sarah J. Wu, "Occupational Risk Factors for Musculoskeletal Disorders in Musicians: A Systematic Review," *Medical Problems of Performing Artists* 22, no. 2 (June 2007): 50.

[11] David Johnson, "Classical Guitar and Playing-Related Musculoskeletal Problems: A Systematic Review" (research document, Lund University, 2009), 15, accessed April 3, 2016, https://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=1530017&fileOId=1530022.

[12] Ibid.

[13] Danelle Cayea and Ralph Manchester, "Instrument-Specific Rates of Upper-Extremity Injuries in Music Students," *Medical Problems of Performing Artists* 13, no. 1 (March 1998): 21.

consistency with the previous findings, which revealed injury rates between 9.5% and 12.1% among females and between 4.9% and 7.2% among males.[14]

Though women seem to be at a higher risk of playing-related injuries, this information should not mislead us since the entire musician population, including students, is at significant risk, not just one group. Through the analysis of different studies, Park, Guptill and Sumsion express their concern with musicians' health, stating that "a large majority of university musicians have or will experience playing-related injuries at some time during their careers."[15] Such concerns are exemplified by the numbers shown by Guptill and colleagues, where college musicians were surveyed and the results revealed that "87% of them reported having experienced a music-related injury."[16] A different research study mentioned by Guptill and Zaza in one of their publications indicated an injury rate of 25% among music students,[17] and while these are contrasting numbers, the lower end of these injury rates still raises concerns.

When comparing student musicians to a control group of non-musicians, Miller and colleagues found that "music students are more likely to report an upper-limb pain problem."[18] Roach and colleagues published similar data and reported that pain in the shoulder, elbow, and wrist were found to be two times more likely in instrumental musicians than in non-musicians, while musicians were 50% less likely

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[14] Ibid., 22.

[15] Anna Park, Christine Guptill, and Thelma Sumsion, "Why Music Majors Pursue Music Despite the Risk of Playing-Related Injuries," *Medical Problems of Performing Artists* 22, no. 3 (September 2007): 89.

[16] Shannon McCready and Denise Reid, "The Experience of Occupational Disruption Among Student Musicians," *Medical Problems of Performing Artists* 22, no. 4 (December 2007): 140.

[17] Guptill and Zaza, 28.

[18] Park, Guptill, and Sumsion, 89.

to have lower-body pain.[19] Ritveld states that the "upper extremity is affected in 78% of the musicians' injuries."[20] Numbers like these support Park, Guptill, and Sumsion's position that playing-related injuries among musicians are a real and powerful risk.[21]

Hagglund's survey with music students from the New England Conservatory and Boston University's School of Music found that a significant percentage of the music students developed symptoms of playing-related injuries during the earlier stages of their music development, namely their high-school and undergraduate studies rather than their graduate school years.[22] The New England Conservatory students claimed that the primary contributing factors to developing playing-related injuries were "long hours (38%), over-practicing (30%), and technically challenging pieces (30%)," while the students from Boston University reported that "performing/preparing for performance (77%), pressures from self (72%), and school requirements (66%)" were the main contributing factors.[23]

The results of these studies presented thus far, using varied sample sizes, populations, and analyses, creates an alarming scenario, placing the entire musician population at considerable risk when pursuing professional activities.

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[19] Sang-Hie Lee et al., "Intervention Program in College Instrumental Musicians, with Kinematics Analysis of Cello and Flute Playing: A Combined Program of Yogic Breathing and Muscle Strengthening-Flexibility Exercises.," *Medical Problems of Performing Artists* 27, no. 2 (June 2012): 85.

[20] Rietveld, 431.

[21] Park, Guptill, and Sumsion, 89.

[22] Wu, 46.

[23] Ibid.

1.1 The Place of Guitarists in this Discussion

As this project focuses on guitarists, it is essential to summarize the studies that isolate individual instrumentalists, especially guitarists. Though it is debatable which instrument is at the highest risk of playing-related injuries, many writers agree that the guitar is one of the instruments that pose the highest risks when compared to the overall population of musicians. A study published by Cayea and Manchester that examined instrument-specific injury rates of university-level musicians indicated that the highest rates of injuries were among pianists, guitar players and harpists, ranging from 12 to 18 injuries per 100 performance major student years.[24] Other authors also place guitar as one of the leading instruments for developing a musculoskeletal injury. Rietveld states that "bowed string-players and guitarists together form 53% of injured musicians,"[25] while Morse's study places guitarists second only to keyboardists in injury prevalence.[26]

In order to demonstrate how guitarists are affected by musculoskeletal disorders, Fjellman-Wiklund and Chesky cite a report from a hand surgical practice that treated 167 instrumentalists that showed that "guitarists presented mostly left-sided or bilateral strains distal to the elbow, inflammatory conditions, nerve problems such as focal dystonia in the hand and fingers, and carpal tunnel syndrome."[27] In addition to those more common medical conditions, the authors also listed "guitar-

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[24] Tim Morse et al., 82.

[25] Rietveld, 431.

[26] Tim Morse et al., 84.

[27] Anncristine Fjellman-Wiklund and Kris Chesky, "Musculoskeletal and General Health Problems of Acoustic Guitar, Electric Guitar, Electric Bass, and Banjo Players," *Medical Problems of Performing Artists* 21, no. 4 (December 2006): 169.

string dermatitis among other skin conditions, tuft finger fractures, and acro-osteosis as evidenced by the shortening of the distal phalangeal finger bones due to mechanical stress on the fingers while playing the guitar."[28]

Fjellman-Wiklund and Chesky also point out that among all types of guitarists, classical players are the most likely to suffer from musculoskeletal problems related to playing.[29] They also emphasize that guitarists who play popular music "also experience playing-related pain in the left hand, wrist, back, and neck."[30] Providing data from the University of Texas Musician Health Survey, Fjellman-Wiklund and Chesky showed that of the 520 popular musicians surveyed, 83% of the acoustic and 74% of the electric guitarists reported "one or more musculoskeletal problems."[31]

Rigg, Marrinan, and Thomas also acknowledge that classical guitarists have their own and unique set of injuries due to their formalized posture and hand techniques, but concluded after a survey of guitarists who play various styles of popular music (including acoustic and electric guitar as well as amateurs, professionals, and students) that a substantial number of these are also currently experiencing playing-related pain.[32] That survey revealed that 61.3% of 261 guitarists suffered some kind of pain over the last twelve-month period.[33] The most often reported location for playing-related pain in this study was the fretting hand with

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[28] Ibid.

[29] Ibid.

[30] Ibid.

[31] Ibid.

[32] Rigg, Marrinan, and Thomas, 150.

[33] Ibid

41.8% of the population surveyed reporting pain over the last twelve months, followed by back and neck pain with 17.2% and 14.9%, respectively.[34]

In contrast with Rigg's study, Dhriti, Agrawal and Aju, distributed a questionnaire to non-professional guitar players with no history of inflammatory or medical conditions between the ages of 18 and 30 years old and found out that the neck and lower back were the leading sites of pain, with 29% of the selected population, followed by wrist and shoulder with 17% and 15.5%, respectively.[35] The authors of this study suggest that the major cause of complaints could be caused by the awkward sitting posture for the guitarists who claimed to play guitar while sitting (87.1%).[36]

Scully performed a detailed study to determine the prevalence of playing-related musculoskeletal disorders to the upper limb in third-level student guitar players and their most affected upper limb location.[37] In this study, 244 students from the University of Limerick (Ireland) completed an on-line survey, and the researchers found out that 21% (52) of the respondents experienced some degree of pain that "affected their ability to play at the level they were accustomed to," with fingers and wrist as the most commonly affected areas (60% and 52% respectively).[38]

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[34] Ibid.

[35] M. Aill Dhrithi, Parul Raj Agrawal, and Kurian Aju, "Prevalence of Playing-Related Musculoskeletal Disorder (PRMSD) Among Amateur Young Guitar Players," *Journal of Musculoskeletal Research* 16, no. 2 (2003): 1-2.

[36] Dhrithi, Agrawal, and Aju, 3-4.

[37] Darren Scully, "The Prevalence of Playing-Related Musculoskeletal Disorders to the Upper Limb in Student Guitar Players" (research document, University of Limerick, 2011), 6, accessed April 3, 2016, https://ulir.ul.ie/bitstream/handle/10344/1526/2011_Scully_D.pdf.

[38] Ibid., 10-13.

Scully's study investigated the specific symptoms that had a direct effect on the guitarists' ability to play at their highest level and revealed that 15% of the respondents reported weakness or fatigue affecting mostly their wrist (59%), thumb (49%) and fingers (46%), while 28% of the participants suffered from lack of control affecting primarily the fingers (58%) and the wrist (57%), with the thumb being much less affected (36%).[39] 3% of the respondents experienced numbness that affected their playing ability and 6% experienced paresthesia (pins and needles), with the fingers being the most common area affected, with 36%.[40]

Overall, excluding mild symptoms of pain, Scully's study found a prevalence of playing-related musculoskeletal disorder in 41% of the respondents.[41] 71% of those affected by the disorder presented one of the symptoms, 19% experienced two symptoms, while the percentage of those who presented three and four symptoms were 8% and 1%, respectively.[42] The author found that fingers and wrist were the most common areas affected among the guitarists surveyed, and that these numbers matched a previous study that stated that "61% of students in a music school reported their fingers and wrists as being the most affected area."[43]

Marques et al. studies both classical and flamenco guitarists in order to show how prone to overuse injuries these types two of guitarists can be. They interviewed 64 professional guitarists (32 flamenco players and 32 classical players) who practiced at least three hours a day and the results showed a high prevalence of overuse

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[39] Ibid., 16.

[40] Ibid., 16-17.

[41] Ibid., 18.

[42] Ibid.

[43] Ibid., 21.

syndromes in both groups, especially among the flamenco technique group.[44] Of the 64 guitarists, 75% showed symptoms of overuse syndrome, and when isolating each type of technique, overuse syndrome was reported by 62.5% of the classical guitarists and 87.5% of the flamenco guitarists, with 50% of the classical guitarists affected reporting deterioration in playing ability and 82.1% of the flamenco group affected reporting the same.[45]

According to this study, both types of players presented dorsal and cervical pain, pain in the forearm, motor discoordination, paresthesia in the fingers, and tension in the upper-extremities as symptoms for overuse syndrome.[46] When asked the possible causes for the appearances of these symptoms, around 40% in each group answered that the increased amount of hours of playing time was responsible for it, 20% of the classical and 57.1% of the flamenco guitarists responded that they did not know the reason, and none of the flamenco players attributed it to the change of repertoire, in contrast to 40% of the classical guitarists. Most symptoms had about even responses in both groups. Dorsal and cervical pain were reported by 53.1% in each group. Pain in the forearm had a slightly higher incidence in the flamenco group, with 65.6% as opposed to 56.3% among the classical guitarists. Paresthesia in the fingers was reported by 6.3% in both groups, and motor discoordination was reported by 18.8% of the classical guitarists and 25% of the flamenco players.[47]

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[44] Djalma Nunes Marques et al., "Flamenco Guitar as a Risk Factor for Overuse Syndrome," *Medical Problems of Performing Artists* 18, no. 1 (March 2003): 11.

[45] Ibid.

[46] Ibid., 12.

[47] Ibid.

One symptom particularly caught the researchers' attention. Tension in the upper extremities had an alarming incidence in 81.3% of the affected flamenco players, compared to a still high 56.3% of the classical guitarists.[48] In the authors' conclusion, the fact that flamenco guitarists often play in ensembles makes them try to accentuate the volume of the instrument, thus unconsciously increasing the amount of tension in the hands while attempting to play louder.[49] This process is also incorporated into practice, which when added to the already tense position of both hands in flamenco technique can result in overuse syndrome. The differences between flamenco performance and style and those of classical playing are the likely reasons for the discrepancy in responses.[50]

When discussing the specific areas in which guitarists are affected, Fertman asserts that fear and anxiety influences the injuries, and under these conditions, guitarists "stiffen up and fall back into all of their worst habits of misuse."[51] This information suggests that the environment and pressure with which guitarists have to deal might increase the number and severity of injuries and must be taken into consideration in the treatment as well as prevention of injuries.

When it comes to female guitarists being more prone to playing-related injuries than their male counterparts, the data is inconclusive. Cayea and Manchester's study revealed that women reported no injuries, compared to 15.4% among the male

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[48] Ibid., 13.

[49] Ibid.

[50] Ibid.

[51] "The Alexander Technique Can Boost Your Health and Your Career," *International Musician* 111, no. 9 (September 2013): 21.

respondents.[52] This study, however, had only 5 female guitarists compared to 39 males. Scully also presented data on the subject, and published that 53% of the female guitarists who responded to the survey reported having some form of playing-related musculoskeletal disorder, compared to 44% in the male group. The author, however, acknowledge that this difference is not statistically significant based on their sample size.[53]

1.2 Seeking Help (Or Not)

The literature might not offer conclusive evidence as to a precise number of injury rates or prevalence of pain among musicians in general and guitarists in particular, but even if the reality falls on the low end of the statistics mentioned, it is still an alarming scenario for performing musicians. Statistics suggest that guitarists may not even know what is causing their playing-related injuries. Many are reluctant to seek professional help, as it would often mean taking time away from the instrument. Furthermore, corrective measures are not always reaching those who need this kind of corrective help.

The unwillingness to go through the healing process can be observed in the findings of Guptill, Zaza and Paul. In their survey of college students, only 25% of the injured group of musicians who responded "sought help from a health professional."[54]

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[52] Cayea and Manchester, 21.

[53] Scully, 19.

[54] C Guptill, C Zaza, and S Paul, "An Occupational Study of Physical Playing- Related Injuries in College Music Students," *Medical Problems of Performing Artists* 15, no. 2 (June 2000): 86-90. Quoted in McCready and Reid, 140.

Park et al. interviewed students who reported an awareness of the risks of playing-related injuries but still opted to play through the pain, since long-term performance rest was not considered a viable treatment option.[55] They also presented numbers from a study that found that "79% of their sample population felt that playing through pain was acceptable in overcoming technical difficulties," confirming that musicians are at many times unwilling to rest in order to preserve their health.[56]

Heming studied a population of 59 musicians where 70% either suffer or have suffered a playing-related injury at some point in their career and found that an encouraging 73% sought help.[57] Although these initial numbers seem encouraging, 75% of the respondents "were reluctant to take time off from playing," confirming the results of the studies discussed above.[58] The numbers in this study are particularly disconcerting, as 27% of the interviewed population had an injury that forced them to stop playing, yet a large percentage were still unwilling to take time off.[59]

When guitarists were asked about their attitudes towards alleviating symptoms of pain or discomfort, classical guitarists had a tendency to take more initiative than flamenco guitarists. The Marques et al. study revealed that 65% of the classical guitarists listed rest as the main precaution taken, with 35% listing a change of

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[55] Park, Guptill, and Sumsion, 94.

[56] Ibid.

[57] M.J.E. Heming, "Occupational Injuries Suffered by Classical Musicians through Overuse," *Clinical Chiropractic* 7 (2004): 58.

[58] Ibid.

[59] Ibid.

repertoire.[60] Regarding flamenco guitarists, "nothing" was the main response of 60.7% of the injured respondents.[61]

Musicians give a variety of reasons for playing through pain. The necessity for income, fear of losing an orchestra job, or the simple need to keep playing were some of the reasons they list as to why they would play through an injury.[62] It might be debatable if such reasons are worth putting someone's long-term career and health in jeopardy, but to many musicians playing through pain is worth the risk and remedial treatment measures, including rest, are not.

1.3 The Effect of an Injury on a Musician's Career

With proper care musicians are usually able to enjoy a full recovery after most playing-related injuries. However, injuries can still be devastating for a musician's career. Recovery time can be long and directly impact the musician's daily routine, possibly also affecting technique, financial income, and psychological state.

The rebuilding of collagen tissue (including tendons, ligaments, and connective tissue) is major part of injury recovery. According to Rietveld, it can take 300 to 500 days for the tissue to be rebuilt, and though the human body has an incredible capability to adapt, responding to "major changes can take over a year."[63]

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[60] Marques et al., 12.

[61] Ibid.

[62] Heming, 61.

[63] Rietveld, 431.

Various types of therapies can prove effective. Heming states that one of the most useful treatments of overuse syndromes is rest.[64] This could mean "a decrease in playing time, a change in technique, or complete cessation of playing and, possibly, other activities regarded as contributory."[65] Authors like Mitchell recommend a combination of therapies such as "Alexander technique, Feldenkrais, acupuncture or acupressure, psychological counseling, and physiotherapy," which together can achieve a high success rate.[66]

Not every possible treatment is necessarily warranted. Mitchell warns against the use of splints, taping, or wraps, classifying them as temporary solutions to a serious problem as they can "restrict circulation, cause atrophy of the muscles in the affected area through restricted use, and decrease flexibility."[67] Steroid injections are also discouraged as they have "long-term health hazards" and only target the pain, which allows the injured tissues to continue to be damaged.[68] Mitchell admits that such high power anti-inflammatories may be "necessary if other treatments have not reduced the inflammation that is causing nerve compression."[69] In rare cases, when other corrective measures prove ineffective, the treatment of playing-related injuries may require surgery.[70]

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[64] Heming., 56.

[65] Ibid.

[66] Tamara Mitchell, "A Painful Melody: Prevention & Treatment of Musicians' Injuries," Working Well Ergonomics Information Website, 2015, accessed March 12, 2016, http://www.working-well.org/articles/pdf/Musicians2.pdf.

[67] Ibid.

[68] Ibid.

[69] Ibid.

[70] Ibid.

Treatments for playing-related injuries may be long and painful and require different therapies. As that would directly affect the routine of a musician, many performers do not seek treatment until the injury is fully developed. Citing multiple authors' reports, McCready and Reid state that "musicians are reluctant to refer to themselves as injured, because they do not want to be compelled to rest or change their routine or technique."[71] They are generally "unwilling to sacrifice practice time in order to recover."[72]

On the psychological issues faced by musicians after an injury, McCready and Reid found student musicians reporting "frustration over their inability to grow as musicians, with many thus experiencing an identity crisis."[73] Other music students in McCready and Reid's study noted an imbalance between the need to practice and the need to care for their bodies. While aware that hard work could eventually lead to injuries and that balancing activity with breaks was necessary, they wanted still to continuously improve on musical and technical abilities, in other words, to hone their musical identity.[74]

When a musician's desire to improve pushes the boundaries of their health, an injury may take place. The enthusiastic students interviewed by Park, Guptill and Sumsion, for example, reported personal experiences of tendonitis[75] and pain that directly affected their academic and personal lives in addition to their musical

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[71] McCready and Reid, 141.

[72] Ibid.

[73] Ibid., 142.

[74] Ibid., 143.

[75] Tendonitis as well as tendinitis refers to the same injury, though different authors choose one word over the other.

pursuits.[76] They reported that once an injury affects technique and causes a decrease in skills, their academic life is affected as they have to postpone juries and cancel rehearsals.[77] Considering that most curricula require performance activities, a playing-related injury can likely delay or even terminate their music studies.[78] In some cases it may even affect their daily lives, such as when a student sustains a back injury that limits activities such as lifting objects, bending over to put on socks, or even walking.[79]

As quoted by Jones, Norris concludes that musicians should take care of their bodies just as they take care of their expensive instruments and that "cardiovascular fitness, flexibility, and strength training" should be incorporated in daily routines.[80] Norris also advises musicians to look into techniques, such as Alexander Technique, that may help them better understand their bodies and improve the quality of their movements.[81] McGowan suggests that musicians should try to stay relaxed when they play and go easy on their bodies; he advocates fractioned practicing sessions with breaks rather than marathons, so that the body would be better able to handle the workload.[82] The consensus is that it is better to avoid the musical, physical, social, and psychological damage that an injury may cause through prevention and taking care of the body.

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[76] Park, Guptill, and Sumsion, 92.

[77] Ibid.

[78] Ibid.

[79] Ibid.

[80] Carol Anne Jones, "Music and Medicine: Preventing Performance Injuries," *Teaching Music* 9, no. 2 (October 2001): 26.

[81] Ibid., 29.

[82] Sean McGowan, "Here's How: Take It Easy," *Acoustic Guitar* 16, no. 3 (September 2005): 46.

CHAPTER 2

THE FOUR BROAD CATEGORIES OF INJURIES AFFECTING MUSICIANS

Musicians are often compared to athletes, and like athletes are more likely to compromise their health when pushing the body to an extreme in order to achieve a goal or overcome job challenges. Negative effects are exacerbated if practice, performance, or even daily activities are done without thoughts to how they will affect the body. Scully states that musculoskeletal disorders can "present themselves as specific diagnoses such as shoulder impingement, ligament sprain, tendinitis, thoracic outlet syndrome, carpal tunnel syndrome and focal dystonia," or "non-specific diagnoses such as regional pain syndrome."[1] McGowan asserts that most of these diagnoses fall into one of the following four categories: 1) cumulative trauma syndromes, 2) nerve entrapment syndromes, 3) thoracic outlet syndrome, and 4) focal dystonia.[2]

According to McGowan, cumulative trauma syndromes are the ones "often called repetitive or overuse injuries," with the most common being "tendinitis (inflammation of the tendons), epicondylitis (an inflammation of the area near the elbow), and bursitis (inflammation of a fluid-filled sac near a joint)."[3] Nerve entrapment syndromes are exemplified by one of the most common syndromes in guitarists: carpal tunnel, which often occurs when the individual bends the wrist too

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[1] Scully, 7.

[2] McGowan, 42-46.

