INJURY PREVENTION BY MEANS OF
HEALTHY CELLO PEDAGOGY

by

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Playing-related injuries among both amateur and professional cellists are extremely common. These injuries are generally caused by overuse or misuse of the body while playing, and many times become severe enough that the cellist needs to either stop playing or alter their playing technique in order to be able to continue. Although most overuse and playing-related injuries in cellists are preventable through healthy pedagogy and mindful instrument practice, many music teachers are completely unaware that deficits in their teaching may lead to an injury in their student in the future. This thesis is an exploration of the most common injuries related to posture and sitting position, left side technique, and right side technique in cellists, in addition to effective ways to prevent the most common music performance-related injuries.
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Injuries among both career and amateur musicians are extremely common. A recent study by leading musicians’ health specialists Alice G. Brandfonbrener and Kristen R. Burkholder estimated that between 60 and 90 percent of musicians develop an injury related to their playing that forces them to either stop playing completely or drastically change aspects of their technique in order to continue playing. The study also states that 76 percent of orchestral musicians have reported a serious injury related to music performance.\(^1\) Other research has shown that the majority of career musicians who experience a performance-related injury struggle to take measures to address the issue, as taking a break from their instrument to heal would likely cause them to lose pay, technical skill, or both.\(^2\) This information, combined with additional studies on injury prevention in musicians, suggests the most effective way for musicians to avoid injury is through prevention training beginning as soon as the student starts learning an instrument.\(^3\) Musicians’ injuries have only recently begun to be taken more seriously in the medical world as musicians are being recognized more and more as a specific type of


athlete whose careers are physically and mentally demanding.⁴ Studies have also shown that playing-related injury in musicians is very often correlated with poor technique, improper instrument sizing, and an imbalance in body nutrition or muscular conditioning.⁵ In many of these cases, overuse and playing-related injuries in musicians could have been prevented via pedagogy that was more inclusive of aspects like mindful body use, balance, correct body mapping, and preventative strategies such as a balance of rest and physical activity, dynamic stretching, and warming up the body properly. Research supports claims that musicians of all ages and levels who employed such strategies or who were taught injury prevention experienced significantly less playing-related pain and discomfort, enjoyed more physical freedom while playing, and experienced “beneficial effects far into [the] future” of their musicianship.⁶

Although most overuse and playing-related injuries in musicians are preventable through healthy pedagogy and mindful instrument practice, many music teachers are unaware that deficits in their teaching may lead to an injury in their student in the future. Additionally, some music students may not even know they should not be experiencing pain or discomfort when they play, and their private teacher may not realize a student’s pain or injury came as a result of incomplete technique. Private teachers may not worry about their students experiencing minor pain or strain because they believe their young students are resilient, or that a little pain or discomfort will not become something serious. Additionally, a common belief among amateur musicians is that only musicians playing at a very advanced level are susceptible to injury—but research shows that although children usually heal at a faster rate than adults they are not any

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⁶ Ibid., 122.
more resilient to injury that is a result of overuse or misuse. Research also shows that injuries can occur at all ages and levels of musicianship.\(^7\)

Every type of musician is at risk for injury, but this thesis focuses specifically on the performance-related injuries that are most common among cellists, in addition to ways in which teachers can encourage healthy technique in their students. There is a broad range of injuries experienced by musicians of all kinds, but this thesis will focus on the injuries that are most commonly related to sitting posture, left side technique, and right side technique of cellists. It does not, for instance, study injuries as specific as deQuervain’s tendonitis, but generally addresses the broader categories under which injuries such as this fall. Rather than including an exploration of every possible injury that could occur in the left side, right side, or relating to sitting position, the most common injuries in each of those categories are discussed in addition to effective ways to prevent the most common music performance-related injuries. Injuries most common in each of these areas are determined by literary analysis of the sources listed as references for this thesis, as are the prevention methods and pedagogical techniques discussed.