[3] Ibid.

much when playing causing pressure on the median nerve on the wrist.[4] Thoracic outlet syndrome occurs when the nerves behind the collarbone, which connects the neck and arms and hands, are compressed to the extent that the individual "may feel pain, weakness or numbness in [the] arm or hand."[5] The fourth category suggested by McGowan, focal dystonia, is described by the author as an "abnormal spasm of isolated muscle groups" that may occur due to holding the breath while playing or awkward body positioning.[6]

Before analyzing the four broad categories McGowan proposed, we must acknowledge that different authors have different classification methods for musicians' injuries. Guptil and Zaza for example, explain that musicians' injuries in the upper extremity such as hand, arm and shoulder injuries are often presented as overuse problems, strains and sprains, inflammatory conditions (such as tendonitis and tenosynovitis), nerve compression problems (such as carpal tunnel syndrome), and other neurological conditions such as focal dystonia.[7] Heming, with a different view, understands that overuse syndromes may be presented "as a neuropathy, tendinitis, tenosynovitis, peritendinitis crepitans, arthritis, spondylosis, reflex sympathetic dystrophy or repetitive strain injury."[8] Therefore, the same injury may be presented in different categories depending on the source.

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[4] Ibid.

[5] Ibid.

[6] Ibid.

[7] Guptill and Zaza, 28.

[8] Heming, 56.

2.1 Cumulative Trauma Syndromes

Cumulative trauma syndromes, or disorders, are defined as the "excessive wear and tear on tendons, muscles and sensitive nerve tissue caused by continuous use over an extended period of time."[9] They include the so-called repetitive or overuse injuries, though we must discuss that these terms are not always appropriate for a diagnosis. Kember and Saba call repetitive strain injury an "umbrella" term. They say it is widely used to include several unclear diagnoses, covering pain from the neck to the hand.[10] "Overuse, misuse, tenosynovitis, and upper-limb disorders" are other terms for this group of injuries.[11] Adding to this list of terms, Rietveld mentions the "acronym CANS ('complaints of arms, neck and/or shoulders'), which was introduced in 2004 to replace the acronym RSI ('repetitive strain injury')."[12] Though CANS is just as broad as RSI, Rietveld criticizes the name of the latter, claiming that although musicians' playing includes repetitive motions, "this fact itself does not cause an injury" and might be misleading.[13]

Muldowney agrees with Rietveld that some of these terms might be misleading and criticizes the term "overuse syndrome." To Muldowney, though the term describes the problem, overuse is probably the least common cause of injuries.

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[9] "Cumulative Trauma Disorder: What Are Cumulative Trauma Disorders, and What Steps Can Be Taken to Help Prevent Employees Working On Computers from Experiencing Them?," Safety and Health Magazine, June 1, 2013, accessed April 1, 2016, http://www.safetyandhealthmagazine.com/articles/cumulative-trauma-disorder.

[10] Jane Kember, "You and Your Guitar - Part 5: Repetitive Strain Injury," *Classical Guitar* (1996): 31.

[11] Ibid.

[12] Rietveld, 434.

[13] Ibid.

Injuries in this category are caused by "a buildup of perpetual tension" that causes inflammation which pinches and injures the nerves. [14] Muldowney clarifies that these injuries are generally the product of "misuse or misapplication instead of actual overuse."[15]

To Marques et al., "overuse syndrome is a generic term that may be applied to a group of ailments affecting many parts of the body, including the upper extremities."[16] These authors claim that "this condition is not always clearly defined," and "it generally appears when fibers are stretched beyond their anatomical and physiological limits."[17] They also point out that it can affect "different groups of professionals whose hands undergo repetitive movement," but it could also be attributed to other causes in some instances, such as psychological conditions.[18] Norris generally agrees with Marques et al.'s description and adds that once "any biological tissue--muscle, tendon, ligament, etc.--is stressed beyond its physical limit," it can "result in microscopic tears to the body part," which "leads to small amounts of bleeding and swelling within the injured area."[19] Explaining what Marques et al. and Norris mean by taking the body parts beyond what they are able to withstand, Muldowney states that injuries could happen when body parts are used "in ways that are unnatural or contrary to their intended use," applying "more force than necessary

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[14] Micah Muldowney, "Optimal Muscle and Tendon Extension for Guitar Players," *Soundboard* 36, no. 4 (2010): 30.

[15] Ibid.

[16] Marques et al., 11.

[17] Ibid.

[18] Ibid.

[19] Richard Norris, "To Your Health: Recognition and Prevention: Overuse Injuries," *International Musician* 103, no. 6 (June 2005): 10.

for a given task, maintaining a static or rigid posture" for a long amount of time, or keeping muscles in a "state of perpetual tension" over an extended period.[20]

2.1.1 Causes of Cumulative Trauma Syndromes

Several authors assert that overuse results from a combination of factors. Rueda sees overuse as "an accumulation of micro-injuries that eventually surpass the physical limitations of the body" as "tissues are not able to make up for the disorders caused by mounting fatigue."[21] Rueda maps the causes of overuse syndromes by listing co-contraction, excess activity in the static muscles, and strained joint positions as relevant risk factors. According to her, co-contraction occurs "when agonist and antagonist muscles contract too much and simultaneously in such a way that the antagonist is unable to relax when the others contract."[22] Rueda also explains that excess activity in the static muscles is usually caused by "holding a posture with no equilibrium," which "hinders the circulation resulting in muscle fatigue,"[23] and that strained joint positions may lead to overuse injuries when "extreme joint positions put too much pressure on the joints," compressing nerves and impeding muscle activity.[24]

According to Rosenbaum el at., joint hypermobility syndrome is a risk factor for the development of playing-related injuries, including cumulative trauma

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[20] Muldowney, 30.

[21] Virginia Azagra Rueda, *The Healthy Guitarist: How to Save Energy, Avoid Injury and Get More Out of Your Playing*. (Madrid: Acordes Concert, 2006), 68.

[22] Ibid.

[23] Ibid.

[24] Ibid.

syndromes.[25] In joint hypermobility syndrome, one's joints can move beyond natural range of motion. When the musician can move his joints beyond its natural limits, muscle contraction becomes the primary stabilization of the affected joint and "the prolonged need for dynamic stabilization leads to pain, fatigue, and spasm."[26] These symptoms, as previously presented, are often tied to the causes of overuse injuries.

2.1.2 Tendon Injuries

Among the most frequent injuries in musicians, tendon injuries are a sub-category of cumulative trauma syndromes that deserves special attention.

Tendons of musicians often suffer as a consequence of bad practice habits and routines. This group of injuries that includes "tendonitis and other inflammatory syndromes of the tendons, tendon sheaths, and muscle-tendon unit" usually have symptoms, causes, and treatments similar to the general overuse syndromes.[27] Therefore, some authors address these injuries in the wider category of overuse syndromes rather than in an separate sub-category.[28] Relevant examples of injuries affecting tendons in musicians are tendonitis, tendinosis, and tenosynovitis such as trigger finger and De Quervain's tenosynovitis.[29]

Such injuries are fairly common in musicians. Tendonitis is, for example, a

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[25] Andrew J. Rosenbaum et al., "Injuries Complicating Musical Practice and Performance: The Hand Surgeon's Approach to the Musician-Patient.," *The Journal of Hand Surgery* 37, no. 6 (June 2012): 1269-70.

[26] Ibid.

[27] Johnson, 14.

[28] Ibid.

[29] Jones, 26.

common complaint. Though it is generally an inflammation of tendons, its name might be misleading as it implies an injury that affects exclusively the tendon. However, such an injury may encompass more than one affected area. Norris defines it as an injury of the muscle-tendon unit, because according to him, the painful part may often be the muscle attached to the tendon rather than the tendon itself.[30] Shafer-Crane explains that this type of "muscle damage diagnosed as tendinitis is caused by micro hemorrhages, tears at the tendon periosteal junction, and sprains and strains of the proximal tendon."[31] Shafer-Crane adds that "extreme fatigue contributes to muscle ischemia and tendon creep, increasing the risk of muscle damage."[32]

Tendonitis can be either acute or chronic. Norris states that an acute injury would occur "following a specific incident of stressing the tissue beyond its limits," exemplified by "a musician who practices a new phrase for several hours, and then wakes up the next day with a stiff and painful hand or arm."[33] Chronic tendonitis on the other hand, would develop over a longer period of time, starting out as a mild discomfort and becoming progressively worse, sometimes ending in severe discomfort.[34]

On the causes of tendonitis, Rueda states that aging tissues with circulatory deficiencies and/or an accumulation of micro-injuries are the most important contributors, and are usually brought on in musicians by inappropriate technical

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[30] Norris, 10.

[31] Gail A. Shafer-Crane, "Repetitive Stress and Strain Injuries: Preventive Exercises for the Musician," *Physical Medicine and Rehabilitation Clinics of North America* 17, no. 4 (November 2006): 828.

[32] Ibid.

[33] Norris, 10.

[34] Ibid.

gestures, muscular overload, and disrupted metabolism.[35] Inappropriate technical gestures often create strained joint positions that contribute to tendonitis by "[causing] the tendons to rub against the joint they run through."[36] Muscular overload is explained by Rueda as a cause of tendonitis when prolonged and static muscle contraction causes continuous "friction against the tendons that are inserted into the bone."[37] These tendons are "responsible for absorbing the forces of muscle contraction" and this friction is potentially traumatic.[38] Rueda explains that disrupted metabolism is related to a person's overall health rather than the performance of an instrument. Water shortage or hormone changes are examples of disrupted metabolism that may contribute to the development of tendonitis.[39]

On the other tendon injuries musicians face, Jones states that tendinosis, "unlike tendinitis, does not involve inflammation, but rather microscopic tears or blood loss to tendons that, if overused, cannot heal and finally form inferior scar tissue."[40]

Another tendon-related injury in musicians is tenosynovitis, which is defined as an "inflammation of the lining of the sheath that surrounds a tendon."[41] Tenosynovitis may occur in different forms, and Jones lists trigger finger (stenosing tenosynovitis) and DeQuervain's tenosynovitis, as the common forms that affect

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[35] Rueda, 71.

[36] Ibid.

[37] Ibid.

[38] Ibid.

[39] Ibid.

[40] Jones, 26.

[41] "Tenosynovitis," U.S. National Library of Medicine, accessed April 1, 2016, https://www.nlm.nih.gov/medlineplus/ency/article/001242.htm.

musicians.[42] The trigger finger condition is caused by "increased finger movement friction and causes tendon thickening, pain, decreased range of movement, and a clicking sensation," while DeQuervain's tenosynovitis refers to "similar friction in the thumb tendons."[43]

Adding to the list of tendon conditions faced by musicians, Jones states that cervical spine tension may also lead to "pain and inflammation in the extremities."[44]

2.1.3 Joint Injuries

Unlike the other types of injuries presented so far, joint conditions that affect guitarists may not have a pattern or a specific recurrent injury. However, these injuries should also be taken in consideration as according to Rueda, "guitarists' joints may be affected by age-related degenerative processes and inflammation, generally caused by repetitive stress on the joint."[45] Besides the repetitive stress on the joints, musicians should also be concerned with joint injuries if they suffer from joint hypermobility syndrome. According Rosenbaum et al., the consequences of joint hypermobility may contribute to the "development of a traumatic synovitis in the affected joints," and create a dangerous scenario for those with this syndrome.[46]

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[42] Jones, 26.

[43] Ibid.

[44] Ibid.

[45] Rueda, 73.

[46] Rosenbaum et al. 1269-70.

Musicians are often warned not to spike playing time as it can increase the risk of injuries.[47] This warning was found to be true particularly regarding joint injuries, per two different studies reviewed by Hoppmann et at. found a direct relationship between number of hours spent playing and a tendency to develop degenerative joint diseases.[48]

2.1.4 Symptoms of Cumulative Trauma Syndromes

The factors that may lead to a musculoskeletal injury are countless and their symptoms even in minor injuries could affect musicians' performance to a significant extent. To Wu, professional musicians are expected to maintain such a "high degree of technical precision" that a work-limiting injury makes this task considerably harder to achieve.[49] Diminished muscular grip strength in the hand muscles, compromised neural integrity, and muscle soreness are the three general symptoms of repetitive strain injuries listed by Mitchel and Montgomery,[50] and it is easy to understand how they would get in the way of a musician's career. Heming adds to the lists of concerns when dealing with a playing-related injury by warning that the basic playing techniques of most instruments "are taught before the age of skeletal maturity, when

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[47] Jones, 24.

[48] Richard Hoppmann, "A Review of Musculoskeletal Problems in Instrumental Musicians," *Seminars in Arthritis and Rheumatism* 19, no. 2 (1989): 122.

[49] Wu, 50.

[50] Mitchell.

there is incomplete fusion of the growth plates." [51] This increases the risk of an injury leading to "dysplasticity, deformity, or malalignment."[52]

Rosenbaum et al. lists "pain, weakness, tingling, fatigue, stiffness and decreased dexterity" as symptoms in which overuse syndromes are often manifested,[53] and Bastepe-Gray adds "swelling, redness, numbness, and restricted range of motion" to the common symptoms of playing-related injuries.[54] These are not the only symptoms of injuries, however, and they may extend beyond overuse and repetitive strain injuries.

Of all the common injury symptoms, pain seems to be the most frequent. Citing a study with 52 musicians with musculoskeletal or neurological problems in the upper extremities, Rosenbaum comments that pain was the most common complaint of all groups of musicians. "Loss of dexterity, cramping/stiffness, weakness, tremors, swelling, and clicking" were also identified.[55] Cayea and Manchester had similar findings in their study. In a sample of 513 students majoring in instrumental performance with playing-related injuries, they reported that "pain was the primary symptom in most cases."[56] This study also found "weakness, tingling, numbness, or

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[51] Heming, 62.

[52] Ibid.

[53] Rosenbaum et al. 1270.

[54] Serap Bastepe-Gray, "Healthy Hands: A Primer in Injury Management for Guitarists," *Soundboard - Guitar Foundation of America* 40, no. 2 (2014): 24.

[55] Rosenbaum et al. 1269.

[56] Cayea and Manchester, 20.

upper-extremity fatigue" as reported symptoms, and the numbers shown were approximately equal in symptoms on both left- and right-side.[57]

Pain is such a common indicator of overuse injury that Norris graded overuse injuries in five pain-related categories. His five categories include: pain at one site only, and only while playing; pain at multiple sites; pain that persists well beyond when the musician stops playing, along with some loss of coordination; all of the previous, in addition to many activities of daily living causing pain; and all of the previous, plus all daily activities that engage the affected body part causing pain.[58] However, although a common symptom of overuse syndrome, pain may not occur in all individuals. Rigg's, Marrinan's, and Thomas's thoughts based on other authors' works suggests that a combination of "personal physical fitness, ability to relax during short pauses, individual levels of muscle tension during work, and different patterns of response to stress" are possible reasons for the occurrence or lack of pain.[59]

2.1.5 Treatment of Cumulative Trauma Syndromes

Interviewed by Jones, Workman states that "if the body hurts, [it is] doing something that is not in line with what it was designed to do."[60] These messages that the body sends must be taken in consideration, as the recovery process may be long and demand a deep understanding of the body. Though the time of recovery from

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[57] Ibid.

[58] Norris, 10.

[59] Rigg, Marrinan, and Thomas, 152.

[60] Jones, 24.

injuries may vary, McCready reporting Dowson's findings stated that recovery "took longer for musicians suffering from injuries to their tendons and nerves than to injuries to other tissues such as muscle."[61] To Rosenbaum et al., the recovery of a musician can be particularly complex just like the cases of elite athletes. In their opinion, "musculoskeletal care of a musician requires a thorough understanding of the extraordinary demands that these patients place on their upper extremities to be able to return them to their pre-injury level of function."[62] The overall recovery from playing-related injuries, however, can be effective. Klickstein states that "with prompt treatment, hurt performers usually enjoy full recoveries," while on the other hand, if left unchecked, "damage to muscles, tendons, joints, or nerves may culminate in merciless long-term disability."[63]

2.2 Nerve Entrapment Injuries

Nerve entrapment injuries are "a group of disorders of the peripheral nerves that are characterized by pain and/or loss of function (motor and/or sensory) of the nerves as a result of chronic compression."[64] In musicians, "sustained postures combined with inflammation in neighboring structures might increase the pressure in these small canals and damage the nerves over time."[65]

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[61] McCready and Reid, 141.

[62] Rosenbaum et al. 1272.

[63] Gerald Klickstein, "Seven Habits for Healthy Performance," *American String Teacher* 53, no. 2 (May 2003): 48.

[64] "Nerve Entrapment," Physiopedia, accessed April 1, 2016, http://www.physio-pedia.com/Nerve_entrapment.

[65] Bastepe-Gray, 24.

Commenting on the occurrence of such injuries in musicians, Templeton states that carpal tunnel syndrome is among "the most common injuries suffered by string players."[66] Listing other injuries involving the nervous system affecting musicians, Jones cites "thoracic outlet, myofascial pain, and the other "tunnel" syndromes" such as cubital (elbow), and tarsal (ankle).[67] According to Jones, "flutists, violinists, and guitarists may be especially vulnerable to cubital tunnel syndrome (compressed ulnar nerve in the elbow)," while musicians "who use foot pedals must beware of tarsal tunnel syndrome."[68]

Though placed here as its own category of injuries, authors often include nerve entrapment injuries in the broad group of overuse syndromes as they often share similarities in the causes and symptoms. In the group of nerve entrapment injuries, authors often include thoracic-outlet syndrome. Thoracic outlet syndrome is considered here as a separate category following McGowan's division.

2.2.1 Causes of Nerve Entrapment Injuries

Trapped nerve injuries occur frequently in musicians, especially among guitarists. Rueda explains that there are two main reasons. The first is the "posture requirements and motor overload." This happens when a muscle group is continuously contracted "in order to hold a posture while playing." [69] In this context, the expanded

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[66] David Templeton, "Finger Tips," *Strings* 18, no. 7 (March 2004): 18.

[67] Jones, 26.

[68] Ibid.

[69] Rueda, 75.

muscle will compress the nerves that run through these muscle groups, "trapping" them.[70] The second main cause pointed out by Rueda is when permanently strained joint positions "irritate and squeeze the joint in certain 'tunnels' in which space tends to be tight."[71] Shafer-Crane states that in musicians, "the prolonged awkward postures of playing many instruments may lead to increased muscle tone and, perhaps, risk of peripheral nerve entrapment."[72] The author goes on to say that "chronic hypertonicity may result in hypertrophy of these compartmental muscles, compressing the nerves within this more limited space."[73]

The causes that lead to nerve entrapment injuries may be a product of multiple factors generally linked to an inadequate technique. Cole warns that even subtle changes in how string players hold their instrument might cause enough changes in the upper-body posture that will contribute to nerve entrapments such as thoracic-outlet, cubital tunnel, or carpal tunnel syndromes.[74] This is why as in cumulative trauma injuries, joint hypermobility syndrome and its ability to move the joints beyond the natural range of motion may create a dangerous scenario for the development of nerve entrapment injuries. Rosenbaum et al. agrees with this statement and lists digital nerve compression and traction neuropathies as possible nerve entrapment injuries caused by joint hypermobility syndrome.[75]

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[70] Ibid.

[71] Ibid.

[72] Shafer-Crane, 829.

[73] Ibid.

[74] Rebecca Cole, "Practical Music: Music & Musicians - The Little Things That Count," *Strings* 21, no. 4 (November 2006): 24.

[75] Rosenbaum et al. 1269-70.

In the case of carpal tunnel syndrome, its occurrence is common among workers whose jobs require gripping and manipulating small objects. According to Goodwin, "repeated contraction of muscles results in the inability of the muscle to return to a full resting state, giving the impression that the space across the base of the hand, between the ends of the first and fifth metacarpals, seems narrow -- the hand cannot open wide."[76] Goodwin points out that the carpal tunnel syndrome occurs in a cycle of tension, starting from a restriction of blood flow, then an edema and further restriction of movement.[77] Such tension "may be due to repetitive movement, [or a] somato-emotional event [originated] from psychological stress."[78]

2.2.2 Symptoms of Nerve Entrapment Injuries

Discussing how to diagnose such injuries, Rosenbaum et al. states that when the musician complains of "pain, loss of strength, and sensory abnormalities, distal nerve entrapment syndromes must be considered in the differential diagnosis."[79] The authors go on to say that these symptoms can sometimes be experienced only during musical activity, and such symptoms will generally result in "loss of dexterity and finger control," making impossible important components of the technique such as "strumming the guitar, manipulating the bow of a cello, or playing the piano."[80]

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[76] Siana Goodwin, "Carpal Tunnel Syndrome and Repetitive Stress Injuries Ways to Avoid It and Work with It: A Rolfer's Perspective," Massage & Bodywork magazine, January, 2003, accessed March 12, 2016, http://www.massageandbodywork.com/.

[77] Ibid.

[78] Ibid.

[79] Rosenbaum et al. 1271.

[80] Ibid.

Dhirithi and colleagues state that playing-related musculoskeletal disorders, including nerve entrapment syndromes, "often become chronic, painful and disabling health problems" that last on average two to five years.[81]

The symptoms of nerve entrapment injuries may be extended to other parts of the body. Cubital tunnel syndrome, for example, typically involves "pain and/or abnormal sensations in the elbow area, along the inner side of the forearm."[82] However, according to Jameson, "the pain can travel downward toward the pinky, accompanied by tingling or numbness in the pinky side of the hand."[83] Jameson notes that as "the forearm muscles can be achy and painful," it may lead to misdiagnosis as tendonitis.[84]

2.2.3 Treatment of Nerve Entrapment Injuries

Described as "a constellation of clinical symptoms and signs produced by compression of the median nerve within the carpal tunnel of the wrist,"[85] carpal tunnel syndrome can be treated generally by "rest, splinting, and sometimes surgery."[86] Goodwin adds that "bodywork can be of great help in reducing tension and edema,

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[81] Dhrithi, Agrawal, and Aju, 2.

[82] Timothy Jameson, "To Your Health: Cubital Tunnel Syndrome in Guitarists," *International Musician* 103, no. 1 (January 2005): 13.

[83] Ibid.

[84] Ibid.

[85] Johnson, 14.

[86] Ibid.

increasing blood flow and encouraging different movements which may reduce or reverse painful symptoms."[87]

Goodwin's suggestions for treating carpal tunnel syndrome seem to be a generic recommendation for other nerve entrapment injuries as well. In an interview by Lavinsky about the healing process of cubital tunnel syndrome, Charness recommends regular exercise for musicians to speed up the healing process, and advises musicians to include breaks in their practice. [88] In some instruments, regardless of a musician's posture, elbow flexion will occur to a significant degree. Only breaks between practice sessions will relieve the ulnar nerve at the elbow.[89] Jameson encourages musicians to use heat on the affected forearm before practicing and ice the elbow and forearm after playing.[90] Heat will help the blood flow to the tissues while playing, and "ice will discourage swelling afterwards."[91] According to Jameson's own experience, the vast majority of patients with cubital tunnel syndrome symptoms overcome it with natural, conservative, chiropractic care.[92]

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[87] Goodwin.

[88] Avram Lavinsky, "Practical Musician: Music & Musicians: Double Trouble," *Strings* 19, no. 5 (December 2004): 16-17.

[89] Ibid.

[90] Jameson, 13.

[91] Ibid.

[92] Ibid.

2.3 Thoracic Outlet Syndrome

Thoracic outlet syndrome occurs when pressures "from the collarbone, the uppermost rib, or the slender muscles that attach nearby injure a major network of nerves."[93] For such reason, thoracic outlet syndrome is often placed in the broad group of nerve entrapment injuries.

Khan explains that "the thoracic outlet is made up of three openings between the neck and armpit" and carries the brachial plexus (a group of important nerves that provides sensation and movement to the neck, arms, and hands), as well as arteries and veins.[94] When certain medical conditions narrow these openings and compress, irritate, or interfere with the blood and/or nerve supply, the symptoms of the syndrome occur.[95]

2.3.1 Causes of Thoracic Outlet Syndrome

According to Fedak, neck and arm positions can compress the "brachial plexus, subclavian artery and vein, and the vertebral artery in the neck."[96] In fact, "any type of prolonged physical stress can cause this problem," and playing an instrument

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[93] Lavinsky, 16.

[94] Asif Khan, "It's Questionable: The Doctor Is in - Shouldering the Burden," *Modern Drummer* 33, no. 2 (February 2009): 24.

[95] Kee Fedak, "To Your Health: Identifying and Overcoming Thoracic Outlet Syndrome," *International Musician* 101, no. 12 (December 2003): 9.

[96] Ibid.

is among them.[97] In guitarists, poor sitting position or improper positioning of the arms can trigger this injury.[98]

Fedak explains that all sorts of musicians can be affected by thoracic outlet syndrome, though "some individuals are more predisposed than others."[99] The author attributes the predisposition for this syndrome to "training, sleeping habits, or just the general anatomical makeup of the person."[100]

The syndrome generally develops over a long period of time rather than being causes by an accident or trauma.[101] However, Fedak acknowledges that physical trauma can trigger thoracic outlet syndrome if one suddenly starts experiencing "bizarre symptoms."[102]

2.3.2 Symptoms of Thoracic Outlet Syndrome

The thoracic outlet syndrome symptoms are numerous and vary depending on the area of compression, though they generally involve "aches and pains in the armpit, pain radiating down the inside of the arm, pain or aching on the inside of the forearm, and tingling in the third, fourth, or fifth fingers."[103] Fedak states that "tingling can occur in the shoulder and neck," while "sharp stabbing pains can occur in the back

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[97] Ibid.

[98] Rueda. 75-6.

[99] Fedak. 9.

[100] Ibid.

[101] Ibid.

[102] Ibid.

[103] Ibid.

between the shoulder blade and the spine."[104] "Chest pain on either side of the sternum where the ribs attach," as well as "headaches, dizziness, funny feelings in the face and ears, jaw pain, and ringing in the ear" are also common symptoms of this syndrome.[105]

Specific symptoms of thoracic outlet syndrome might be connected to the body part that is being compressed. Fedak links "numbness in the arms or hands and a feeling of weakness" to the compression of the subclavian artery.[106] Swelling in the forearms, wrist and fingers, and a feeling of heaviness in the whole arm as well as a feeling of fullness in the hands, are likely caused by compression of the subclavian vein.[107] If the nerves of the brachial plexus are affected, "upper extremity pain, weakness and numbness, clumsiness, and a feeling of coldness in the hands" may occur.[108]

Individuals may start noticing this syndrome when, for no reason, they drop things, or have difficulties with activities that involve fine motor control such as writing or playing an instrument.[109] They may also notice quick fatigue in the hands and arms after performing normal daily activities.[110] Fedak explains that musicians may notice the syndrome if the "pushing and pulling of muscles becomes out of sync," and that it is common for string players to start losing their vibrato as well as

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[104] Ibid.

[105] Ibid.

[106] Ibid.

[107] Ibid.

[108] Ibid.

[109] Ibid.

[110] Ibid.

having back or chest pain.[111] According to Fedak, the combination of these symptoms may lead to secondary problems such as tendonitis.[112]

2.3.3 Treatment of Thoracic Outlet Syndrome

The treatment for thoracic outlet syndrome is rather simple. Khan recommends to most patients a conservative treatment that includes "stress avoidance, job site modification, and work simplification" to avoid "sustained contraction and repetitive or overhead (high cymbal placement, heavy sticks) work that exacerbate symptoms."[113]

Different authors recommend specific stretching and strengthening exercises to help alleviate the symptoms of thoracic outlet syndrome. Khan provides a list of examples to "aid in stabilizing and opening the thoracic outlet at the shoulder."[114] Khan's list of exercises includes shoulder shrugs and rolling the shoulders to provide trapezius and rhomboid strengthening, hand circles and standing corner pushups for shoulder mobilization, and postural exercises such as neck and lower back spine extension.[115] Fedak generally agrees with Khan's suggestions, and emphasizes that certain priorities must be given to correct the origin of the problem. For example, if a

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[111] Ibid.

[112] Ibid.

[113] Khan, 24.

[114] Ibid.

[115] Ibid.

structural problem with the neck or rib cage is causing muscle spasm or nerve irritation, the priority should be correcting the structural imbalance.[116]

Fedak advises individuals suffering from thoracic outlet syndrome to avoid sleeping on the side, particularly if that side is bothering them. According to Fedak, sleeping in this position can compress the "shoulder and rib cage further into misalignment."[117] The author also recommends swimming as an activity to improve the condition, particularly the back-stroke. According to Fedak, it is "helpful in building up the muscles in the back, as well as stretching out the muscles in the front."[118]

Once the musician is symptom-free, he can return to musical activities.[119] Fedak states that "prognosis for recovery [of thoracic outlet syndrome] is usually good, as long as there are no complicating factors involved that may require surgery."[120]

2.4 Focal Dystonia

The types of injuries previously described affects nerves, muscles, tendons or joints. Focal dystonia, on the other hand, may be considered to be in its own category because its cause is associated with the brain itself.[121] Brandfonbrener, quoted by

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[116] Fedak, 9.

[117] Ibid.

[118] Ibid.

[119] Khan, 24.

[120] Fedak, 9.

[121] Jones, 24-5.

Jones, states that "focal dystonia is a generally painless, task-specific nerve damage" occurring in the brain rather than in the periphery of the nervous system.[122] It is often manifested as "loss of control over even one muscle, such as in an embouchure or finger [movement]," and it is generally a career-ending injury.[123]

2.4.1 Causes of Focal Dystonia

Focal dystonia is considered "one of the rarest musical medical problems" and is presented with a "much higher incidence in the musician population than in the population at large."[124] According to Altenmüller and Jabusch, the incidence of focal dystonia in the general population, "including writer's cramp, blepharospasm, and cervical dystonia, is estimated as 29.5/100,000 in the United States and 6.1/100,000 in Japan."[125] In the professional musician population, however, approximately 1% develops focal dystonia.[126] According to Rietveld, though the reasons for such high incidence are unknown, this injury is even more common in guitarists, with its pain-free loss-of-control symptoms "occurring only during music making without complaints in daily life activities."[127]

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[122] Ibid.

[123] Ibid.

[124] Ibid.

[125] Eckart Altenmüller and Hans-Christian Jabusch, "Focal Dystonia in Musicians: Phenomenology, Pathophysiology, Triggering Factors, and Treatment.," *Medical Problems of Performing Artists* 25, no. 1 (March 2010): 3.

[126] Ibid.

[127] Rietveld, 433.

Although it was shown that female musicians are more susceptible to playing-related injuries, in the case of focal dystonia the situation is the opposite. In regard to gender, the ratio of male/female musicians with focal dystonia is 4:1.[128] Also, musicians seem to be more prone to develop it between the tenth and twentieth years of their career.[129]

Analyzing the types of musicians who tend to develop focal dystonia, Altenmüller and Jabusch states that epidemiological data shows that those who play instruments "requiring maximal fine-motor skills" are at a higher risk of developing focal dystonia.[130] Available data suggests that the probability of developing dystonia varies according to the instrument played, and that guitarists, pianists, and brass players seem to be at higher risk.[131] When comparing bowed instrument players, those playing violin and viola tended to be more affected than those who play cello and double bass.[132] This information suggests that the string tension, naturally higher on instruments such as violin and viola, may relate to development of this injury.

Focal dystonia also had a tendency to occur in the more active hand on instruments that required different levels of workload between the hands.[133] Upon review of a study performed with musicians suffering from dystonia, Altenmüller and Jabusch concluded that the hand with a higher total workload is more likely to be affected as the majority of right-handed patients presented symptoms in the right

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[128] Altenmüller and Jabusch, 3.

[129] Rueda, 81.

[130] Altenmüller and Jabusch, 3.

[131] Ibid., 4

[132] Ibid.

[133] Ibid., 3.

hand, while the majority of left-handed patients presented symptoms in the left hand.[134] It was found that musicians who played keyboard instruments (piano, organ, harpsichord) and plucked instruments (guitar, electric bass) were primarily affected in the right hand, while bowed string players were predominantly affected in the left hand, linking the injury to the generally most active hand on the instruments played.[135]

Though the correlation between the muscle groups involved in the repetitive musical activity and the occurrence of focal dystonia is acknowledged, Rosenbaum et al. states that the "pathophysiology and risk factors of focal dystonia are unclear."[136] Authors have proposed genetic predisposition and specific triggering events, such as a trauma, as possible causes.[137] Altenmüller and Jabusch for example, state that "overuse and intense working behavior, spatiotemporal constraints, and special psychological conditions, including anxiety and extreme perfectionism" may accentuate a possible genetically determined predisposition.[138]

Strengthening the argument that behavioral factors may contribute to the development of focal dystonia, a pattern of "anxiety and extreme perfectionism" was observed in musicians who developed dystonia which was not observed in healthy musicians.[139] Altenmüller and Jabusch attribute the "unyielding reward and punishment frame in the classical music performance scene" as a contributor to stress in musicians that may encourage the development of this injury. The authors contrasts

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[134] Ibid., 4.

[135] Ibid.

[136] Rosenbaum et al. 1271.

[137] Ibid.

[138] Altenmüller and Jabusch, 8.

[139] Ibid., 4-5.

classical musicians with improvisational jazz musicians, who seem less pressured in performance and boast a lower incidence of dystonia.[140] Though this association may be true, it is important to keep in mind that these classes of musicians may have different patterns and volumes of practice that might affect the outcome of this equation. However, the fact that the majority of musicians do not suffer from this injury might indicate that environment acts more like a trigger for those with a genetic predisposition for focal dystonia rather than the cause itself.[141]

2.4.2 Symptoms of Focal Dystonia

Discoursing on the symptoms of focal dystonia, Rosenbaum et al. state that besides the frequent involuntary movements and postures while playing the instrument, the musician is often affected with stiffness and cramping.[142] The disorder affects precise movements and often does not affect similar gestures as patients are able to perform these movements in the air for doctors.[143] Altenmüller and Jabusch explain more specifically that in the early stages of this disorder a subtle loss of control in fast passages is experienced, along with other symptoms such as "finger curling, lack of precision in forked fingerings in woodwind players, irregularity of trills, fingers sticking on the keys, involuntary flexion of the bowing thumb in strings, and impairment of control of the embouchure in woodwind and brass players in

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[140] Ibid., 8.

[141] Ibid., 5.

[142] Rosenbaum et al. 1271.

[143] Rueda, 81.

certain registers."[144] Once musicians start to notice these symptoms, the common perception is that they lost dexterity due to a technical problem or lack of practice, which may cause them to intensify their music workload. This approach, however, "often exacerbates the problem."[145]

To understand the real life impact of this disability, Shafer-Crane provides an example of how focal dystonia affects the routine of a pianist. She explains that unintentional movement of the fingers and painful cramping are noticed during the music-making process, and that "muscle groups, such as the intrinsic hand muscles and long flexors of the thumb and fingers, contract uncontrollably, resulting in marked flexion of the digits, which is relieved only by discontinuing the activity and redirecting or resting the digits."[146]

2.4.3 Treatment of Focal Dystonia

Unfortunately, the forms of treatment available only allow a minority of musicians to regain full motor control of their movements.[147] Johnson states that due to the lack of consensus on the causes of focal dystonia, it is considered the most difficult playing-related musculoskeletal disorder to treat, which may explain why this is often a career-ending injury.[148] According to Rosenbaum et al., the current approaches to manage focal dystonia revolve around technical retraining, attempting

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[144] Altenmüller and Jabusch, 3.

[145] Ibid.

[146] Shafer-Crane, 828.

[147] Altenmüller and Jabusch, 3.

[148] Johnson, 14.

to "purge a musician of a presumed maladaptive motor sequence in hopes of developing a more normal pattern."[149] One example of successful treatment utilizing this approach was the multiple award-winning guitarist Mark Ashford, who after two years working on "retraining his right hand using sensory and neurological exercises" was able to enjoy a full recovery and resume his performing activities.[150]

Since full focal dystonia recovery is not often achieved, Rueda focuses on prevention, saying that "being able to make smooth movements without inducing muscle fatigue" is a key factor to avoid this neuro-muscular injury.[151] In order to do so, the guitarist will have to search for a progressive and measured relaxation of the antagonist muscles during performance.[152] Besides the technical concerns, stress surrounding the musician's routine should also be addressed as it has been shown to contribute to this disorder. For example, in the opinion of Altenmüller and Jabusch, the new era of audio-recording deserves part of the blame for stress in performers. Today's "laboratory music" produced with edited, perfected and remastered recordings sets "unrealistic expectations in listeners and interpreters."[153] Therefore, musicians need to manage the physical stress caused by playing their instruments and also take care of their emotional health by setting realistic goals in their practice and performance to create a scenario that is not favorable to the development of focal dystonia.

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[149] Rosenbaum et al. 1271.

[150] Thérèse Wassily Saba, "Classical Guitar News: Mark Ashford's Focal Dystonia," *Classical Guitar Magazine* 26, no. 11 (July 2008): 6.

[151] Rueda, 20.

[152] Ibid.

[153] Altenmüller and Jabusch, 9.

CHAPTER 3

GENERAL CONSIDERATIONS ON RISKS, PREVENTION AND PROACTIVE IDEAS

Authors have discussed the variables that may contribute to the development of overuse injuries in musicians. The list includes many things both related and unrelated to actually playing the instrument. Johnson mentions that among the common risk factors for playing-related musculoskeletal disorders are "size, shape, weight, and type of instrument, playing technique, playing position and posture, amount of time and intensity of practice, repertoire, and the stress of the performance."[1] Regarding non-music related variables that are possible predictors for the development of playing-related injuries, Johnson lists "general health, gender, age, anthropometry, hypermobility and psychological characteristics."[2]

Rietveld warns musicians that a "change of teacher, instrument, repertoire, or practice habits" may play a large role in causing injuries.[3] Guptill and Zaza mention that "a rapid increase in practice time seems to predispose musicians to injury," adding that "awkward body positions mandated by the shape and weight of the instrument, the technical difficulty of the repertoire, and playing unfamiliar instruments may also contribute to injuries."[4]

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[1] Johnson, 13.

[2] Ibid.

[3] Rietveld, 431.

[4] Guptill and Zaza, 29.

Addressing the instrument issues that may contribute to overuse injuries, Norris exemplifies that "a wind instrument with leaky valves or pads, a string instrument with a bridge that is too high, or a piano that 'speaks' poorly in the middle register necessitates extra or excessive force on the part of the player."[5] Regarding the guitar specifically, most issues can be addressed by adjusting the instrument by lowering its bridge, using strings with a softer tension or employing an ergonomic guitar support to elevate the guitar. Guitarists have gradually developed ergonomic tools to correct posture issues, and their functionality and efficacy will be further discussed in later sections.

Repertoire and increased amount of practice hours associated with irresponsible practicing habits may cause injuries. When injuries are linked to repertoire and the number of hours practiced they should be addressed together with practice strategies. Forcing to play through successive difficult passages without mastering them may cause the cumulative tension that may result in overuse injuries. Authors have addressed that muscle fatigue can lead to chronic pain, for example. Horvath states that "fatigue and the resulting reduced blood flow can eventually lead to microscopic tears in the muscle and the build-up of scar tissue."[6] Sectional practice, that is, isolating specific sections of a piece to work on, is a good strategy to approach a difficult passage of music without putting the musician's body under constant stress. The short amount of time spent on each section and the short breaks taken before practicing the same section again provide a degree of relief that the body needs to reduce the fatigue that Horvath mentions. The guitarist may also choose to practice a

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[5] Norris, 10.

[6] Janet Horvath, "Causes of Overuse Injury," *International Musician* 109, no. 8 (August 2011): 8.

difficult section in a slower tempo until he develops the skills necessary to play it at regular speed. If the section practiced still stresses his hands, he may consider practicing easier sections in-between difficult sections in order to relieve stress.

Norris agrees that a flawed practice routine might contribute to overuse injuries. He believes musicians should approach playing an instrument as a physical activity for the entire body by including a warm-up activity for the "neck, arms, shoulders, and upper and lower back." [7] Norris also suggests that practice should be divided into sections of forty-five minutes each, with a break of at least five minutes between each section.[8]

Improper body mechanics and posture are also seen as general factors that predispose a musician to suffer from overuse injuries.[9] Norris emphasizes the importance of discovering errors of technique that might create excessive tension and cause muscles to work harder than necessary. He cites the example that string players tend to increase body tension particularly in the left hand when playing *forte*.[10] Shafer-Crane states that the "repetitive grasping of the strings and neck of the violin, guitar, and cello" by the left hand may increase the risk of repetitive strain injuries such as lateral epicondylalgia.[11]

Horvath believes musicians are reluctant to admit that they could have a faulty technique, whether it was learned improperly or because "bad habits crept into their

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[7] Ibid.

[8] Ibid.

[9] Ibid.

[10] Ibid.

[11] Shafer-Crane, 828.

playing."[12] This causes them to neglect the single most important factor to prevent overuse injuries: good posture.[13] Horvath emphasizes, however, that just like outstanding athletes, musicians can be injured regardless of their talent and even if they are doing everything correctly.[14] Musicians interviewed by Park and colleagues acknowledged that they play a role in injury prevention but also mentioned that uncontrollable factors may lead to injuries.[15] Among those uncontrollable risk factors mentioned were increased demand from their musical environment, anatomical factors that may increase susceptibility to injuries, and "even abstract factors such as fate."[16] Norris says that musicians' activities in the nonmusical environment such as sports or hand-intensive activities such as knitting, woodworking, writing or typing could contribute to trauma or overuse.[17]

Inadequate rehabilitation of previous injuries and a lack of physical conditioning adds to the list of factors that contribute to overuse injuries.[18] Some injuries allow the musician to resume his activities before being completely healed. However, when doing so, any additional stress could cause a slow down or a reversal in healing.[19] For this reason, Norris recommends that musicians pursue therapy until

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[12] Horvath, 8.

[13] Ibid.

[14] Ibid.

[15] Park, Guptill, and Sumsion, 93.

[16] Ibid.

[17] Rebecca Barton and Judy R. Feinberg, "Effectiveness of an Educational Program in Health Promotion and Injury Prevention for Freshman Music Majors," *Medical Problems of Performing Artists* 23, no. 2 (June 2008): 52.

[18] Norris, 10.

[19] Ibid.

they are completely free of pain, have a full range of motion, and have fully regained endurance, strength, and coordination.[20] Though it may sound surprising, the overall physical condition of musicians also has a direct relationship with the appearance of injuries. Horvath states that "an untoned body is more injury-prone because it is less resilient," as "muscles that are tight and weak are at greater risk than strong and flexible muscles."[21] Complementing Horvath's statement, research has also indicated that musicians with a higher body mass index (BMI) are at a higher risk of injuries.[22]

Chronic injuries seem to be common occurrence for musicians, and guitarists do not escape the rule. Muldowney comments that the majority of guitar injuries "are not sustained due to trauma," such as a bump or a break, but rather are due to chronic conditions that fall in the category of overuse and misuse injuries, just like the average musician population.[23] However, as an instrument of great popularity, the guitar merits closer examination.[24] Classical guitarists' particularly elevated injury rates, as presented in Chapter 1, may be explained by the fact that their unique set of techniques such as bars, slurs, *rasgueados*, fast scalar passages and large shifts may cause an excessive amount of tension.[25] The fact that mistakes in classical guitar performance are easily heard since the guitarist usually plays as a soloist also

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[20] Ibid.

[21] Horvath, 8.

[22] Guptill and Zaza, 29.

[23] Muldowney, 30.

[24] Kiseok Sung et al., "Development of the Two-Dimensional Biomechanical Hand Model for a Guitar Player," *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 57, no. 1 (September 2013): 1653.

[25] Bastepe-Gray, 25.

contributes to an increase in tension.[26] The lack of consensus regarding safety in the evolving guitar technique adds to the picture and creates a scenario favorable to injuries.

Much has been discussed so far on the importance of prevention of playing-related injury. While there is a consensus among therapists and researchers on some approaches to prevention, there is still a lack of evidence on others that will be discussed over the following pages. Starting from the big picture, taking care of one's overall health seems to be a good starting point to prevent injuries, as previously mentioned by Norris.[27] Jones-Bey cites the opinion of two physicians with experience in musicians' injuries who agree that a healthy lifestyle, "including rest, diet, exercise, fitness, good playing posture, and proper instrument fit are crucial factors in restoring and maintaining a healthy music-making physiology."[28] Commonly utilized non-technical strategies such as warm ups, breaks, rests, and stretches are some of the most discussed preventive measures by authors, but their efficacy should be discussed before advising a musician to include them in a practice routine.