Each subsequent chapter of this document addresses aspects of cello technique and injury prevention relating to posture and sitting position, left side of the body, and right side of the body. Chapter Two of this thesis addresses topics related to posture and sitting position, namely: proper chair height, hip angle, and foot placement, followed by an exploration of common posture-related ailments and their preventative pedagogy with regard to cello playing. Chapter Three is dedicated to understanding healthy playing technique and injury prevention in the left side of the body, and includes pedagogical explanations of elements of playing technique in

\(^7\) Ibid., 119.
addition to common injuries related to some of these techniques. Chapter Four follows the pattern of Chapter Three, this time exploring the use of the right side in cello-playing technique and detailing risk factors for injury. In each chapter, the sections detailing aspects of playing position and technique cover only the most foundational principles of the technique, and are based on both personal experience of the author and reputable books and articles written on cello pedagogy. The sections explaining risk factors, potential injuries, and prevention relating to incomplete technique are divided by body part, although many of these injuries can inhabit multiple body parts. Every cellist has slightly different proportions, so exercises to help individuals explore variations of technique and sitting position that are most comfortable for them are included when applicable.

This thesis is intended to be a basic and concise pedagogical resource for the use of the author and for other cello instructors wishing to learn how to supplement teaching strategies in order to prevent the most common injuries in cellists relating to the three previously mentioned categories. The pedagogy cited in this thesis was written with the assumption that those reading already possess a sound understanding of cello or string-playing technique. Although there are pedagogical exercises and strategies detailed in this document, this thesis is not based on any one specific style of string pedagogy (i.e. Suzuki, Havas, Rolland, or others) and does not include research involving the psychology of music learning or performance psychology. This thesis does not discuss injuries that are accident or trauma-related, implications of the mental and emotional strain of musicianship, practice methods unrelated to playing technique and posture, or music performance-related injuries involving sight, hearing, or tension of the muscles in the face and jaw. It also does not suggest or endorse the use of any specific medications during the
process of injury recovery. This document was not written by a medical professional, although it includes research by some medical professionals. Any music teacher or student reading this who is experiencing a playing-related injury or an injury affecting their playing is encouraged to seek professional medical advice for diagnosis and injury recovery. The information in this thesis is based solely upon findings gathered in the sources cited, which include: personal interviews with professional musician-pedagogues and books, journal articles, and peer reviewed studies whose authors range from professional musicians to medical doctors.
CHAPTER TWO - POSTURE AND SITTING POSITION

Chapter Introduction

Studies show that simple preventative strategies can provide musicians with the tools needed to avoid playing-related pain and injury, thereby increasing playing longevity and more of a sense of fulfillment. Researchers who study musicians’ health have found evidence which shows, “behavioral, environmental, and educational risk factors are manageable, and, consequently, musicians’ injuries are preventable.”

This chapter covers the most common injuries cellists experience related to poor posture and simple pedagogical ways in which cello teachers can encourage healthy posture in their students, thereby preventing such injuries. The primary elements of cello-playing posture covered in this chapter include basic elements of sitting position, spine alignment, and head/neck position.

Before delving into specific cello posture and setup, it is important to recognize that a cellist’s ability to avoid common posture-related pain or injury will largely depend on their level of body awareness and whether they have correct ideas about how their joints work and how their body parts naturally interact. The pedagogical strategies detailed in this and subsequent chapters in this document are based upon the goal of helping students develop such body awareness and understanding of how their body moves naturally. They will provide each individual with the ability to be able to recognize the early signs of injury in themselves, learn specific muscle groups to use and those to avoid overusing, and know when to adjust their

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technique accordingly. These skills will serve them throughout their musical lives whether they become career musicians or pursue playing only as a hobby. (Those wishing to further increase their level of body awareness beyond what is discussed here could consider studying somatic practices such as the Alexander Technique or Feldenkrais Method, increasing their physical activity, or the study of anatomy and kinesiology.)