3.1 Warm-up Sessions

In the words of the physician and hand surgeon Robert Markinson, a musician should never play cold handed.[29] The reason is that blood flow is of great importance

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[26] Fjellman-Wiklund and Chesky, 175.

[27] Park, Guptill, and Sumsion, 92.

[28] Hassaun Jones-Bey, "Hands On: How to Avoid and Treat Guitar-Related Hand Injuries," *Acoustic Guitar* (September 2000): 68-9.

[29] Templeton, 21.

when it comes to injury prevention. Therefore, cold-handed players are "at far greater risk than warm-handed players."[30] Klickstein goes further saying that a warm-up routine should involve the entire body and not just the muscles controlling the fingers.[31] Whole body movements and appropriate clothing in cool surroundings should be a starting point.[32] Then, the musician should proceed to the instrument playing at moderate tempos as the blood flow increases.[33] Klickstein says that only after the body is warm should speed, volume, and intensity be carefully escalated.[34] Guptil and Zaza agree with this practice, recommending that pianists and string players utilize slow and comfortable playing of scales, arpeggios, or easy repertoire during the warm-up session.[35]

Though few studies exist to confirm that the statements in the previous paragraphs are accurate or that a warm-up is the most efficient way to prevent injuries, available studies suggest that musicians can benefit from warm-up routines. In a study performed by López and Martínez in the High Conservatory of Music of Salamanca, Spain, students enrolled in a course that taught them warm-up habits among other injury prevention strategies were compared to a group that did not take the course. Findings showed that among those enrolled in the course, injuries decreased greatly

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[30] Ibid.

[31] Klickstein, 50.

[32] Ibid.

[33] Ibid.

[34] Ibid.

[35] Guptill and Zaza, 29.

by the end of the study,[36] leading to the conclusion that "consistently doing warm-up exercises is of vital importance in the prevention of musculoskeletal injuries in instrumental musicians."[37] Russell and Higgins mention a different study, performed by Rarding, which had similar findings. The students who participated in this study, with "an injury prevention program that included physical warm-ups, reported having less pain than they did before the program."[38]

A questionnaire developed by Zaza and Farewell also linked warm-up routines to healthier musicians. In the group of healthy musicians, 69.6% (119/171) claimed to do a musical warm-up before the practice session, and 18.7% (32) claimed to do a physical warm-up. In the injured group (110 subjects), 60% (66) had done musical warm-ups and 9.9% (9) physical warm-ups.[39] The numbers showed that the injured musicians tended to neglect warm-up habits, and that warming up may be linked to a certain extent to the prevention of playing-related injuries.[40]

Evidence for the efficiency of warm-up programs can also be taken from sports medicine data. Though the results and findings do not necessarily translate to musicians, they seem to show the same linkage between warming up and injury prevention.

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[36] Tomás Martín López and Joaquín Farías Martínez, "Strategies to Promote Health and Prevent Musculoskeletal Injuries in Students from the High Conservatory of Music of Salamanca, Spain," *Medical Problems of Performing Artists* 28, no. 2 (June 2013): 105.

[37] Ibid., 106.

[38] Joshua Russell and Paul Higgins, "Avoiding Discomfort and Injury in Young String Players: A Stretching Activity Guide," *American String Teacher* 63, no. 2 (May 2013): 21.

[39] C. Zaza and V.T. Farewell, "Musicians' Playing-Related Musculoskeletal Disorders: An Examination of Risk Factors," *American Journal of Industrial Medicine* 32, no. 3 (September 1997): 296.

[40] Ibid., 297.

Soligard et al. performed a study with 125 female soccer clubs around Norway. Of those, 65 clubs were used as the intervention group, and the other 60 clubs as the control group. The total population of all the clubs were for 1892 female players aged 13-17 years old.[41] The study lasted eight months and the intervention included a comprehensive warm-up program focusing on improving "strength, awareness, and neuromuscular control during static and dynamic movements."[42] The activities consisted of "running exercises at slow speed combined with active stretching; six different sets of exercises, including strength, balance, and jumping exercises, each with three levels of increasing difficulty; and speed running combined with football specific movements with sudden changes in direction."[43] At the end of the study, there were 121 injuries in the intervention group of 1055 players (injury rate of 11.5%), and 143 injuries in the control group of 837 players (injury rate of 17.1%).[44]

Through review of the data acquired, Soligard et al. observed that "there was a significantly lower risk of injuries overall," including both overuse injuries and severe injuries in the intervention group,[45] leading the authors to believe that a structured warm-up program "can prevent injuries in young female football players."[46] Such findings in the sports medicine area seem to confirm that the benefits of warm-up

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[41] Torbjørn Soligard et al., "Comprehensive Warm-Up Programme to Prevent Injuries in Young Female Footballers: Cluster Randomized Controlled Trial," *British Medical Journal* 338, no. 7686 (January 10, 2009): 96.

[42] Ibid.

[43] Ibid., 97.

[44] Ibid., 96.

[45] Ibid., 98.

[46] Ibid., 96.

sessions apply to the entire body, supporting Klickstein's thoughts expressed above, that the musician may benefit from a whole body warm-up rather than limiting it to specific musical instrument warm-ups. Injuries in musicians are not limited to the body extremities, although we must acknowledge the importance of focusing warm-up sessions on the most utilized body parts during music making.

3.2 Breaks and Rests

A common suggestion for a healthy playing routine is taking breaks during practice. A break can be understood, however, in several ways. It can be understood as stopping the musical activity, or stopping any muscular activity for a period of time. The duration of a break as well as the duration of the practice sessions must also be considered, and the intensity of the practice must be factored in as to how it will impact the need to take time from the instrument.

Klickstein explains the general benefits of taking breaks. Comparing the routine of musicians to athletes he states that "breaks are like fresh, cool water to a parched athlete," as they "quench the body's thirst for rest."[47] Klickstein highlights that "playing obsessively without pausing is treacherous--even for musicians with relaxed and efficient techniques."[48] Breaks help them not just on the physical level, but also revitalize their mental and emotional energy as well.[49] This information is useful considering that as reported by Jones-Bey, it is common to see musicians

[47] Klickstein, 52.

[48] Ibid.

[49] Ibid.

deliberately increasing the number of practice hours when there is a performance or recital coming up.[50] Advising on what constitutes a resting period, Klickstein instructs musicians to stay away from computers, potato peelers, and other gadgets requiring hand activity,[51] allowing the full relaxation of the muscles that were utilized during practice.

Bastepe-Gray poses the argument that certain aspects of playing an instrument, in this case the guitar, require one to "sustain asymmetrical postures and suboptimal alignment and range."[52] The author says that the guitarist's left elbow remains in "constant flexion around ninety degrees during play," causing the ulnar nerve to curve around the "funny bone" through the cubital tunnel, remaining under increased pressure during the time the guitar is played.[53] Guitarists would benefit from rest breaks as "the optimum angle at the elbow for the lowest pressures in this tunnel is around 130 degrees."[54]

Klickstein states that the break should last a total of ten minutes of each practice hour,[55] while, according to Tubiana and Amadio, "most teachers suggests a five-minute break for every thirty minutes of practice."[56] Other authors stated that these numbers "vary significantly with the instrument, repertoire, and student

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[50] Jones-Bey, 68.

[51] Klickstein, 50.

[52] Bastepe-Gray, 26.

[53] Ibid.

[54] Ibid.

[55] Klickstein, 52.

[56] Raoul Tubiana and Peter Amadio, *Medical Problems of the Instrumentalist Musician* (London: Martin Dunitz, 2000), 544. Quoted in Guptill and Zaza, 30.

familiarity with the piece practiced."[57] These numbers seem a generic suggestion, though, as there is a lack of data on what works most efficiently on injury prevention.

Providing data from the sports medicine field, Bastepe-Gray states that "depending on the volume and intensity of the activity, it might take up to forty-eight hours for the muscles and soft tissues to fully recover from exercise."[58] Volume and intensity are the key words as these variables directly impact the time necessary for the body to fully recover. For this reason, Bastepe-Gray acknowledges the many rest cycles of different durations, such as a "five-minute rest every thirty minutes, one day off every week, alternating short days with long days," among other options, as an important component of a musician's routine to allow tissue recovery and to "maintain the natural capacity of the muscles and soft tissues."[59]

The general idea of taking breaks seems to be supported by studies. A study performed with 281 subjects who responded to a questionnaire showed that taking breaks was linked to a decrease in playing-related injuries.[60] Of the 110 subjects who were alleged to have had playing-related musculoskeletal disorders, 60 claimed to take breaks in their practice sessions, corresponding to 54.5% of the group. Of the 171 subjects in the control group, that is, who answered "no" when asked if they have had a playing-related musculoskeletal problem, 119 included breaks in their practice sessions, corresponding to 69.6% of the group.[61] This information shows that healthy musicians tend to take breaks at a higher proportion than injured musicians, which

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[57] Ibid.

[58] Bastepe-Gray, 26.

[59] Ibid.

[60] Zaza and Farewell, 296.

[61] Ibid.

causes Zaza and Farewell to agree that breaks are a protective measure against playing-related musculoskeletal disorders.[62]

A survey performed by López and Martínez showed that in the High Conservatory of Music of Salamanca (Spain), although the surveyed population had an overall tendency to take breaks during their practice sessions, those who practiced in sessions lasting around 81 minutes had the highest incidence of injuries.[63] After intervention, reducing the duration of this practice sessions to 56 minutes, a significant decrease in the number of injuries was noted,[64] suggesting that more frequent breaks seems to be more effective in the prevention of injuries.

Studies performed with non-musical workers also showed the positive impact of breaks on injury prevention and fatigue management. Tucker compiled multiple sources and concluded that breaks are most effective when taken to coincide with periods of fatigue.[65] Frequent breaks also showed some positive impacts, while self-managed breaks had an optimal response in fatigue management.[66] Regarding the length of the breaks, his findings were conflicting and the optimal length depended upon task context.[67]

Contradicting the findings stated in the previous paragraphs, Buckley and Manchester's study found through a survey of sixty folk musicians who claimed some

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[62] Ibid., 297.

[63] López and Martínez, 100.

[64] Ibid.

[65] Philip Tucker, "The Impact of Rest Breaks Upon Accident Risk, Fatigue and Performance: A Review," *WORK and STRESS* 17, no. 2 (April / June 2003): 127.

[66] Ibid., 131.

[67] Ibid.

sort of playing-related injury that 37 (61.7%) included breaks in their practice routine; in the control group of 51 subjects free of injury, twenty-two (43.1%) took breaks in their practice.[68] Though the authors acknowledged that due to the sample size the discrepancy was not statistically significant, they claim that such an unexpected result might mean that the musicians interviewed did not take breaks as a preventive measure, but rather took breaks "in response to the onset of pain."[69]

Breaks should not, however, be limited to taking a few minutes after practicing stretches. During each practice session, micro-breaks can be incorporated that may help release tension and reduce fatigue. Guptil and Zaza acknowledge the importance of this strategy and recommend it to musicians. In their understanding, a micro-break "might consist of stopping for thirty seconds or counting rests when practicing a piece with accompaniment."[70] Their suggestion is not limited, and smart practicing such as fractioning the piece into small fragments can naturally generate these little breaks. For example, rather than playing through the whole piece every time, if the musician chooses multiple short fragments of the piece to practice, he would naturally benefit from a few seconds of break for every time he interrupts his playing before playing the fragment again. Guptil and Zaza share this opinion stating that students should not be taught to start at bar 1 and play through the piece until a double bar, highlighting that it is smarter to practice "short chunks of music."[71]

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[68] Buckley and Manchester, 83.

[69] Ibid., 82.

[70] Guptill and Zaza, 30.

[71] Ibid., 31.

Evidence indicates that this practicing strategy is beneficial to musicians. According to Heming, it has been found that "as musicians play long movements or pieces, their posture gets progressively worse as the muscles fatigue."[72] Maintaining a good posture through practice is relevant since it has been shown that musicians who "moved the most effortlessly on the instrument were less prone to injury."[73] Therefore, any strategy that reduces fatigue and helps musicians preserve a good posture during practice should be adopted. Musicians have to occasionally play through entire pieces or an entire concert program. However, this should not be the foundation of their practice. The tension and fatigue that accumulate during prolonged hours of non-stop practice contribute to causing the injuries discussed in the previous chapter.

3.3 Stretching

Completing the tripod of the most suggested strategies to avoid playing-related injuries, stretching appears to be the most controversial of them all. Many stretching routines can be found for musicians along with recommendations to do them before, during and even after practicing. However, there seems to be a lack of evidence to support such a practice. Conflicting data show that stretching may not be as effective as is generally thought.

Supporting the benefits of stretching, authors such as Crifasi and Hogg provide lists of stretching exercises believed to help musicians prevent playing-related

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[72] Heming, 64.

[73] Adam Perlmutter, "Workshop: Guitar and Keyboard - Demystifying the Taubman Technique," *Teaching Music* 17, no. 5 (February 2010): 49.

injuries. Crifasi claims that "after 15 to 20 minutes of concentrated playing," musicians should stop and stretch, as "prolonged periods of intense playing may cause swelling and inflammation" in the hand and wrist.[74] Hogg believes that warming up and stretching alleviates playing-related tension, and that stretching should be done "before, during, and after" practice sessions to "relieve muscle tension and prevent [any] possible injury."[75]

There are two main points to consider in Crifasi and Hogg's statements though. The first is that neither of these authors provides facts that substantiates that stretching is effective against injuries. The second is that both authors link stretching with either warm-up activities or with breaks and rests, measures with evidence that they have an impact in preventing playing-related injuries. The general impression is that authors tend to support "common sense" ideas, without worrying too much whether there is evidence or not to support these claims.

Bastepe-Gray highlights the importance of being aware of the mechanics of stretching, and the differences between dynamic and passive stretching. The author defines the dynamic type as the stretching of a tissue "within a movement, through active muscle action, such as in Tai Chi or when a newborn baby stretches after waking up." Passive stretching consists of "using another extremity or a stationary prop to stretch the tissue by pulling with or pushing on it."[76] Bastepe-Gray advocates against the use of passive stretching, stating that studies have shown that "athletes who engage in passive stretching before athletic activity tend to get injured more

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[74] October Crifasi, "No Pain, No Gain? Not True!," *Acoustic Guitar* 24, no. 14 (August 2014): 35.

[75] Karen Hogg, "Practicing: Stretch It Out," *Acoustic Guitar* 18, no. 4 (October 2007): 34.

[76] Bastepe-Gray, 26.

frequently."[77] The author also warns that excessive stretching can injure or reinjure musicians by "pulling on the tissues and causing micro-tears."[78]

Guptil and Zaza acknowledge that the literature is inconclusive regarding stretching in musicians. They also bring references from athletes saying that "trainers in the past have claimed that stretching improves performance and reduces injuries in athletes; however, there is no conclusive evidence that stretching prevents injury in healthy individuals."[79] The authors agree with the above opinion of Bastepe-Gray, who stated that bouncing the limb during stretching should be avoided. Guptil and Zaza also state that even though there is evidence that dynamic stretching has benefits for high-speed movements, such benefits did not apply to musicians.[80] Shafer-Crane advises that vigorous stretching should be performed only "when the muscles are warmed up to prevent muscle damage from a rebound effect that increases hypertonicity," and that gentle stretches within range of motion are preferred.[81] They also point out to the lack of evidence that stretching helps prevent repetitive strain injuries.[82]

In the music field, professionals recommend that musicians include stretching in their practice routines.[83] Similarly in sports medicine, Cheung, Hume, and Maxwell state that stretching is often recommended to athletes as a preventive measure for

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[77] Ibid.

[78] Ibid.

[79] Guptill and Zaza, 29.

[80] Ibid.

[81] Shafer-Crane, 830-31.

[82] Ibid.

[83] Klickstein, 50.

delayed onset muscle soreness.[84] As for musicians, recommending stretching to athletes has similar problems. Investigation has shown that stretching prior to, after, or before and after exercise, produces no preventative effect.[85] Debating stretching as an injury prevention measure, Cheung and colleagues sum up the problem saying: "Although stretching is publicly recommended as an injury prevention measure, the rationale for stretching has yet to be validated by future research."[86]

Using data from studies on army recruits in military training, Herbert and Gabriel state that "muscle stretching before exercising does not produce useful reductions in injury risk."[87] Two studies showed that stretching decreased the risk of injury by 5%, but because of the sample size of the studies, the results were statistically non-significant.[88] The authors point out that even if one assumes the results were not due to a sampling error, stretching would still not have practical significance in army recruits, whose injury rates are estimated to be 20% over a training period of twelve weeks. A decrease of 5% in relative risk "implies a reduction in absolute risk of about 1%."[89] Herbert and Gabriel puts these numbers in perspective stating that about 100 people stretching for twelve weeks would prevent only one injury, and the average individual "would need to stretch for twenty-three years to

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[84] Karoline Cheung, Patria A. Hume, and Linda Maxwell, "Delayed Onset Muscle Soreness: Treatment Strategies and Performance Factors," *Sports Med* 33, no. 2 (2003): 154.

[85] Ibid.

[86] Ibid. 160.

[87] Rob D. Herbert and Michael Gabriel, "Effects of Stretching Before and After Exercising On Muscle Soreness and Risk of Injury: Systematic Review," *British Medical Journal* 325, no. 7362 (August 31, 2002): 469.

[88] Ibid., 470.

[89] Ibid.

prevent one injury."[90] The authors also reminds that most athletes are exposed to lower risks of injury, which would make the absolute risk reduction for them to be even smaller.[91]

In a collection of studies with seventy-seven subjects, Herbert and Gabriel investigated the impact of stretching on reducing muscle soreness in the twenty-two hour period after the exercise.[92] However, just as for the injury prevention data, the results were insignificant and the author concluded that stretching was not worthwhile in preventing delayed muscle soreness.[93]

Though the data provided from the sports medicine field does not necessarily confirm that stretching is inefficient for preventing musculoskeletal disorders in musicians, the lack of evidence that stretching is an effective injury prevention measure indicates there is no reason to encourage musicians to use stretching for injury prevention or soreness reduction. Instead, musicians should concentrate on what has been proven effective.

3.4 Other Preventive Measures

Though not cited as frequently as taking rests, warm-up routines and stretching, some authors recommend that musicians pursue healthier lifestyles away from their instruments in order to improve their physical and mental health so they are

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[90] Ibid.

[91] Ibid.

[92] Ibid., 469.

[93] Ibid.

able to handle the demanding workload their job requires. Klickstein states that healthy performers exhibit good habits of nutrition, rest and exercise.[94] Shafer-Crane also mentions the importance of "hydration and the avoidance of caffeine, nicotine, and other stimulants" as building blocks for a prevention program.[95] Though no specific data has been produced on the relationship of good nutrition and prevention of playing-related injuries in musicians, it is easy to understand why such advice is given as nutrition is key for a well-functioning human body.

Horvath emphasizes the importance of good physical conditioning for musicians. She states that "an untoned body is more injury-prone," while also mentioning that reports have linked injury risks to fitness levels.[96] She says that "muscles that are tight and weak are at greater risk than strong and flexible muscles." Therefore, "conditioning, flexibility, endurance, muscle balance, body alignment, and strength" are all factors that can aid in injury prevention.[97]

Goodwin advises people to get regular exercise as it may decrease their chances of developing carpal tunnel syndrome.[98] Goodwin points out that poor cardiovascular condition of the body exacerbates one of the causes of carpal tunnel syndrome: not having enough blood circulating in the hand area "to support a high level of activity in the hands."[99] This can be addressed by engaging in regular

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[94] Klickstein, 52.

[95] Shafer-Crane, 830.

[96] Horvath, 8.

[97] Ibid.

[98] Goodwin.

[99] Ibid.

exercises.[100] Shafer-Crane also mentions the importance of aerobic exercise, which "increases peripheral circulation" as well as the amount of "blood available for neural nutrition."[101]

Besides aerobic exercises, Shafer-Crane suggests other forms of exercises to produce additional benefits for the musician. She points that "endurance training, with free weights, elastic bands or tubing, or exercise machines, prepares the musician for long hours of practice and performance, and helps ensure that the muscles and joints are more than up to the stresses and strains endured."[102] Echoing Norris, Klickstein agrees that the musician should develop "overall strength, endurance, and flexibility."[103]

Lee et al. have different ideas. They state that "for musicians, low-resistance, high-frequency strengthening exercises are more suitable than the high-resistance varieties designed to produce muscular mass."[104] Though this may be good advice in general, it might not apply to all cases. Rickert et al. cite an example where a strength program may indeed benefit the musician. They pointed out that in their study, cellists had "signs of muscular imbalance in the shoulders, with a significantly high proportion of students exhibiting more than a one-third difference in strength between the internal and external rotators."[105] The authors see such imbalance as a risk factor

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[100] Ibid.

[101] Shafer-Crane, 830.

[102] Ibid.

[103] Klickstein, 53-4.

[104] Lee et al., 86.

[105] Dale Rickert et al., "A Study of Right Shoulder Injury in Collegiate and Professional Orchestral Cellists: An Investigation Using Questionnaires and Physical Assessment.," *Medical Problems of Performing Artists* 27, no. 2 (June 2012): 70.

for shoulder injuries as it was seen in other elite performance domains.[106] Therefore, different physical activities may be needed to provide the specific benefits various musicians may need.

3.5 Make the Instrument Adapt to You

One of the biggest changes that have occurred in guitar playing over the last few decades is the understanding that in order to achieve optimal posture and technique it is necessary to adapt the environment to the musician. For example, the instrument can be adapted to the musician by using a device or clothing that will avoid friction between the instrument and the guitarist's forearm, a guitar support to replace the footstool, a different shaped guitar or lower string tension. From the moment guitarists start to embrace these changes, they create new possibilities to achieve an ideal posture and better technique to help prevent injuries.

3.5.1 Ergonomics

Over the centuries, guitarists have used different methods to place their instrument in a position that optimizes their technical capabilities. In the nineteenth century, Fernando Sor recommended resting the instrument on a table, and Dionisio Aguado recommended a tripod to hold the guitar in the correct position. In the twentieth century a footstool became the default tool to raise the left leg to fully optimize the classical guitar technique.

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[106] Ibid.

For guitarists, these types of tools are of extreme importance. According to Rueda, the femur, tibia and fibula (See Figure 1) are the "load-bearing pillars for the weight of the body." [107] Once poor foot support occurs, "all the upper body parts must be adapted, which may lead to imbalance and asymmetry, even when sitting."[108] For these reasons, though the footstool is currently one of the most commonly utilized tools, it is far from ideal and authors have been criticizing the imbalance that it causes in the guitarist's body. Rueda points out that when guitarists use a footstool, the left and right legs are imbalanced in their height. Also, the right leg is positioned further to the right side in abduction "in order to support the lower bout of the guitar."[109] In Mitchell's analysis of the posture generated by the use of a footstool, she reinforces the criticism of the device concluding that it throws the pelvis off balance, straining the lower back, and the resulting bent and twisted posture cramps upper torso and arms.[110]

[107] Rueda, 14.

[108] Ibid.

[109] Ibid., 47.

[110] Mitchell.

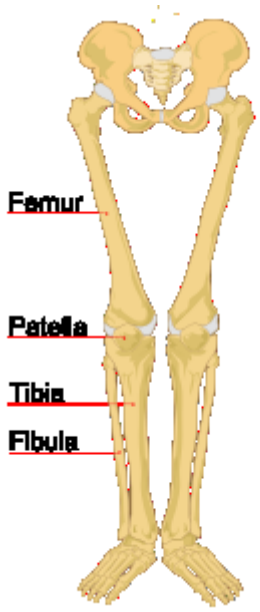

Figure 1. Femur, tibia and fibula: "the load-bearing pillars for the weight of the body." *Source:* Mariana Ruiz Villarreal, "Human Leg Bones Labeled," Wikimedia Commons, accessed May 14, 2016, https://commons.wikimedia.org/wiki/File:Human_leg_bones_labeled.svg.

Rueda explains in detail what happens to the guitarist's posture when a footstool is used. According to her, "the more the hip is flexed by raising one leg above the horizontal, the more the pelvis and lumbar spine are pushed back."[111] Another problem is generated from this imbalanced height. The support on the sacrum and pelvis becomes asymmetrical and "the spinal column resorts to scoliosis," described by Rueda as a "sideways deviation of the spine which is successively compensated for further up the back until the entire backbone is an elongated S-shape."[112] As a result of such imbalanced posture, the "muscles around the concave region tend to shorten and become more rigid" while "those around the convex curve

[111] Rueda, 47.

[112] Ibid.

lengthen and become weaker," which may cause further problems.[113] The footstool often causes one of the guitarist's knees to bend or extend too much.[114]

Rueda describes the behavior of the pelvis as being like a pulley. She states that "according to its degree of rotation on the hips, the tension in the muscles in one chain is greater and in the opposite chain lesser."[115] Again, this imbalance is the result of wrongly making the body adjust to the footstool. In order to fix these problems, guitarist should search for a tool that allows him to place both feet at equal height distributing equal weight through all the points of contact.[116] Rueda says that once guitarists distribute their weight correctly, the work required by the muscles is minimized.[117]

Most of the problems caused by the footstool can be corrected by the use of ergonomic guitar supports such as the different models of ErgoPlay guitar supports or cushions that raise the guitar without altering the position of the body. Upon analysis of the posture produced by such ergonomic tools, Mitchel states that they allow the guitarist to sit upright in a balanced position with both feet flat on the floor.[118] The use of these tools provide additional injury prevention benefits that will be discussed later in this project.

The second relevant aspect of making the practice environment adapt to the musician is the placement of the music stand. Mitchel states that the musician should

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[113] Ibid., 37.

[114] Ibid. 47.

[115] Ibid., 37.

[116] Ibid.

[117] Ibid.

[118] Mitchell.

search for a neutral position when sitting, which in his definition is an upright posture, producing a balanced and less stressful position. [119] To Mitchel, this is the position that provides the most stability for the musician.[120] However, simple things such as the improper placement of a music stand can interfere negatively with the neutral position. Mitchel says that musicians should make sure that it is placed "at eye level so [they are not] slumping to see the music."[121]

Another important and often overlooked component to create a neutral position is the chair used by guitarists. According to Rueda, comfort and correct posture will "depend largely on the type of chair" the guitarist use.[122] Mitchel explains that "in order for the spine to be truly balanced over the 'sit bones' that places the hip joint in its least stressful position, the seat needs to be slightly tilted forward."[123] Rueda agrees and describes "the ideal angle between the thighs and the torso" as being around 110˚.[124] She explains that this idea was inspired by the drivers of old horse drawn carriages who had seats in a forward-slopping inclination of 30˚ that helped ensure a good hold.[125] Chairs that tilt forward usually have fixed or adjustable angles between 5 and 30˚. However, according to performance trials, angles greater than 15˚ may feel "unstable and difficult to adapt to."[126] If chairs with forward inclination cannot be

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[119] Ibid.

[120] Ibid.

[121] Ibid.

[122] Rueda, 44.

[123] Mitchell.

[124] Rueda, 44-5.

[125] Ibid.

[126] Ibid.

found, Mitchel suggests that musicians "place a foam wedge, a sloped cushion, or a folded towel near the rear of the chair to provide the necessary tilt."[127]

3.5.2 The Instrument

Part of adapting the environment to the musician is making sure the instrument itself is not one of the risk factors. Søgaard states that the root of many injuries is the way in which the guitarist interacts with his instrument, adapting himself to the instrument instead of finding an instrument that is appropriate to his body.[128] Klickstein has a similar position on this issue. Believing that many injuries "start with mismatches between players and instruments," Klickstein claims that in order to play with ease, the instrument should be aptly "sized, adjusted and positioned."[129]

Jones-Bey describes a different approach by physicians to diagnose the causes of playing-related injuries. Doctors focus on the variables related to the instrument such as strings, fretboard, and obvious changes such as whether the musician is playing a different instrument.[130] The physicians' focus on these variables emphasizes that musicians should not be a slave to their instrument and they should be encouraged to make changes if any aspect of their instrument is getting in the way of their health.[131]

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[127] Mitchell.

[128] Paul Anders Søgaard, "Ergonomics of the Guitar: A Study in Physical and Psychological Aspects of Guitar Playing - Part 3: Prevention and Rehabilitation," *Classical Guitar Magazine* (June 2006): 25.

[129] Klickstein, 50.

[130] Jones-Bey, 73.

[131] Ibid.

Such concerns are supported by multiple studies linking improperly sized instrument to the risk of injuries. Wagner states that a study with Japanese pianists "with relatively small hands" demonstrated the pathogenic effect of executing "strenuous piano techniques such as octaves, chords, arpeggios [and] *fortissimo* dynamics," and concluded that "hand size could be considered a risk factor in piano playing."[132] Another study of this same issue was performed comparing "the effect of a reduced-size keyboard (7/8) with the standard keyboard on two 'small-handed' pianists."[133] According to Wagner, the conclusion from this study was that the pianists self-perceived an improvement in their performance, as it required less effort.[134] Also, the transition to an instrument of different size was shown to not be a problem.[135] A third study comparing the effect of a reduced-size keyboard to the standard keyboard was performed by Yoshimura and Chesky, and according to Wagner their results also "showed the advantage of a reduced-size keyboard for small-handed pianists."[136]

Based on such findings, Wagner implies that a simple solution would be one that many are reluctant to provide: producing instruments of different sizes to fit the musicians' needs.[137] The guitarist should look for a guitar with an overall appropriate size, including a reasonable width of the guitar neck and scale size, as well as spacing between the strings.

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[132] Christoph Wagner, "Musician's Hand Problems: Looking at Individuality: a Review of Points of Departure." *Medical Problems of Performing Artists* 27, no. 2 (June 2012): 57.

[133] Wagner, 58.

[134] Ibid.

[135] Ibid.

[136] Ibid.

[137] Ibid.

Mencimer tells the story of a guitarist with myofascial pain syndrome in his knuckles who was told by his orthopedist that he would never play again.[138] However, it was noted that the patient had large hands incompatible with the thin neck of his guitar causing him to use a "pincher grip" to play. It was determined that this type of grip was the root of his injury. As soon as he used a guitar with a wider neck, his symptoms ceased.[139] Therefore, the guitarist should be encouraged to experiment with instruments of different sizes as well as different tensions of strings or string action (distance from the strings to the fretboard). Low string tension and low string action are generally easier to play and allow more relaxation while playing, though it may affect the timbre and sustain of the instrument and cause fret buzzes.

3.6 The Education Factor

Musicians experience a high incidence of injuries. These injuries can compromise their career in many ways. The fact that we are able to track the causes of such injuries and develop tools and strategies to avoid them makes prevention the wisest strategy against playing-related injuries. Prevention must then be one of the pillars of instrumental pedagogy.

Prevention seems to be the most effective way to keep a musician healthy. Norris states that even though overuse injuries are quite common among instrumentalists, they are also largely preventable if approached by a combination of

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[138] Stephanie Mencimer, "Tuba Lips, Guitar Nipples and Other Musical Maladies," *Washington Post*, March 25, 2003.

[139] Ibid.

proper care and changes in "habits or activities that caused them."[140] For musicians, among the modifiable risk factors to prevent injuries, Guptil and Zaza list warm-up, breaks, posture, playing position, technique, repetition and pacing.[141] As previously noted, studies confirm that these topics have positive impact on injury prevention.

It may seem obvious that it is crucial to prepare musicians to their ability to physically play through their entire career. However, reports shows that proper care of injuries as well as the techniques Guptil and Zaza listed for prevention of injuries are often not addressed in the musicians' learning process.[142] Babin emphasizes that musicians with injuries that he interviewed did not have injury prevention addressed on any time from a young age or throughout their professional training.[143] This flaw in the musical education process could share significant blame for musicians' injury. Muscle memory and repetition are a basic part of performance. Therefore, learning correct movements is important so that the musician can rely on practicing safe movements while playing.[144] On the other hand, if improper movements and flawed practice habits are not corrected during the learning process, the repetition of these gestures as well as muscle memory will increase the chances of a musician developing chronic injuries.

Shafer-Crane agrees that the most effective "treatment" of repetitive strain injuries is prevention as musicians are often reluctant to seek professional help,

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[140] Norris, 10.

[141] Guptill and Zaza, 29.

[142] Angela Babin, "Health and Care of Performing Artists in Cuba," *Medical Problems of Performing Artists* 22, no. 2 (June 2007): 79.

[143] Ibid.

[144] Guptill and Zaza, 31.

reluctant to go through the recovery process, and afraid of being labeled an "injured musician."[145] To Rickert et al., an appropriate injury prevention program should rely first on establishing causation.[146] This however, is considered difficult by the authors as musicians' injuries result from a "complex interaction of instrument-specific, individual, social, and environmental factors, and to date no research has managed to map their interactions."[147] Due to the proximity of the instrumental teacher to the student and to the fact that they are often a primary source for establishing good (or bad) instrumental habits, the teacher should be prepared to transmit information on injury prevention and help the student self-identify the situations which could potentially lead to an injury.

Believing that education is a good approach for effective injury prevention, Barton and Feinberg state that instruction on injury prevention and maintaining good health are of critical importance to the career of a musician. They believe such instruction should be introduced to the student "as early as possible" in their careers.[148] The authors also believe the role of teaching prevention should be extended to therapists, recommending that their treatment should not be limited to the remedial aspect, but should also be combined with preventive and educational strategies.[149]

The results from a survey performed by Redmond and Tiernan showed that musicians educated on injury prevention were most likely to teach their students about

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[145] Shafer-Crane, 827.

[146] Rickert et al., 65.

[147] Ibid.

[148] Barton and Feinberg, 47.

[149] Ibid., 48.

such practices if they felt comfortable with the topic.[150] In multiple cases, programs to increase a musician's body awareness have been shown to have a positive impact. For example, Lee et al. studied a group of students who participated in an intervention program to increase their body awareness that included a set of breathing exercises as well as a muscle-strengthening program.[151] The post-intervention data showed that the program "improved physical efficacy by increased awareness of posture and tension."[152] Such results were also confirmed by changes in the motion analysis data performed pre and post- intervention in some participants.[153]

Students and teachers in Germany also reported positive feedback after a seventeen-week program implemented by Hildebrandt and Nubling.[154] Barton and Feinberg explain that the authors noticed an improvement of "movement patterns and posture used to play the instrument and their improved use and understanding of prevention which impacted playing health and overall health."[155] Another similar course implemented at the Zurich Conservatory of Music in 2001 had 22 student musicians attending a weekly program consisting of "lectures and lab activities on preventive measures for musicians."[156] Data collected pre and post- intervention in the

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[150] Margaret Redmond and Anne M. Tiernan, "Knowledge and Practices of Piano Teachers in Preventing Playing-Related Injuries in High School Students," *Medical Problems of Performing Artists* 16, no. 1 (March 2001): 32.

[151] Lee et al., 85.

[152] Ibid.

[153] Ibid., 91.

[154] Barton and Feinberg, 48.

[155] Ibid.

[156] Ibid.

test group showed a decrease in "playing-related symptoms, emotional disturbances, and anxiety" when compared to the control group.[157]

Performing their own experiment, Barton and Feinberg used a sample of 26 freshmen students enrolled as music majors who attended an eight-session module on Health Promotion and Prevention of Injury.[158] The researchers used three tests to evaluate the benefits of the program, the first performed before the program, the second on the day after the last class, and the third exam given six weeks after the last day of class.[159] The tests included questions regarding medical problems and common risk factors for musicians, as well as questions addressing issues regarding promotion of good health and injury prevention strategies.[160] With a total of 40 points available, the average score on the first test was 25.5, on the second test the average score increased to 31.6, while on the third test the average had a slight decrease staying at 29.7.[161] From these results, the authors concluded that participants "improved in their overall knowledge of the content covered" in the program and in "their self-perceived application of health promotion and injury prevention strategies during their daily routine."[162] Although there was a slight decrease of scores in the exam performed six weeks after the end of the program, the students retained a significant amount of what was learned in the course.[163]

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[157] Ibid.

[158] Ibid.

[159] Ibid.

[160] Ibid., 49.

[161] Ibid.

[162] Ibid., 51.

[163] Ibid.

López and Martínez performed an experiment with 146 music students, divided into an experiment group of 90 subjects and a control group of 56 subjects. The experiment group was taught how to evaluate the possible risks associated with the practice of their instruments.[164] In the year-long program, they were provided with "information about the most frequent medical problems of musicians, warm-up habits, postural hygiene, effective prevention strategies, and different treatment options for these pathologies."[165] During the course, they were surveyed three times showing improved results in the experiment group only. According to their results, of the 77 students in the experiment group who suffered from physical problems in the initial survey, only 17 continued to report problems at the end of the program, a decrease of 77.9% in the injury rate.[166]

As shown above, musicians become significantly more aware of the risks of injuries and of the methods of prevention once they are exposed to such information. Once they become teachers, they tend to pass this information on to their students, and as demonstrated, such information has a direct impact by decreasing the injury rate in musicians. Such results suggest that if teachers are trained in injury prevention methods, we should be able to drastically reduce the injury statistics described in chapter 1.

Discussing what music teachers should teach their students regarding injury prevention, authors agree with many of the conclusions drawn in this dissertation. Klickstein for example, suggests that teachers should encourage students to practice in

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[164] López and Martínez, 102.

[165] Ibid.

[166] Ibid.

multiple short sessions and choose a repertoire suited to their level of skills.[167] Besides teaching students safe practice methods, Klickstein states that teachers should also be responsible for identifying the warning signs and symptoms of injury in their students and advise rest and professional help.[168] Stein states that "using the body correctly is most important with beginning students."[169] He claims that at this stage, the student tries diligently to learn new body movements, so the teacher should intervene if the student is struggling and encourage them to enjoy being a beginner and not to try too hard so they do not put too excessive pressure on the body.[170]

Aware of the research done and the positive results of injury prevention programs, Barton and Feinberg state that undergraduate music students are an important group to be targeted by these programs as evidence suggests that "students transitioning into college are at greater risk for the development of playing-related problems."[171] The authors recommend that such preventive training should include "physical conditioning, stress management, relaxation and body awareness training, and proper education regarding appropriate instrument choice and performance technique."[172] Such recommendations seem to make sense as they target several of the topics covered in this chapter that are relevant to the prevention of injuries. The type of training suggested by Burkholder and Brandfonbrener includes the topics discussed

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[167] Klickstein, 48-50.

[168] Ibid., 53.

[169] Charles Jay Stein, "The Alexander Technique: Its Basic Principles Applied to the Teaching and Performing of Stringed Instruments," *American String Teacher* 49, no. 3 (August 1999): 75.

[170] Ibid.

[171] Barton and Feinberg, 47.

[172] Ibid.

in the studies cited here, and the efficacy of such training is supported by the weight of tested and controlled evidence.

In summary, as Lee et al. stated, research indicates that "behavioral, environmental, and educational risk factors are manageable, and, consequently, musicians' injuries are preventable."[173] Although the injury rate in musicians is high, as Lederman and Calabrese warns, "student and performer must approach practice and performance with the understanding that the body has limitations that cannot be exceeded with impunity."[174] Such understanding, which results in reduced injuries, can be taught by teachers trained in injury prevention.

[173] Lee et al., 85.

[174] Klickstein, 48.

CHAPTER 4

SPECIFIC SITES OF INJURIES IN GUITARISTS AND PREVENTION

In the previous chapters, we explored broad overviews of strategies that musicians, including guitarists, can use to prevent injuries. However, the guitarist may be at greater risk of certain injuries, in certain parts of the body, that may be avoided by an approach specifically suited to guitarists. Though this chapter will provide general information for all musicians, it will provide a more in-depth analysis of injuries affecting guitarists. It will discuss affected body parts, specific causes of injuries related to the guitar, and what the guitarist can do to prevent these injuries.

Before suggesting any alteration in technique or posture, one must consider Muldowney's statement that "the human body is designed to be capable of occasional movement well beyond the bounds of its natural extension and alignment without sustaining injury."[1] Muldowney highlights that risk only occurs when such positions are sustained longer than the time needed to accomplish a task, thereby creating sustained moments of tension which may weaken the musician's muscles and tendons and cause injury.[2] Rueda complements explaining that "an elongated muscle has more capacity for contraction than a shortened one,"[3] but on the other hand, "when a muscle is stretched to its maximum length, its antagonist is shortened making the contraction of this muscle rather inefficient."[4] Therefore, the conclusion that we can draw from

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[1] Muldowney, 31.

[2] Ibid.

[3] Rueda, 21.

[4] Ibid.

Rueda and Muldowney's thoughts is that the guitarist should not necessarily stick to a fixed position when playing. More tensioned postures may be efficient to perform certain passages. Musicians should, however, return to a neutral position where the least tension is applied over their muscles and joints as soon as those postures are no longer required.

An abrupt change in technique is one factor that puts musicians at risk of injury. This may not be because of the change of technique itself, but because students may try to apply the newly learned gestures without self-awareness of the tension that they are imposing. A gesture that should be more relaxed and efficient may become tensioned and harmful if the student does not correctly understand it. Stein agrees with this claim and states that often guitar teachers tell their students to perform a release movement, yet the student performs a lock down.[5] Once a more efficient posture is introduced to the student, the instructor or the student himself must pay attention to how this new concept is approached to make sure it is fully understood and correctly executed by the student. In theory the advice should improve the quality of their posture, however, if not approached correctly it may end up being harmful to the musician's health.

When applying new concepts to correct posture or technique, musicians should be aware of the possible mismatches that may block their path to the new playing technique. Size, weight, and string tension may create barriers between musicians and an efficient technique.[6] Sometimes even improper breathing can generate tension, and according to Lee at al., paying attention to it may allow "muscular coordination to

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[5] Stein, 72.

[6] Rosenbaum et al. 1269.

function more freely."[7] In summary, a more relaxed technique requires a context in which all the variables of instrument, ergonomics and practice strategies mentioned up to this point are considered.

4.1 Back and Leg Injuries

Some of the most damaging injuries that guitarists suffer occur in the back and legs. As these injuries affect body parts that are responsible for most daily activities, like picking up and carrying objects, they usually have consequences beyond the effects on the guitarist's playing ability. The incidence of these injuries is more frequent than most people believe. Rueda states that "the likelihood of a guitarist sustaining a back injury is above average," and some injuries "do not manifest themselves for several years."[8]

As for many injuries, poor posture is usually the most common cause of back injuries. When playing the guitar, a different sitting position can modify the structure supporting the body. Rueda explains that the stress of a pelvic displacement modifies the equilibrium and shape of the spine.[9] Once the pelvis tilts forwards or backwards, it increases or decreases the curvature of the lumbar spine, which affects all vertebral segments above it.[10] In addition, once the pelvis is moved sideways by raising one hip, it creates a "compensatory lateral spine movement."[11] Cole states that "small

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[7] Lee et al., 86.

[8] Rueda, 41.

[9] Ibid, 14.

[10] Ibid.

[11] Ibid.

movements in the lower spine create larger changes in the rest of the spine, and everything connected to it: rib cage, collarbones, shoulder girdle, and arms."[12] According to Rueda, such unnatural positions often generate poorly distributed pressures on the spine, which "can speed up degenerative processes in the spinal joints, trigger damage to the intervertebral discs and compress nerve roots as they leave the vertebral column."[13]

A common consequence of such asymmetrical pelvic positions is lumbago, which occurs from the muscle overload caused by scoliosis,[14] a consequence of the unnatural pelvic position.[15] Rueda also warns that besides muscular ailments such as overloading and contractions, as well as mechanical joint irritations, musicians should be aware of possible degeneration of the intervertebral discs and emergence of herniated or slipped discs, as these can also be consequences of too much strain and lumbar compression.[16]

Poor sitting posture causing improper pelvic position is the root of most back problems in guitarists. Guptil and Zaza suggest that musicians should maintain the normal curvatures of the spine when sitting or standing, and to do so, they need to understand it.[17] Figure 2 illustrates the normal configuration of the spine. The authors

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[12] Cole, 24.