These strategies are not fool-proof, nor do they claim to be one-hundred percent effective. Each cellist has slightly different proportions and physical features that will affect their approach to playing. As a result, a sensitive partnership between student and teacher will be essential as they work together to find the best way for that particular student to approach playing the cello. As teacher and student work together, they would do well to remember the following before attempting to change anything regarding playing posture or setup:

1. Learning to play the cello with healthy technique is a continual process of self-discovery, requiring patience and creativity on the part of both student and teacher. For example, this could mean utilizing mirrors in teaching and practice, with both sides being very communicative about how certain aspects of posture and technique feel and look.

2. Except in the case of rare chronic disease or similar conditions, pain is always an indicator that something needs to change or stop.

3. Something feeling “strange” is not always a bad sign. Teachers can help students understand that as they learn something new, they may think that movement is unnatural

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9 Ibid., 86.
10 Sazer, New Directions, 2003, XIII.
simply because it is different or they need to build muscle before it becomes comfortable. If strain or pain persist, the change should be re-evaluated.

4. If a change in physical approach causes static tension, restricts breathing, or prevents free movement, try to find another solution. Similarly, if a change in physical approach improves breathing/mobility and releases tension, it is likely the right solution.

5. Pain and strain does not always mean something is wrong technically, but rather that the individual is simply doing too much of something and needs rest.\textsuperscript{11} Body use adds up outside of just instrument-playing, so cellists should be open to considering that perhaps strain may indicate cumulative overuse in their general activities.

\textbf{Sitting Position: Chair Height, Hip Angle, and Foot Placement}

The way cellists set up their instruments will critically impact their ability to develop healthy sitting posture. Aspects like chair height, hip angle, and foot placement when sitting will all directly affect each player’s ability to achieve and maintain proper alignment, which will be their primary defense against posture-related injuries.

\textit{Chair Height}

Appropriate chair height will vary depending on the individual body proportions of each cellist. As Victor Sazer so eloquently points out, “no sitting strategy will help you if your chair is

too high or too low."

Most cellists and researchers agree that the healthiest sitting position for cellists will have the knees at least 1-3 inches below the level of the hip joint.\(^{12}\) In general, shorter-than-average cellists will need a shorter chair, and the opposite is true with taller-than-average cellists. If the cellist is unable to choose their chair height, shorter cellists should sit far enough forward on the chair that their thighs are not resting on the seat - this will prevent the restriction of circulation in the legs. Very tall cellists could use an extra cushion to increase chair height, place cello blocks under the legs of the chair, or stack two chairs in order to achieve their desired chair height. As always, cellists and teachers should work together to find the most comfortable sitting position for each individual. Chair height will need to increase as the student grows, and students of similar heights may require different chair heights if they have different proportions.

\textit{Hip Angle}

This aspect of cello setup is often overlooked but can seriously impact musician health. Recent research has determined that the body “was not designed to sit with the hips and knees bent at a 90 degree angle.”\(^{15}\) Sazer points out in his book that attempting to sit at a 90 degree angle forces the sit bones “to tilt 30 degrees instead of pointing downward. This reverses your lumbar curve, flattens your diaphragm and collapses your chest, which limits full breathing.” Further, he explains this causes one’s center of gravity to be “shifted behind your sitting bones in this position and ‘considerable muscular force’ is needed to sit upright.”\(^{16}\) Over time, this causes

\(^{13}\) Ibid., 61.
\(^{15}\) Sazer, \textit{New Directions}, 2003, 56.
\(^{16}\) Ibid., 57.
fatigue, strain, and injury, in addition to preventing proper back and neck alignment. Cellists should aim for a hip angle range of closer to 60-75 degrees to enable alignment and freedom of movement. At this angle, the sit bones will be fully facing the seat and the lumbar curve will remain intact. Still, many chairs are not equipped for proper sitting posture. If this is the case, cellists could consider using a wedge-shaped pillow to help guide the angle of the hips forward into proper alignment, or, if possible, select a chair made specifically for this sitting position. Cellists should avoid chairs sloping backward at all costs, as this will drastically increase their chances of developing injury.\(^\text{17}\)