[13] Rueda, 15.

[14] Rueda defines scoliosis as a "sideways deviation of the spinal column in a series of curves." She also explains that it is in fact often a scoliotic attitude rather than scoliosis, as the deviation generally disappears when the pelvic position is corrected.

[15] Rueda, 79.

[16] Ibid.

[17] Guptill and Zaza, 30.

warn, however, that musicians should not lock themselves into one playing position and encourage them to move with the music as required.[18]

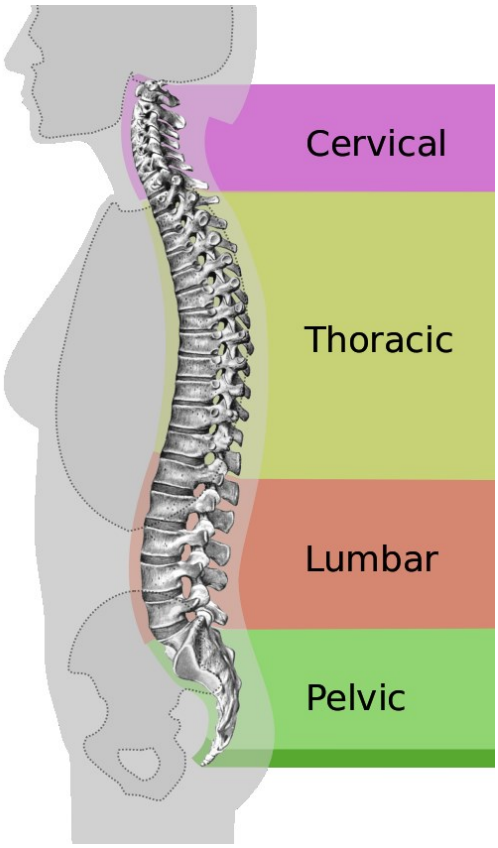

Figure 2. Normal configuration of the spine.
Source: "Spinal Column Curvature," Wikimedia Commons, accessed May 14, 2016, https://commons.wikimedia.org/wiki/File:Spinal_column_curvature-en.svg.

Even though musicians may know the consequences of improper pelvic position, classical guitarists often use a footstool to raise one leg to put the guitar in a certain position. Søgaard warns that if a footstool is used, this position should not be sustained for long periods of time.[19]

[18] Ibid., 30.

[19] Søgaard, 25-6.

Alternatives to the footstool that allow the guitarist to rest both feet on the floor have been developed,[20] eliminating raising the side of the pelvis. However, Søgaard warns that these devices can displace the guitar, not placing it in the center of the legs, forcing the guitarists' arms "to take on an active role in holding and balancing" the instrument.[21] In a study case using one model of an ErgoPlay guitar support to hold the guitar, Søgaard states that the "misuse of the arms contributed to an increase in muscular pain and lack of freedom of movement," particularly in difficult passages as the musicians' muscles became tense from a subconscious muscular pressure in both hands.[22]

Søgaard's case study cannot be generalized to all ergonomic supports; the model chosen was incompatible with the size of the guitarist as it did not elevate the instrument to the proper height.[23] This caused the player to bend his back in order to securely hold the instrument against his chest and reach certain positions of the guitar fingerboard. When considering an ergonomic alternative to the footstool, the guitarist should look for a solution that will place the guitar at a proper height and centered to his body. As seen in Figure 3, different ergonomic supports might adapt better to different players and conditions, due their sizes, adjustment possibilities, and placement on the guitar.

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[20] Søgaard, 26.

[21] Ibid.

[22] Ibid.

[23] Ibid., 25.

Figure 3. Different types of guitar ergonomic supports.
Sources: "Ergoplay Troester," ErgoPlay, accessed May 14, 2016, http://www.ergoplay.de/englisch/downloads/product/troester.jpg; "Ergoplay Tappert," ErgoPlay, accessed May 14, 2016, http://www.ergoplay.de/englisch/downloads/product/tappert.jpg; "Oasis Quadret Guitar Support," All StringsNylon, accessed May 14, 2016, https://allstringsnylon.com/media/catalog/product/cache/1/image/17f82f742ffe127f42dca9de82fb58b1/o/a/oasis-quadrest-guitar-support-oh25-closeup_lrg.png; "Dynarettexl," Grand Salon de Guitare, accessed May 14, 2016, http://www.salondeguitare.com/accessories/GUITAR%20SUPPORTS/dynaretteXL.jpg.

Other variables such as the chair should also be considered when using ergonomic supports like the ErgoPlay. A chair of the wrong height may create instability if the seat it is too high, while a low chair may cause elevation of the right shoulder, generating tension depending on the minimum height adjustment of the ergonomic support.

Utilizing anti-slip cloths may be useful to provide stability so that guitarists will not feel the need to use the arms to maintain the position of the guitar. These cloths are particularly helpful if the guitarist wants to have the guitar leaning back towards the chest. The guitarist will not have to lean towards the instrument to provide stability, thus creating a more relaxed position without bending the back.

Though not as common as back injuries, guitarists should guard against trapped nerves in the legs. According to Rueda, poor ergonomics can also have a negative effect in the nerves of the legs, particularly when one leg is raised with the

use of a footstool.[24] The author mentions "cases of meralgia paraesthetica related to sitting for long periods," especially in these positions.[25] Rueda explains that this syndrome is caused by the "entrapment of the lateral cutaneous nerve of the thigh in the groin area."[26] According to the author, this nerve "supplies sensation to the upper and lateral thigh and has no motor fibers," meaning that "the only symptoms for such injury are tingling or decreased sensation in the affected area itself."[27] Rueda states that these symptoms are usually short-lived, and also experienced in the entrapment of the sciatic nerve, in the back of the thigh, "caused by sitting on the edge of one's seat for too long."[28]

Though the suggestions for sitting and playing postures, as well as the ergonomic tools presented in the previous paragraphs, can help guitarists maintain their physical health for a longer period of time, Rueda warns that no matter how energy-saving and symmetrical these positions are, they are not entirely healthy if fixed.[29] Therefore, guitarists are advised to adopt slight movements during their playing, vary tasks and stand up from time to time to relax the muscles used in the sitting position, such as legs and lower back.[30]

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[24] Rueda, 76.

[25] Ibid.

[26] Ibid.

[27] Ibid.

[28] Ibid.

[29] Ibid., 50.

[30] Ibid.

4.2 Shoulder and Neck Injuries

Even while sitting in a neutral position with the help of ergonomic and supporting tools, the guitarist should still pay attention to other changes of posture during playing that may lead to prolonged tension. Rueda states that guitarists often adopt a craned neck when trying to see their hands or read the music, which results in "greater contraction of the neck muscles."[31] As a consequence, the intervertebral discs of the cervical column are put under unhealthy levels of pressure, increasing the risk of injuries.[32] According to Rueda, if this position is sustained over a long period of time, it eventually becomes a posture habit causing the neck muscles to shorten definitively, becoming much more fibrous and rigid.[33] In addition to the neck muscles, Rueda warns that the trapezium is also affected by muscular tension caused by poor posture.[34]

Søgaard's study showed that all right-handed guitarists turned their upper body to the left side, dropping their heads in order to see the fretboard.[35] As analyzed by the author, this position caused "muscular tension and pain in the neck, back, shoulders and arms."[36] Justifying such postures, the guitarists explained that turning their body and dropping the head was unavoidable in order to see the left-hand action.[37]

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[31] Ibid., 36.

[32] Ibid.

[33] Ibid.

[34] Ibid., 70.

[35] Søgaard, 25.

[36] Ibid.

[37] Ibid.

The need to look at the left hand is an undeniable occurrence while playing the guitar. However, it is not always necessary to look at the hand, so a guitarist should develop skills to work around this habit. Developing muscle memory to execute the music without the need of visual support is one strategy: this would provide a more relaxed position as a player could rely periodically on muscle memory to release tension in the neck. Rueda agrees that playing without looking at the guitar overcomes this problem, and also suggests that the guitarist may want to use a mirror during practice to check that they are not craning the neck.[38]

If turning the head is necessary, the movement should be kept to a minimum. The guitarist should search for the most economic head position, paying attention to the tension caused by excessive turning. Hogg advises guitarists to not "hunch over the guitar" in order to see their hands' action,[39] while Søgaard states that when necessary, guitarists should "drop their eyes" instead of dropping the head and neck towards the chest.[40] Søgaard emphasizes, however, that a sitting position with the head facing forward in a neutral position should allow the guitarist to see what the left hand is doing to some extent "without having to turn the head or the eyes."[41]

Besides turning the head to see the left hand, Guptil and Zaza note that the height of the music stand may encourage poor posture if not placed at the level of the student's eye focus.[42] Rueda agrees with this and states that this position may generate

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[38] Rueda, 49.

[39] Karen Hogg, "Here's How: Play Without Pain," *Acoustic Guitar* 18, no. 11 (May 2008): 34.

[40] Søgaard, 24.

[41] Ibid.

[42] Guptill and Zaza, 30.

pain as a result of muscle overload.[43] Her proposed solution is to place the music stand at a position such that the guitarist looks down at an angle of 15 to 25°.[44] Søgaard adds that the guitarist should observe the position of his mandible.[45] He states that it has an important "connection with the balance of the head" as it hangs "directly from the skull."[46] His case study showed closed mouth, which leads to clenching of the teeth, generates significant muscular tension.[47] Based on his observations, Søgaard recommends that while playing, guitarists should consider slightly dropping the jaw in order to release muscle tension.[48]

As a consequence of neck tension, the shoulders sometimes become overloaded and can be at significant risk of injury. Wu, citing Fry, states that in musicians, the shoulder ranks third in incidence of injuries, falling behind hand/wrist and neck injuries.[49] Discussing the causes of injuries in guitarists' shoulders, Bastepe-Gray states that playing passages that exceed one's skill level triggers compensatory sustained isometric contraction of the shoulder muscles, generally increasing the risk of injuries.[50] Søgaard adds that tension in the right shoulder can be generated through

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[43] Rueda, 49.

[44] Ibid.

[45] Søgaard, 25.

[46] Ibid.

[47] Ibid.

[48] Ibid.

[49] HJ Fry, "Incidence of Overuse Syndrome in the Symphony Orchestra," *Medical Problems of Performing Artists* 1, no. 2 (June 1986): 51-55. Quoted in Heming, 64.

[50] Bastepe-Gray, 25.

improper posture, and that the shoulder should not have an active role on holding the guitar.[51]

In general, the large muscles in the shoulder should contract just enough to stabilize the guitarist's arms.[52] If the guitar is not set at a proper height or if there is not enough friction between the guitar and legs, for example, the guitarist will have to generate extra force in the shoulder to keep the guitar stable while playing. The ideal scenario for the right shoulder is one where the weight of the arm resting on the body of the guitar is enough to keep the instrument stable. Once again, for the complete stabilization of the instrument and minimal use of the shoulder as a stabilizing force, all the variables such as chair, ergonomic support, and extra accessories such as anti-slip cloths must work together to allow complete relaxation of these muscles.

Cole, quoting Lippincott, reminds us that the sitting position has an important effect on the shoulder's position because even small movements in the lower spine become amplified into the upper back and shoulders.[53] Cole confirms this saying that sitting with the left hip forward causes left shoulder to naturally shift forward as well, and uneven elevation of the legs causes one shoulder to raise higher than the other.[54]

Though specific data from shoulder injuries in guitarists is not available, Rickert et al. provide information on cellists that may shed light about how guitarists are vulnerable to such injuries. Through a questionnaire and a physical testing protocol, they found that right shoulder injuries were common amongst both student

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[51] Søgaard, 26.

[52] Bastepe-Gray, 25.

[53] Cole, 24.

[54] Ibid.

and professional cellists, with injury rates of 20% and 42%, respectively.[55] According to Rickert et al., "of the cellists that declared themselves currently injured, 34% had injuries on their right-shoulder and 29% on their neck and upper trapezius."[56] According to the authors, these injuries were associated with a "potential lack of strength in the scapular stabilizers, as well as potential degenerative changes in the rotator cuff."[57] The symptoms manifested as pain and stiffness in the professional cellists and "evidence of decreased muscular support in the students."[58] Based on the data, Rickert et al. suggest that the intervention methods for these shoulder injuries in the cellist population should be focused on exercises for the scapular stabilizers and muscles of the rotator cuff.[59]

While this study does not necessarily translate to the guitarist population, the right arm position used by cellists has similarities to how guitarists embrace the instrument, suggesting that the same type of tension may occur if the technique is faulty. The guitarist's right shoulder should ideally be resting on the instrument and not tensed to stabilize the instrument; however, strengthening the shoulder region with exercises might be an interesting regimen to decrease the probability of shoulder injuries, especially if a problematic posture is not corrected.

Rotator cuff tendonitis is among the most common shoulder injuries and one of the most common forms of tendonitis in both cellists and guitarists.[60] Rueda states

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[55] Rickert et al., 65.

[56] Ibid., 69.

[57] Ibid., 65.

[58] Ibid.

[59] Ibid.

[60] Rueda, 71.

that this injury "affects the shoulder tendons beneath the joint that links the collarbone to the shoulder blade."[61] She explains that "during combined abduction and rotation movements . . . , the smaller tendons deep inside the shoulder . . . are subject to intense friction possibly leading to gradual erosion and even tears."[62] The musician affected by this injury may suffer from periods of acute inflammation, known as periarthritis humeroscapularis, "which may affect the entire shoulder joint and completely prevent movement."[63] Discussing the causes of rotator cuff tendonitis, Rueda states that besides tension in the positioning of the shoulder, "poor neck and head postures often aggravate this complaint," and just like the cause of many neck injuries, "thrusting the head forward 'drags' the shoulder blades with it resulting in further shoulder imbalance and friction."[64]

Other injuries in the shoulder area common in musicians are posture-related cervicobrachialgia (pain originated from the "compression of nerve roots of the cervical spinal cord"),[65] myalgia (muscular pain)[66] of the trapezius descendens and thoracic outlet syndrome.[67] Among those, thoracic outlet syndrome is one of the most

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[61] Ibid.

[62] Ibid.

[63] Ibid.

[64] Ibid.

[65] *Encyclopedia and Dictionary of Medicine, Nursing, and Allied Health*, 7th ed., s.v. "Cervicobrachialgia," accessed May 11, 2016, http://medical-dictionary.thefreedictionary.com/cervicobrachialgia.

[66] *Encyclopedia and Dictionary of Medicine, Nursing, and Allied Health*, 7th ed., s.v. "Myalgia," accessed May 11, 2016, http://medical-dictionary.thefreedictionary.com/myalgia.

[67] Rietveld, 431.

frequent injuries among guitarists.[68] Rueda attributes the possible causes of thoracic outlet syndrome in guitarists to poor sitting position, "tensing the thorax and pectoral girdle, and continually raising the shoulders without enough breaks."[69]

To avoid general shoulder injury problems, Rueda states that the shoulders should be as symmetrical as possible, with both shoulders at the same height and same plane, where one shoulder "is not much further forward than the other."[70] She addresses the problems in the right shoulder specifically due the prolonged abduction (lateral movement) and internal rotation positions (rotated towards the chest). She warns that such movements are accentuated when guitarists move their right shoulder "too far forward" in order to "lay the forearm flat against the guitar" and advises to avoid "impinging the underside of the right forearm against the guitar's upper bout."[71]

The solutions proposed by Rueda include finding an angle of the neck of the guitar that allows the guitarist to "comfortably place [the] left hand on it without pushing the left shoulder up, down, back or forward," while the fingers "comfortably reach the strings with [the] wrist in the neutral position."[72] She states that guitarists should also avoid pushing their shoulders up and back as this modifies the whole posture and creates a compensatory movement of pushing their neck forward.[73] Not letting the shoulders sink will also prevent "misalignment of the shoulder joint and

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[68] Rueda, 75-6.

[69] Ibid.

[70] Rueda, 48.

[71] Ibid.

[72] Ibid., 49.

[73] Ibid., 51.

inefficient muscle action at the root of the arm."[74] Rueda claims that if the shoulders sink, the muscles will be unable to stabilize the arm, causing the "humerus and forearm [to rotate] inwards and, eventually, [leading] to the hand being imbalanced."[75]

Being conscious about the position of the shoulder and neck should not only prevent local injuries, but should also contribute to the overall health and optimal performance of guitarists. Goodwin's advice to the general population is that relaxed shoulders in any task will help reduce hand strains.[76] Heming, for example, emphasizes the importance of good posture to the ability to breathe correctly while playing,[77] showing that poor positioning of the neck and shoulders can affect not only those areas directly, but other parts of the body as well. Therefore, an optimal technique requires the posture for the whole body to be efficient and in harmony.

4.3 Arms and Wrists Injuries

The arms and wrists pose a variety of injury possibilities for guitarists. Among the general musician population, Rietveld states that wrist injuries are behind only the shoulders in incident numbers, and that they are manifested through a large variety of injuries such as tendinopathies (tendon diseases), carpal tunnel syndrome, De Quervain's disease, intersection syndrome, dorsal ganglion and "carpal boss."[78] When the scope is focused on guitarists only, the incidence of hand and wrist injuries rises to

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[74] Ibid.

[75] Ibid.

[76] Goodwin.

[77] Heming, 64.

[78] Rietveld, 433.

surprising numbers. Sung et al. state that guitar players have a higher incidence rate of overuse syndrome than do orchestra players,[79] and that 45% of such injuries are "strongly tied to the hand and wrist."[80] The authors attribute the high incidence of such injuries in guitarists to the fact that string players exert "excessive strain on the hand and wrist."[81]

Among wrist injuries, Rietveld lists intersection syndrome, also known as "drummers' wrist," as common injury. According to the author, this is a "friction syndrome" with pain at the intersection of the extensor carpi radialis (longus and brevis) and extensor pollicis brevis muscles and abductor pollicis longus muscle in the forearm; it is caused by a "combination of repetitive movements with simultaneous tension in both the wrist and thumb extensors."[82]

Osteoarthritis of the first carpometacarpal joint is another injury common in musicians. Occurring when the "protective cartilage on the ends of the bones wears down over time,"[83] they are often treated with a "simple thumb splint" in daily activities.[84] In the case of guitarists, the splint may be used during music making if the injury is on the left wrist.[85] Jensen and Sherson state without a definitive conclusion,

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[79] Sung et al., 1653.

[80] Ibid.

[81] Ibid.

[82] Rietveld, 433.

[83] "Diseases and Conditions: Osteoarthritis," Mayo Clinic, accessed April 2, 2016, http://www.mayoclinic.org/diseases-conditions/osteoarthritis/basics/definition/con-20014749.

[84] Rietveld, 433.

[85] Ibid.

that intense work-related strain of the carpometacarpal joints may be risk factors for this injury.[86]

Rietveld says that the "turn-over rate of connective tissue, especially in the hands," can be over a year, making "patience and graded activities with frequent short breaks" a key to rehabilitation.[87] For guitarists, injuries caused by arm, hand and wrist positioning can be prevented. Goodwin emphasizes that hand strains can be prevented if the elbows are not bent at angles lower than 90º as compression of blood vessels and nerves will be avoided.[88] Miller points out that improper hand positioning, such as when guitarists use their left-hand thumb to fret the sixth string, is inefficient and a possible cause of cramping or more serious injuries.[89]

The entire wrist should be a concern for the guitarist. Rueda describes the wrist as "a relatively vulnerable structure since it undergoes repetitive movement and traction and must stabilize finger movement whilst remaining flexible."[90] Understanding the vulnerability of this part of the body, Hogg advises guitarists to observe the tension in their wrists and stop to see whether they are bending their wrists "past a 45 degree angle."[91] She argues that "poor technique is the most common

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[86] Jens Christian Jensen and David Sherson, "Work-Related Bilateral Osteoarthritis of the First Carpometacarpal Joints," *Occupational Medicine* 57 (2007): 456.

[87] Rietveld,.433.

[88] Goodwin.

[89] Jane Miller, "Of Thumbs and Necks," *Acoustic Guitar* 24, no. 9 (March 2014): 35.

[90] Rueda, 15.

[91] Hogg, Here's How: Play Without Pain, 37.

culprit" in wrist injuries, and they are usually generated from "bending the wrist of the fretting hand excessively."[92]

Improper use of the forearms may also lead to a series of nerve entrapments such as median neuritis. To understand the impact that this type of injury has on guitarists, Rueda explains that the median nerve participates in several motions utilized in guitar playing, as the nerve "takes electrical stimuli to a range of muscles whose job it is to flex the wrist and fingers, particularly the hand muscles that enable the thumb to pinch and oppose itself."[93] This nerve travels through "a series of narrow gaps" in the forearm and in the carpal tunnel and may be directly affected by guitar playing activity. Rueda states that for the forearms, "co-contraction leading to too much muscle tone at this level, repetitive gestures such as strumming or attacking steel strings with a plectrum, and any intense finger flexion-extension movements" without a proper warm-up routine "can damage this nerve."[94] Other causes of damage in this nerve listed by the author are associated with the "prolonged compression of the front side of the forearm," such as "when the right forearm is rested against the lower bout of the guitar."[95] Based on the causes of median neuritis at the forearm level, specific instruction for its prevention will depend on individual technique deficiencies. However, guitarists should generally pay attention to relaxation of both forearms. For an economical technique, they should apply only the minimal necessary

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[92] Ibid.

[93] Rueda, 76.

[94] Ibid.

[95] Ibid.

tension and pressure to perform gestures that require the contraction of the forearm and release it as soon as the gesture is finished.

Another location where the median nerve is commonly trapped is in the carpal tunnel. Known as carpal tunnel syndrome, this entrapment is one of the most frequent complaints among guitarists.[96] Rueda explains that "all the tendons that flex the fingers and the median nerve must squeeze" through a narrow, tight and rigid gap on the "inner side of the wrist made up of the concave carpal bones."[97] Because the space in the carpal tunnel is limited, repetitive friction can cause inflammation, compressing the median nerve.[98] Excessive wrist bending or flexion are known as significant risk factor for carpal tunnel syndrome in guitarists, and the symptoms include "tingling and numbness coupled with pain in the first three digits,"[99] as well as "muscle weakness" in the wrist's intrinsic muscles such as the flexor and opponens pollicis (See Figure 4).[100] Without proper care, muscular atrophy may occur, limiting finger and thumb movements.[101]

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[96] Ibid.

[97] Ibid.

[98] Ibid.

[99] Ibid.

[100] Goodwin.

[101] Rueda, 76.

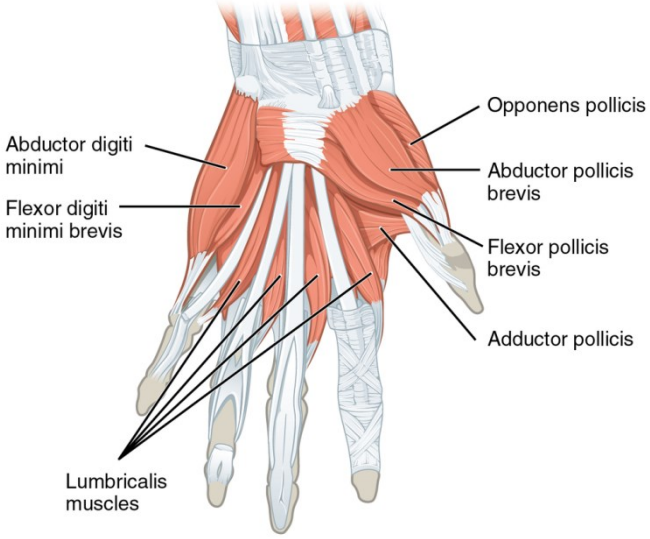

Figure 4. Muscles in the hand.
Source: "Intrinsic Muscles of the Hand Superficial," Wikimedia Commons, accessed May 14, 2016, https://commons.wikimedia.org/wiki/File:1121_Intrinsic_Muscles_of_the_Hand_Superficial_sin.png.

As carpal tunnel syndrome is also common in the general population rather than just guitarists, Goodwin gives directions for its prevention that guitarists may want to embrace. The author suggests that keeping the hands moving is beneficial as "frequent small variations in hand position reduce repetitive strain."[102] When resting, intentionally keeping the hands with the palms up opens up the space between the ulna and radius (bones in the forearm) and "reduces compression on the palmar surface of the hand, wrist and forearm."[103] Therefore, Goodwin advises that if one must work with hand palm-down, it should be placed in a palm-up or thumb-up position every moment possible.[104] In contrast, if the hands are resting in a palm-down position,

[102] Goodwin.

[103] Ibid.

[104] Ibid.

compression in the carpal tunnel and other vulnerable structures may occur, contributing to the injury.[105]

Goodwin suggests players minimize the amount of time spent closing together the thumb and little finger, which contracts or narrow the palm of the hand.[106] According to Goodwin, this movement contributes directly to carpal tunnel pressure.[107] Still, this left-hand gesture is used constantly in guitar playing, and is therefore unavoidable. The guitarist should simply avoid making it worse by having the hand in this position in other daily activities while away from the instrument. Goodwin agrees that if a job requires the use of the hands, leisure activities should not cause additional stress. As an example, the author states that instead of racquet sports, one should consider sports such as soccer.[108]

Goodwin also states that in order to avoid carpal tunnel syndrome individuals should try most of the time to keep the wrists in a "near-neutral angle," neither flexed nor extended.[109] The flexed and extended positions put significant "strain on the carpal tunnel," with the extended position causing nearly "three times as much strain" than the flexed position.[110] This is valuable information as again, playing the guitar requires some degree of both. The guitarist should, however, with the assistance of a proper chair, ergonomic support and a properly sized guitar, look for wrist angles that allow an effective playing technique that will not require significant degrees of flexion

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[105] Ibid.

[106] Ibid.

[107] Ibid.

[108] Ibid.

[109] Ibid.

[110] Ibid.

or extension. When flexed or extended positions are unavoidable, guitarists should return as quickly as possible to a more neutral position.

Playing with the wrists in neutral position may prevent multiple injuries besides carpal tunnel syndrome, including lateral epicondylitis, also known as "tennis elbow." Although its name may suggest this injury is limited to a group of athletes, it is just as common in guitarists.[111] According to Rueda, "forced wrist extension (or dorsal flexion) coupled with repetitive finger movements" are the causes of this injury, which is generally manifested as "localized pain on the outer side of the elbow or forearms," possibly "spreading towards the wrist, hand or shoulder."[112]

If wrist extension contributes to lateral epicondylitis, wrist flexion is a risk factor for medial epicondylitis. Also known as golfer's elbow, this injury according to Rueda, is aggravated by "prolonged 'unsafe' wrist flexion," along with the "repetitive flexion-extension motion of the fingers against the resistance of the strings."[113] She explains that this type of tendonitis "affects the inner elbow at the point where it is attached to the flexor muscle of the fingers and the wrist flexors," and that it can be particularly damaging to guitarists as the affected areas are largely used in left hand finger movements.[114]

Of the common types of tenosynovitis in guitarists, Rueda highlights digital flexor tenosynovitis. To explain how this injury occurs, Rueda describes how the "tendons of the flexor muscles in the fingers run through the carpal and metacarpal-

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[111] Rueda, 71-2.

[112] Ibid.

[113] Ibid.

[114] Ibid., 72.

phalangeal and interphalangeal joints" and that these joints are "covered by synovial sheaths that protect against the friction caused by movement of the tendon."[115] According to the author, "excessive action and strained wrist positions may cause these sheaths [in the fingers] to swell or the synovial fluid to leak out and press against the tendon, particularly around the carpal."[116] Once again, focusing on a neutral and relaxed wrist position is key to the prevention of this playing-related injury.

Guitarists are also vulnerable to the type of tenosynovitis known as trigger finger (stenosing tenosynovitis). Rueda explains that when the tendon sheath swells and thickens, it pushes "against the tendon in the finger area," inflaming the tendon itself and forming a "palpable, painful nodule."[117] The popular name of this injury reflects the symptoms of this injury. The nodule in the affected area creates resistance when the finger has to be opened.[118] This causes a "snapping sensation" that once repeated through multiple gestures may lock the finger as it is closed.[119] In guitarists, the middle and ring fingers are the most frequently affected.[120] As the causes of this injury is related to "repeated movement or forceful use" of the fingers,[121] guitarists should distribute the required effort to make finger gestures throughout the whole hand and arm instead of using only the muscles in the fingers to pluck or fret a string. For example, when plucking a string the guitarist should use not only the movement

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[115] Ibid., 73.

[116] Ibid.

[117] Ibid.

[118] Ibid.

[119] Ibid.

[120] Ibid.

[121] "Trigger Finger Causes and Treatment," WebMD, accessed April 2, 2016, http://www.webmd.com/osteoarthritis/guide/trigger-finger.

of the multiple finger phalanges, but the weight of the hand and forearm as well to avoid concentrated tension in the fingers. This will help create an economic gesture that may help in the prevention of stenosing tenosynovitis. Understanding how the fingers function in the hand may also be a powerful tool against this injury. Sung et al. states that the little finger motion is tied to the ring finger motion, that is, "when the little finger is lifted up, the ring finger is also lifted up."[122] Considering that the ring finger is one of the main sites of the trigger finger, planning the movements of these fingers so that they are not doing opposing and conflicting gestures, such as extending the little finger while the ring finger is contracted on either hands, will release any tension in the area creating a more natural movement.

Among injuries found in the hands, wrists, and forearms of musicians, Rosenbaum et al. call attention to musculotendinous overuse syndrome. They state that this type of injury may be due to eccentric contraction "involving injury to the musculotendinous junction" as a consequence of "overstretching of contracting muscles," inflammation of the tenosynovium, or due to injury to "muscles, tendons, ligaments, and joint capsules, and tendon sheath inflammation."[123] Rosenbaum et al. also state that string players generally have these problems in the flexor and extensor muscles of the right hand as well as in the muscles "involved with ulnar deviation in the left hand."[124] For guitarists, exaggerated and unnatural positioning of the hands should be observed and avoided to prevent this type of injury. In the left hand, adjusting the inclination of the neck of the guitar may help balance the need for such

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[122] Sung et al., 1657.

[123] Rosenbaum et al. 1270.

[124] Ibid.

deviated positions, while for the right hand, ulnar or radial deviation can be simply avoided by adapting the technique.[125]

Some of the concepts presented thus far may prevent not only specific playing-related injuries, but injuries in multiple sites as improper form usually overloads different muscles, tendons and nerves at the same time.

In a discussion of the neutral position of the hands and wrists, Mitchel states that "the tendons and muscles of the forearm extend down into the hands," and therefore, in order to minimize friction on these tissues, the hands and wrists should be in a straight alignment with the forearm "without unnecessary bends."[126] She explains that the hands and wrists should be adjusted for each note rather than keeping a fixed position; small sideways deviations should still be considered as neutral positions for the hands.[127] Mitchel believes that these slightly deviated positions can be efficient in different circumstances, and if multiple notes are being played at the same time, the musician should look for a midpoint between the neutral positions for each finger activated.[128]

Mitchel also examines fingerings choices, a topic that plays a significant role in healthy technique. Mitchel says that when learning a new piece, musicians should consider fingerings that "reduce awkward and stressful motions."[129] Fingerings are important to guitarists because they affect voice-leading and timbre; still, it may

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[125] Ulnar deviation is a lateral wrist movement towards the little finger. Radial deviation is a lateral wrist movement towards the thumb.

[126] Mitchell.

[127] Ibid.

[128] Ibid.

[129] Ibid.

sometimes be advised to sacrifice some level of musicality for the sake of a less stressful hand position.

Understanding the mechanics of the fingers is also a key to an optimal technique. For example, Mitchel explains that "the thumb has the flexibility to move in a circular motion," while the other fingers primarily only move up and down.[130] With these mechanics in mind, she points out that if the musician restricts the thumb movements to "forwards and backwards," not allowing it to "circulate freely from its base joint, it can become stiff, unreliable, and susceptible to strain."[131] This suggests that the guitarist, whenever possible, should strike the string with a semi-circular motion allowing the thumb to complete its circular trajectory to return to its resting position.

Muldowney discusses the overall posture of the fingers stating that they should be "relaxed, with the fingers together" and stretching only as needed.[132] To achieve this posture the author suggests that the guitarist should take care, for example, to not have the right hand in a high degree of supination (rotated towards a palm up position), or to not leave the fingers that are not being used on either hand stretched out.[133] Mitchel agrees that after striking a note or holding a chord, tension in the fingers is unnecessary and should be released so the fingers are relaxed.[134] The author also believes that "fingers should operate independently so that the muscular effort of

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[130] Ibid.

[131] Ibid.

[132] Muldowney, 31-2.

[133] Ibid.

[134] Mitchell.

the finger being used does not result in muscular activity" of the other fingers.[135] The ring finger is, however, an exception. The ring and little fingers are connected, and trying to make them operate independently may lead to injury.[136]

It is a common technical problem of musicians, including guitarists, to maintain tension in a finger after it is used. Mitchel states that releasing the tension may take practice and specific playing and relaxation exercises may be necessary.[137] For example, she recommends that guitarists "play a scale slowly, one note at a time, relaxing all the fingers not involved in playing the note and relaxing the whole hand between notes."[138] Bastepe-Gray agrees with this general idea while adding that a "repertoire with concentrated rapid passages in the upper positions, where the string action is high and where there is limited time to fully release and re-press the strings," maintain constantly high levels of tension in the left hand.[139] Rueda expresses concern regarding fast passages, especially on how they affect the extensor muscles of the wrists and fingers. According to her, these muscles "are frequently affected by intense action involving force and speed."[140] Rueda states that even though these muscles possess fast contractile fibers, they are easily tired: forcing them "to maintain wrist stability while repeatedly performing rapid movements, runs the risk of overloading the musculature."[141]

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[135] Ibid.

[136] Ibid.

[137] Ibid.

[138] Ibid.

[139] Bastepe-Gray, 25.

[140] Rueda, 70.

[141] Ibid.

While the statements of Bastepe-Gray and Rueda are generally true, the guitarist can use some workarounds to reduce these problems to a certain degree. When playing in positions on the fretboard where string tension is higher, the guitarist can reduce stress by using the stronger first and second fingers rather than the weaker third and fourth fingers, or favoring the third finger over the fourth finger whenever possible. The same concept can be applied to fast passages. The lack of time to release tension in a fast passage will not cause significant muscle overload in the stronger first and second fingers. Figures 5 and 6 exemplifies these suggestions:

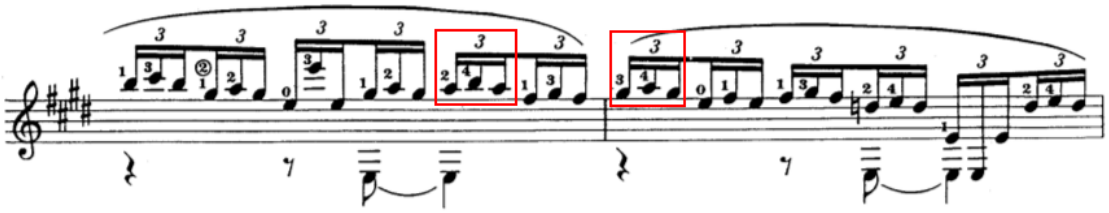

Figure 5. Fragment of Joaquin Rodrigo's Fandango in the original fingering.
Source: Joaquin Rodrigo, *Tres Piezas Españolas* (Mainz: Schott, 1963), 5.

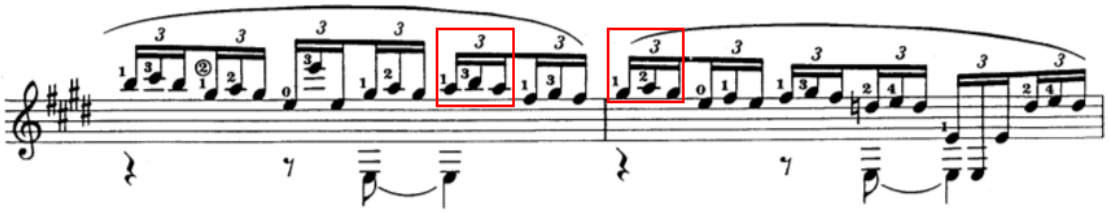

Figure 6. Fragment of Joaquin Rodrigo's Fandango in the suggested fingering.
Source: Joaquin Rodrigo, *Tres Piezas Españolas* (Mainz: Schott, 1963), 5.

Rodrigo's "Fandango" is a technical challenge for most guitarists, and extended tension may be worsened by poor technical decisions. In the two measures in Figures 5 and 6, tension in the left hand will be entirely at a high level since this passage is played in a range where string tension is at its highest. However, by favoring the stronger first and second fingers, the passage in Figure 6 will require a

smaller degree of tension compared to Figure 5, where the weaker fingers have a more active role.

Strategies for reducing right-hand tension include playing scales incorporating the thumb or ring finger rather than only alternating the index and middle fingers, and playing arpeggios using the thumb to eliminate or reduce the use of the ring finger. Figures 8 and 10 show how guitarists may incorporate these fingering choices in their playing as alternatives to conventional fingerings (See Figures 7 and 9).

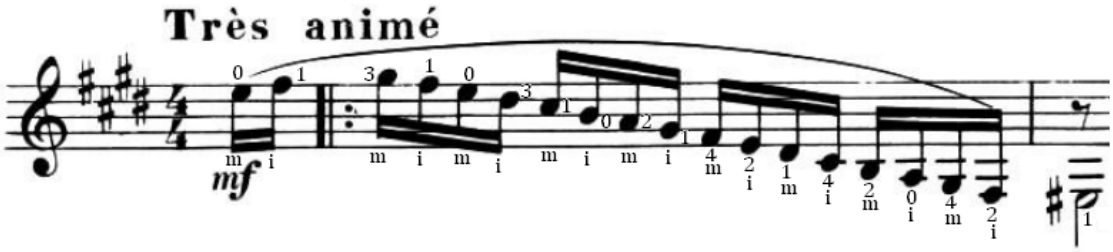

Figure 7. Fragment of Heitor Villa-Lobos' Etude n° 7 with a conventional right hand fingering.
Source: Heitor Villa-Lobos, *Douze Études Pour Guitare* (n.p.: Éditions Max Eschig, 1953), 16.

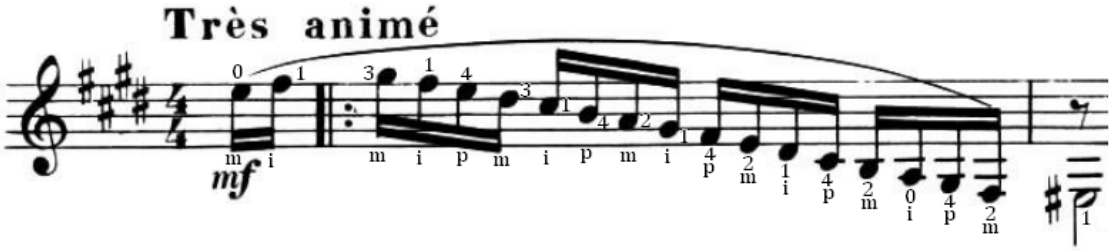

Figure 8. Fragment of Heitor Villa-Lobos' Etude n° 7 with an alternative right hand fingering.
Source: Heitor Villa-Lobos, *Douze Études Pour Guitare* (n.p.: Éditions Max Eschig, 1953), 16.

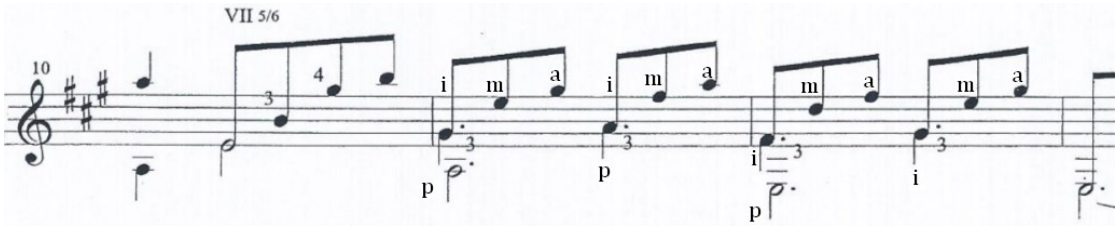

Figure 9. Fragment of Antonio Lauro's *Pasaje Aragüeño* with a conventional right hand fingering.
Source: Antonio Lauro, *Pasaje Aragüeño* (n.p.: Caroni Music, 2005), 11.

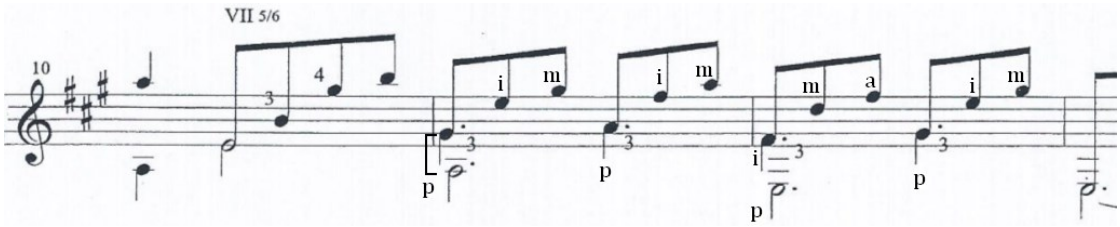

Figure 10. Fragment of Antonio Lauro's *Pasaje Aragüeño* with an alternative right hand fingering.
Source: Antonio Lauro, *Pasaje Aragüeño* (n.p.: Caroni Music, 2005), 11.

Scales played alternating right hand fingers i and m, and arpeggios using i, m and a fingers may cause fatigue. While the use of the alternative finger patterns in Figures 8 and 10 may alter the timbre of the passages or require extra dexterity to maintain a uniform sound, the excerpts show that using carefully planned alternative fingerings can be an effective way to save energy and reduce tension, particularly in fast passages.

Mitchel states that the "joints function most efficiently in the mid-range of their potential range of motion." [142] This is also where they should be when relaxed.[143] She states that the further from the midpoint the joint is moved, the more easily it will

[142] Mitchell.

[143] Ibid.

tire and the weaker it will be. [144] Therefore, the fingers should stay "gently curved" as often as possible, even when they are not playing, as this is their midpoint.[145] This concept can also be applied to the other joints of the body. For example, Mitchel tells us that the optimal position for the wrist is "straight and level."[146]

Guitarists often neglect this optimal wrist position. Baste-Gray points out that excessive flexion in the left or right wrist is a common issue, which overstretches the extensor tendons at the back of the hands and changes "the dimensions of the 'tunnel' at the wrist,"[147] increasing the chances of injury. Fjellman-Wiklund and Chesky, state that clinical practice shows that hyper-flexed wrist positions are largely what generates musculoskeletal disorders in musicians, and that "playing with a neutral wrist position generates fewer problems."[148]

According to Rueda, besides "ensuring joint stability, midline joint positions allow muscles to work at their repose length."[149] "Because all movements are based on coordinated agonist-antagonist action," Rueda explains, "maintaining an extreme joint position may facilitate the action of some muscles but it seriously thwarts all antagonist movement."[150] In order to understand the concept of a neutral position for the arms and wrists, Muldowney proposes that the musician should let his arms fall

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[144] Ibid.

[145] Ibid.

[146] Ibid.

[147] Bastepe-Gray, 25.

[148] Fjellman-Wiklund and Chesky, 173-4.

[149] Rueda, 51.