**Foot Placement**

There is a broad range of opinions regarding foot placement in modern cello pedagogy. The goal of any style of pedagogy regarding sitting position is to most directly serve the cellist’s ability to play comfortably and musically, and most cello pedagogues agree that the feet should be able to “support all of the body’s movements,”\(^\text{18}\) regardless of differing opinions on what that may mean specifically. The following exercise and subsequent reflection questions from *New Directions in Cello Playing* will help each cellist determine which foot position will help them feel the most supported:

1. Sit tall on the front edge of your chair [without your cello] and place your feet:
   - behind your knees
   - straight down from your knees
   - various distances in front of your knees;
2. Test each position by moving your trunk forward and backward [at the hips]. Find the position which feels most comfortable and stable;
3. Repeat step 1.; and
4. Raise and lower your arms repeatedly to find the foot placement that makes your

\(^{17}\) Ibid., 62.

\(^{18}\) Ibid., 56.
arms feel the lightest. Which foot placement provides the greatest comfort and stability in Step 2? Which foot placement makes your arms feel lightest in Step 4? How does this differ from the way you usually place your feet?\textsuperscript{19}

\textbf{Common Ailments and Preventative Pedagogy}

\textit{Back/spine}

Poor posture directly affects the health of the back and spine. Most injuries, including back injuries, start with simple fatigue that escalates into pain. Unless the cellist adjusts their physical approach to playing, this symptom can develop into chronic back pain. If left unaddressed, it can grow worse until it turns permanently debilitating. In his book \textit{New Directions in Cello Playing}, Victor Sazer cautions, “cellists commonly injure their backs by using techniques which compress or twist the spine. This can rupture spinal discs and stress back muscles and tendons. Sitting positions which keep the body off balance are a major cause of back pain.”\textsuperscript{20} Injuries like disc herniation, pinched nerves (nerve entrapment), and sciatic pain are among the most serious cello-playing related back injuries, and “among musicians, cellists are known to have the highest frequency of back problems.”\textsuperscript{21} Cellists experiencing sciatic pain should be aware that a chair that is too high or sitting back too far on the chair could be causing or further aggravating their condition. Either of these variables will cause the chair to press on

\textsuperscript{19} Ibid., 64.  
\textsuperscript{20} Sazer, \textit{New Directions}, 2003, 12.  
\textsuperscript{21} Ibid., 2.
the back of the thigh which will compress the sciatic nerve. If this is the case, cellists should experiment with moving forward on their seat or finding a shorter chair.\textsuperscript{22}

Other than unnecessary twisting, maintaining unnatural curvature in the spine over a long period of time most commonly causes disc issues and deterioration in the lower lumbar spine. Many musicians are told to “sit up straight” in order to avoid the tendency to slouch, but this can often cause them to force their backs to be too straight. A back that is too straight will not have its natural curve (specifically in the lower lumbar spine), thereby putting excessive pressure on certain spinal discs more than others and leading to injury. Ideally, cellists should be taught how to find proper spine alignment, which will preserve the natural curve in the lower spine without forcing a sitting position that is stiff or too straight. In her book \textit{Teaching Healthy Musicianship: The Music Educator’s Guide to Injury Prevention and Wellness}, Nancy Taylor suggests the following exercise to help young students begin to establish healthy sitting position:

1. Have your students stand up tall, and then tell them to act like a bunny with a big, fluffy tail.
2. Say, “Show off your big, fluffy tail.” Stick out your bottom to arch your back and wiggle your tail a little.
3. After they stop laughing hysterically, say, “Now, keep that fluffy tail up, and sit down in the chair. Don’t sit on your tail!”

Sitting up tall is a skill that takes muscle strength. Your students probably won’t be able to maintain this for more than a few minutes at first, so give them plenty of breaks and opportunities to reset their sitting posture.\textsuperscript{23}


\textsuperscript{23} Ibid., 52.
Students who are old enough to understand some basic anatomy could be shown a visual aid demonstrating the curve of the back in its natural and aligned position, and then be guided through a simple exploration to find their most freeing sitting position and alignment. Additionally, Victor Sazer suggests that a simple breath and movement test to accompany exploration of any postural change can help cellists determine healthy posture. The body works in such a way that any individual with normal anatomy will find the most freedom of movement and breath when they are at optimum alignment.\textsuperscript{24} Cellists could first experiment with the extremes of sitting - slouching and sitting too straight - testing the mobility of their arms and head and their freedom of breath in each position. With experimentation, knowledge that the back curves in slightly at the lower lumbar spine, and some guidance from a mirror or an experienced teacher, cellists can learn to find their optimal sitting alignment.

\textit{Head/neck}

Performance-related pain, strain, or injury in the head and neck is generally also caused by poor postural alignment. Although injuries in the neck and at the base of the head can often be painful and long-lasting, they are generally not as severe as playing-related spine injuries. Still, cellists with poor head alignment are at risk of chronic pain, tendonitis of the tendons in the neck, prolonged neck tension, muscle weakness, and headaches. If caught early, these symptoms will be temporary. If poor neck alignment is habitual, it may take weeks or months of physical therapy or other forms of medical care combined with correcting posture in order for musicians to fully recover. In addition, for every inch that the neck is out of alignment, an additional 10

\textsuperscript{24} Sazer, \textit{New Directions}, 2003, 59.
pounds of strain is added to the muscles and ligaments in the neck. This causes muscle tension, and neck tension often causes other spots of tension to crop up in the back, shoulders, and upper extremities.

Nancy Taylor instructs all musicians to think of aligning their ears over their shoulders in order to find proper spine head/neck alignment. Musicians should do this frequently, whether sitting or standing, while keeping their eyes level. Musicians who struggle keeping their head aligned should remind themselves to do this every few minutes while they are getting accustomed to better posture. Additionally, she suggests that musicians

Feel the lump on your spine at the base of the neck - that’s your seventh cervical (neck) vertebra. It isn’t a joint at which one should bend… Instead, try to keep your head facing forward, and use your eyes to look down. Prolonged [poor neck] posture ... causes the back, shoulders, and neck muscles to lengthen and subsequently causes the chest muscles to shorten, resulting in forward head posture.

Many cellists duck their heads forward while playing. Sometimes this is caused by an endpin that is not long enough, thereby positioning the C peg in a place that prevents the head from aligning correctly (which can also be remedied with the use of a Posture Peg or bent endpin); sometimes cellists develop the habit of ducking their head forward when playing in thumb position; sometimes it is a result of poor seating or spine mis-alignment. Aligning the head by putting the ears over the shoulders—in addition to understanding that the seventh cervical vertebra is not meant to be a joint—will help individuals prevent playing-related injuries and provide a release

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27 Ibid., 3.
of common playing-related muscle tension. Further, keeping the back of the neck soft will help
retain this alignment and release tension throughout the neck and back. Cellists will feel that
proper head/neck alignment allows them greater freedom of movement. The head can (and
should) still move, but cellists who move the head from the base of the skull rather than
habitually from the base of the neck will be able to play more comfortably and avoid
playing-related pain or injury in the head and neck.
Chapter Introduction