[150] Ibid.

loosely at the sides.[151] According to the author, this position will make the player see that even with gravity pulling the arms down from the weight of the hands and forearms, the elbows are "still ever so-slightly bent," and that wrists and forearms "naturally hang in a slightly pronated position," that is, "rotated towards the body or towards a palm down position."[152] Muldowney concludes then that "the optimal arm position at the elbow includes a range of slightly bent postures, with the wrist and forearm slightly pronated."[153]

Though extreme joint positions often lead to muscle strain and tendonitis,[154] Mitchel reminds us that even though the musician should look for the mid-range position of their joints, it does not mean that wrists and fingers should be held at these positions during the entire playing time. Instead, "joint movement should be flexible and fluid within the midrange of motion."[155] Muldowney believes that fluid and flexible movements help prevent injuries based on the fact that one of the leading causes of repetitive strain injuries and overuse syndromes is "holding a rigid or static posture."[156]

Discussing forearm motion, Mitchel points out that their rotation can "add power" to many playing gestures.[157] In the case of string instruments, forearm

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[151] Muldowney, 31.

[152] Ibid.

[153] Ibid.

[154] Rueda, 51.

[155] Mitchell.

[156] Muldowney, 32.

[157] Mitchell.

rotations make it possible for the fingers "to fall where they are needed."[158] Mitchel emphasizes that the forearm muscles must remain relaxed when forearm rotation is used to "relieve the fingers from awkward positions and unnecessary muscular motion."[159] However, forearm rotation should be used wisely. The author warns that too much forearm rotation can be counterproductive. When "the forearm muscles are tensed in a rotated position, the space between the two bones can become restricted and cause friction in the tendons and connective tissues."[160] Muldowney explains that our forearm muscles "are optimally relaxed when our palms are facing each other," and that "the farther away they are from this position, the more isometric contraction" is needed in the muscles responsible for either supination or pronation of the hands.[161] With that in mind, Muldowney says that playing with the fretboard positioned at angles "lower than forty-five degrees with the horizontal plane," and "keeping the left hand in scalar position all the time," with "fingertips aligned with one string" (the standard position taught by most teachers today), may result in "increased sustained supination of the left hand."[162] As for the right hand, the author says that excessive rotation towards the thumb "may result in increased sustained pronation."[163]

Our attention on musicians' technique is usually focused on the hands and fingers. However, guitar technique depends on the engagement of the larger muscles to offer proper support for the motions of the hand and fingers. Bastepe-Gray says that

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[158] Ibid.

[159] Ibid.

[160] Ibid.

[161] Bastepe-Gray, 25.

[162] Ibid.

[163] Ibid.

the musician's trunk and shoulders need to support the forearms and hands so they can achieve their optimal functionality.[164] Decreased engagement of the large muscles due to poor biomechanical habits, or due to lack of strength or flexibility, may cause the muscles in the arm and forearm to overcompensate with unnecessary tension.[165] It is important, then, to pay attention to how the entire body is used to identify the possible cause for an injury to the arms and hands.

Certain injuries are caused by specific movements from one side of the body, causing the incidence of the specific injury to be significantly higher in one side. Specific unilateral problems are isolated in the following subsections for a more in-depth analysis.

4.3.1 Issues and Injuries of the Left Arm, Hand and Wrist

Authors acknowledge that tension may occur in the left hand of guitarists due to holding a chord too tightly, placing too much pressure on the thumb, flexing the wrist too much, or fretting bar chords. Most of these situations can be addressed by simple improvements in technique. Hogg suggests that in order to solve the problem of gripping the neck too tightly, the guitarist should use a lighter touch with just enough pressure to keep notes "free of fret buzz."[166] Rueda, addressing the tension caused by bar chords, suggests smart practicing and limiting practicing sessions of

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[164] Ibid.

[165] Ibid.

[166] Hogg, Here's How: Play Without Pain, 37.

these chords to avoid stress in the arm, hand, and wrist.[167] However, some tension issues in the left hand may require more complex technical approaches that will be discussed later in this section. The guitarist should not be reluctant to apply such technical changes. They must remember that if not addressed, faulty technique may lead to a series of injuries in the left hand, wrist and arm.

Neuropathy of the ulnar nerve (ulnaropathy) in the cubital tunnel at the elbow, is an injury with surprisingly high incidence in musicians. According to Rietveld, ulnaropathy represents up to 9% of all musicians' injuries, and is caused by the intense use of the ulnar nerve during music making as it innervates almost all intrinsic hand muscles.[168] The author points out that significant flexion of the elbow over extended periods of time stretches the ulnar nerve in the cubital tunnel increasing the risk of this injury, while "local pressure by the sound-box" on the ulnar nerve may also be a contributor.[169] It is possible to conclude that guitarists are at particularly high risk considering that their left elbow is often in constant flexion at acute angles, while the guitar sound-box may also add pressure on this nerve in the right arm.[170] When treating ulnaropathy, Rietveld states that "a splint is provided to reduce flexion of the elbow during the night and, if possible, elbow-flexion should be diminished during music making."[171] To prevent this injury, Rueda suggests that the guitarist "check the position of the guitar and its neck" in relation to the left arm, "making sure that the

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[167] Rueda, 58.

[168] Rietveld, 432.

[169] Ibid.

[170] Ibid.

[171] Ibid., 433.

elbow is not bent too far."[172] The guitarist should find a way to position the body and the angle of inclination of the neck of the guitar that optimizes and reduces flexion in the left elbow. He should also avoid extra-musical activities that utilize elbow flexion to avoid overloading this nerve.

Besides ulnaropathy, the left arm positioning used in guitar playing may also cause supinator syndrome. This syndrome may occur when the left arm used in maximal supination for extended periods causing an "entrapment of the deep motor branch (ramus profundus) of the radial nerve in the supinator muscle ('arcade of Frohse')" (See Figure 11).[173] According to Rietveld the treatment for supinator syndrome revolves around "explanation, specific stretching, and support of supination in daily activities."[174] This injury is also common in violinists and violists due to the same supinated approach to the neck of the instrument.[175] Paying attention to overall practicing load, resting, and monitoring of other daily activities seem to be the best choice for prevention.

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[172] Rueda, 76.

[173] Rietveld, 433.

[174] Ibid.

[175] Ibid.

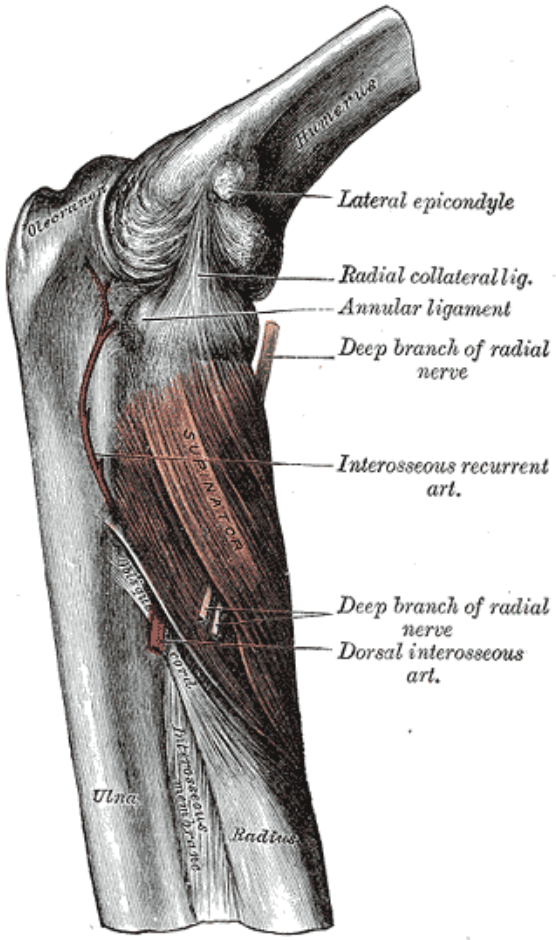

Figure 11. Deep branch of radial nerve.
Source: Henry Gray, "Deep Branch of Radial Nerve," Wikimedia Commons, accessed May 17, 2016, https://commons.wikimedia.org/wiki/File:Gray420.png.

Digital neuritis is the result of an entrapment of the collateral finger nerve. It often occurs in the left hand of guitarists because of bar chords. Rueda explains that when "excess pressure is put on the side of the left index finger" when performing bar chords, it "can have an impact on the small nerves in the finger and disrupt sensation."[176]

Besides nerve injuries, bar chords may also cause joint and muscular injuries. Rueda states that capsulitis of the trapeziometacarpal thumb joint, an inflammation on

[176] Rueda, 76.

the joint capsule, is a common joint condition in guitarists. It can be caused by "pushing too hard against the neck of the guitar."[177] She explains that when a joint is subject to excess or repetitive pressure, it may react by producing more synovial fluid in order to absorb impact. This will cause the joint to swell, triggering pain and limiting movement.[178] Rueda states that the muscles at the base of the thumb are prone to overload "when [bars] and strained positions are performed with the left hand," and that "these muscles may feel stiff and painful to touch, especially after a hard day's practice."[179] Though reducing excessive pressure during performance should help reduce the risk of these injuries, we should keep in mind Rueda's advice to limit the practice of bar chords to "a few minutes a day."[180]

Muldowney expresses concern over the improper left-hand thumb technique used by many guitarists. The author states that correct positioning of the thumb is not only one of the most important factors in maintaining a healthy hand, but is also a crucial factor in the correct positioning of the wrist.[181] Muldowney argues that the wrist position is "dependent on how the thumb is placed behind the neck."[182] The author states, "If the thumb is placed lower, it moves the wrist out. If the position of the thumb is inconsistent, the wrist will rock back and forth."[183] These positions stress muscles and compress nerves and should therefore be avoided. On bar chords, extra

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[177] Ibid., 74.

[178] Ibid.

[179] Ibid., 70.

[180] Ibid., 58.

[181] Muldowney, 31.

[182] Ibid.

[183] Ibid.

attention should be given to the left-hand thumb. According to Muldownney, it should be placed "lower behind the neck" in order to allow the first finger to "straighten itself," then released, allowing it to return to a more balanced position after the bar is completed.[184]

Among the common injuries of the left hand, Rueda includes "the long flexor muscles of the fingers," found in "the front side of the forearm."[185] The author explains that when the flexors forcefully contract to overcome the resistance of the strings, particularly with excess wrist flexion, their action can be obstructed.[186] However, she says that many times, just being aware of this may be "enough to avoid strained positions." Rueda also acknowledges that sometimes these positions are inevitable.[187]

Acknowledging the issues with the positions of the left wrist, Muldowney advises that its optimal position includes only a "slight bend in the wrist, with the knuckles far enough forward to maintain a comfortable curvature of the fingers, while still allowing [the guitarist] to use the tips of the fingers to fret the strings."[188] Muldowney warns that this should be performed without rocking the wrist. Shifts should be done by moving the arm so that the disposition of the wrist and fingers can remain more-or-less constant while playing.[189] The position of the thumb should also be taken into consideration to maintain this wrist position. If the thumb is placed too

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[184] Ibid.

[185] Rueda, 70.

[186] Ibid.

[187] Ibid.

[188] Muldowney, 31.

[189] Ibid.

low on the neck, the wrist may end up flexed in an undesirable position; if too high on the neck, strain can result from supinating the wrist. [190] If the left-hand thumb is left behind on hand shifts, the thumb will not be counterbalancing the strength applied by the other fingers;[191] therefore, excessive strength is required by finger muscles to fret the strings.[192] Because these positions may result in unnecessary stress on hand,[193] the thumb should stay in an optimal position to be able to counterbalance the strength applied by the other fingers, generally staying in the midpoint between the fretting fingers and following the hand shifts to maintain this position.

As excessive tension is the root of most of the problems mentioned in the left hand, the guitarist should incorporate in their technique one factor that is ignored by most authors, which is gravity. If the guitar is slightly inclined towards the chest in the horizontal axis, the weight of the left arm hanging on the guitar will pull down the hand at an angle to provide some extra strength without adding tension in the muscles. See Figures 12 and 13 comparing the strength vectors when the guitar is positioned in a vertical position versus inclined towards the chest:

[190] Ibid.

[191] Ibid.

[192] Ibid.

[193] Buckley and Manchester, 84.

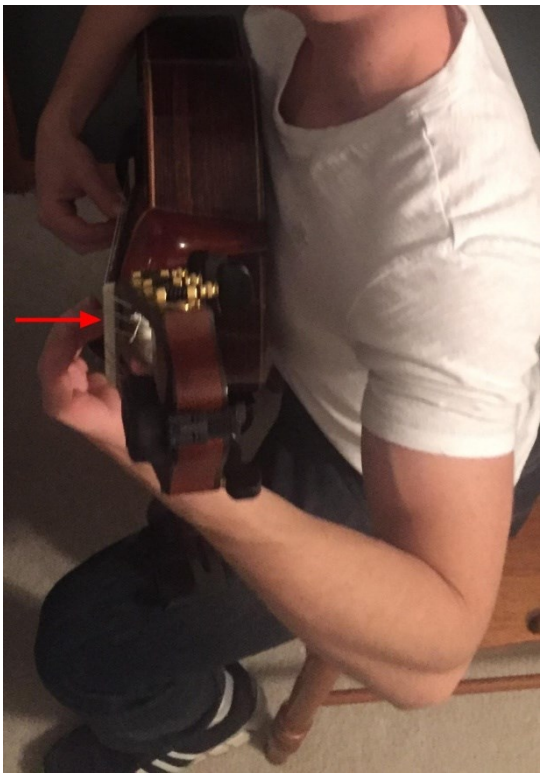

Figure 12. Guitar standing in a vertical position.

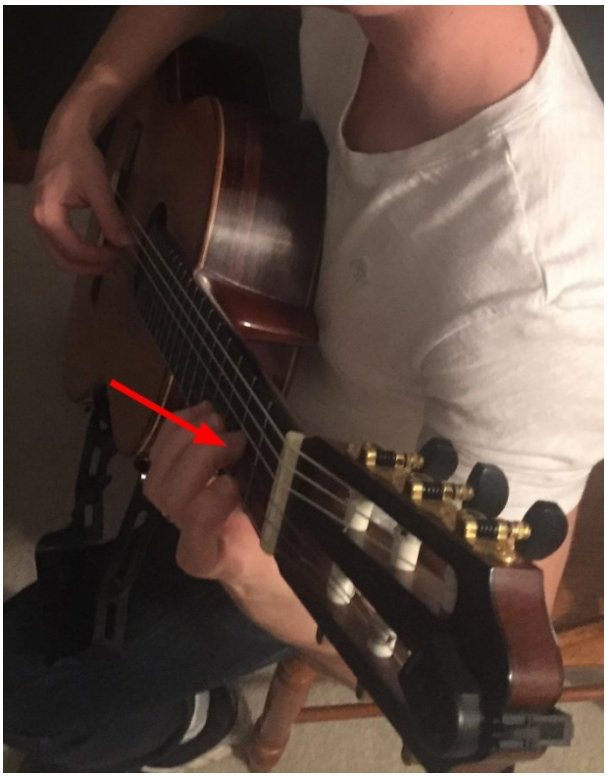

Figure 13. Guitar inclined towards the guitarist’s chest.

In Figure 10, the guitarist has to primarily use his own strength to fret the string, squeezing the string between the finger and thumb. In Figure 11, the guitarist hangs his arm on the neck with a natural grip, allowing gravity to pull his arm down and transfer the weight of his arm to his hand. Using the weight of the arm helps prevent fatigue and overload of hand muscles, allowing the musician to play in a more relaxed manner and reduces the chance of injury. Mitchel supports this concept recommending that musicians position their arms and hands in such a way to use the weight of a body part, or the strength of the larger muscles of the arms and shoulders to reduce the effort required by the small finger muscles.[194]

4.3.2 Issues and Injuries of the Right Arm, Hand and Wrist

The right arm, hand and wrist are also at risk for their own set of potential injuries, often originating from a faulty playing technique with too much wrist deviation.

Bastepe-Gray reminds us that the pulley mechanism in the forearms works more efficiently if the muscles and tendons are properly aligned, and that playing with ulnar or radial deviation of the right hand wrist "may lead to excessive wear and tear in tendinous structures."[195] According to Rueda, ulnar deviation in the right hand is in fact "the forerunner to much tendonitis."[196] The cause of these problems is that wrist deviation may narrow the canals though which the nerves pass to reach the hands.

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[194] Mitchell.

[195] Bastepe-Gray, 25.

[196] Rueda, 56.

Guitarists with improper technique often flex or extend their wrists too far, compressing these tunnels even more.[197]

Playing with ulnar deviation may lead to a type of tenosynovitis known as De Quervain's syndrome. Rueda explains that "the long abductor tendons and short extensor thumb tendon slide through the same tunnel formed by the edge of the radius near the base of the thumb," and as they leave this tunnel, the tendons bend, "forming an angle that may exceed 90˚ in certain thumb separation movements."[198] Repeatedly making extension movements with the wrist held in ulnar deviation may trigger the syndrome by causing friction between the tendon, sheath and bone, leading to swelling and causing pain in the region.[199]

Marques et al.'s study with flamenco and classical guitarists found that flamenco technique required the guitarist to use the wrist in a more flexed position. This position was pointed out as being one of the reasons why the flamenco guitarists had a higher incidence of injuries than the classical guitarists.[200] According to the authors, the sitting position of the flamenco guitarists with the guitar placed on the right leg causes them to over flex the right wrist resulting in the thumb playing in an "almost exactly perpendicularly" position to the strings.[201] This position limits muscle freedom and increase tension in the region.[202] Their predominant playing technique, the *apoyo* (rest stroke), is also highlighted as one of the causes of excessive tension in

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[197] Bastepe-Gray, 25.

[198] Rueda, 72.

[199] Ibid.

[200] Marques et al., 13.

[201] Ibid.

[202] Ibid.

the right hand. In the rest stroke technique, once a note is played, the finger remains pressed on the upper string, requiring "flexion and extension of the proximal phalanges of the three middle fingers."[203] Though classical technique uses mostly "incomplete flexion of the middle phalanges of the same fingers,"[204] the flamenco technique is sometimes used by classical guitarists to emulate the flamenco sound or to play with more volume. Using this technique should be approached with caution to avoid tensing the hand for extended periods of time.

Different authors have addressed the issues of deviations in the right hand. Muldowney states that the optimal position for this hand is achieved with a "slightly bent-forward wrist position" with at least some degree of pronation.[205] The author states this should not be a static position. However, "unnecessary rocking of the wrist joint left-and-right or up-and-down can stress the tendons and undermine the development of a relaxed posture," and should therefore be avoided.[206] Rueda goes further, advising guitarists to position their right wrists with no more than 15 to 20º of radial or ulnar deviation, as this position allows the tendons to "glide through their sheaths with as little friction as possible."[207] She also recommends that wrist flexion and extension should not exceed 15-20º. According to Rueda, wrist flexion often leads to muscle strain, compressive syndromes, and other injuries. Keeping the wrists within this degree of flexion-extension "enhances muscle efficacy" and creates a "favorable

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[203] Ibid.

[204] Ibid.

[205] Muldowney, 31.

[206] Ibid.

[207] Rueda, 52.

angle of attack that facilitates the posterior action of the [finger] extensors as well as [optimal thumb] action."[208]

A factor often ignored by authors that helps achieve a neutral right hand position is the rotation of the guitar in the horizontal axis. If the guitar is inclined towards the guitarist's chest, it will be angled in a way that the musician will not have to arch the wrist as much to reach the strings (See Figure 14). If the guitar is positioned vertically, the guitarist has to arch the wrist to reach the strings (See Figure 15).

Figure 14. Wrist gently curved to reach the strings.

Figure 15. Wrist is arched to reach the strings.

[208] Ibid.

Besides helping to keep the wrist flat, having the guitar leaning towards the chest creates more stability for the instrument without having to use the arm as a stabilizing force (See Figure 16). If the instrument is positioned, it can bounce to either side, requiring the right arm to hold it in place (See Figure 17). The inclined position also creates resistance against the weight of the forearm requiring less strength from the forearm to hold a playing position. Finally, the inclined position also allows the right hand to use the weight of the forearm as an extra strength to strike the strings without increased muscle tension. In the vertical position, the guitarist must use only his own forearm strength to hold the hand in playing position and hand strength to strike the strings.

Figure 16. No extra forces required to hold the instrument.

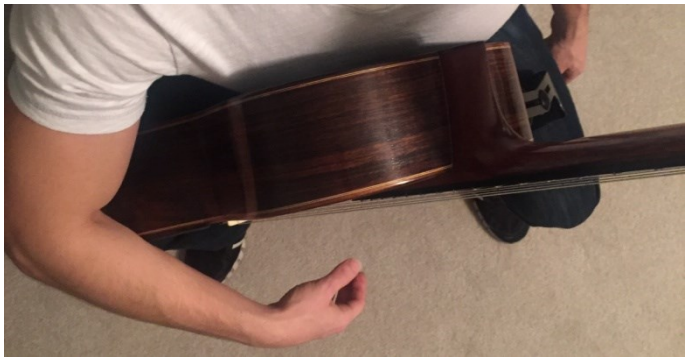

Figure 17. Right arm must be used to hold the instrument.

The ideas provided in this chapter are only suggestions based on the literature available on injury prevention. By no means are they the only and definitive solutions to injury prevention in guitarists. There are still many questions to answer on how guitar technique should be adapted to prevent injuries. New research in the field of performing arts medicine will help us make informed decisions as guitar technique continues to evolve.

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VITA

Bráulio Bosi was born on Novermber 4, 1987 in Colatina, Espírito Santo (Brazil). He studied Music Education at the Federal University of Espírito Santo (Brazil) where he received his Bachelor Degree in 2010. During those years of study, he was awarded in multiple instrumental competitions in Brazil.

Mr. Bosi moved to the United States of America in 2010 to continue his guitar studies. He was awarded a talent based scholarship at Oklahoma City University and graduated with high honors in May 2012. During that year Bráulio Bosi was invited and joined Pi Kappa Lambda National Music Honor society.

In 2013 Mr. Bosi was offered multiple scholarships to attend the University of Missouri-Kansas City. He began working on his DMA on Fall of 2013. During his program, he became an International Student Ambassador at this institution and accepted an invitation to join Omicron Delta Kappa, a national leadership honor society for his academic achievements and community work. Upon completion on his degree requirements, Bráulio Bosi plans to continue developing his teaching, performing and researching career.