Pablo Casals famously said, “The difficulty of playing the cello is knowing how to get from one note to the next.” For many cellists, this challenge is made more difficult by a lack of well-rounded instrument pedagogy. This deficit is a leading cause of physical misuse in musicians, which is a major contributor to music-related overuse injury. According to Rosenbaum et al., “Overuse syndrome is the most common affliction of instrumental musicians. This disorder represents the culmination of playing beyond the point of muscle fatigue and can present with pain, weakness, tingling, fatigue, stiffness and decreased dexterity.” Many musicians have not been taught to stop or take breaks when they feel pain or fatigue, how to effectively structure their practice, or how to balance the physical demands of their workload. The lack of these practice skills leads to the escalation of simple fatigue into strain and injury. He continues, “during both practice and performance, thousands of notes are played, mandating precision of force and timing of joint flexion, extension, and rotation. The most critical risk factor is constant repetition during hours of intense practice,” and that string players are the most regularly affected group when it comes to musicians suffering from overuse injuries. Dawson et al. supports these findings with a research study of upper-extremity overuse injury in

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28 Sazer, New Directions, 2003, 130.
31 Ibid., 1270.
approximately 1500 musicians spanning 15 years, finding that between 77.7 and 79.6% of a group of keyboardists and string players had experienced overuse-related conditions. These injuries were usually various forms of tendonitis, muscle strain, and nerve problems. Unfortunately, “even the slightest decline” in a musician’s ability to play their instrument has the potential to stall or end their career. Rosenbaum et al. suggests that “similar to the care of elite athletes, musculoskeletal care of a musician requires a thorough understanding of the extraordinary demands that these patients place on their upper extremities.” Although this quote is directed toward medical professionals treating musicians, music teachers (especially applied private teachers) have a responsibility to understand the implications of incomplete pedagogy—namely: the essential elements of healthy body use in instrument-playing; and common playing-related injuries and their causes. This chapter briefly covers the basic principles of healthy left-side use in cello playing, in addition to common playing-related ailments and ideas for their preventative pedagogy. (The author recognizes that there are many different schools of thought about these aspects of cello technique, but has based the information in this section on the pedagogical resources cited within this thesis and her personal training.)

Basic Principles of Healthy Left-Side Use

Although cello-playing requires the use of the entire hand-arm unit on both sides of the body, some playing techniques require motion to be centered around one or two particular joints

33 Ibid., 70.
at a time.\textsuperscript{35} The following section briefly addresses important technical aspects regarding left side
technique (each based on release of physical tension and natural body movement): the arm’s
approach to the cello, fingering, vibrato, shifting, thumb position, and three and four-note chords.

\textit{The Arm’s Approach to the Cello}

Every aspect of left-side technique in cello-playing requires a combination of movement
and activation of various muscle-groups. Larger muscle groups carry the hand and arm generally
where it needs to go, while smaller muscle groups perform the small, precise actions required.
Healthy left-side technique in cello playing starts with the arm’s approach to the cello itself.
Although there are various ideas about this approach, many contemporary cello pedagogues both
speak and write about an approach emphasizing natural and tension-free playing. Additionally,
the majority of professionals agree that the arm “carries your finger toward its destination,”\textsuperscript{36} and
that using as much as possible of the body’s natural arm weight will help reduce tension in cello
playing. In general, using larger muscle groups rather than an excess of “finger action” to help
the hand navigate around the instrument will help cellists develop healthy left-side technique. As
cellists move their arm, their fingers are “lifted by [their] arm and rotating forearm as [their]
finger drops to the string.”\textsuperscript{37} The muscles and tendons in the hand are quite weak, which is why
they can be easily overworked. The use of the body’s natural arm weight to drive motion and
momentum in the arm will help prevent this.

\textit{Fingering}

\textsuperscript{35} Sazer, \textit{New Directions}, 2003, 137.
\textsuperscript{36} Ibid., 136.
\textsuperscript{37} Ibid., 136.
Left-hand fingering in cello playing generally falls into two categories: fast fingering and slow fingering. In this section, fast fingering refers to very rapid left-hand fingering, and slow fingering addresses everything except very rapid left-hand fingering. Each type of fingering requires a slightly different approach, usually with more cellists struggling to master fast fingering than slow fingering. In all types of fingering, the left thumb should remain relaxed so that it grazes the back of the neck without squeezing. It is also important for teachers to note that there are no muscles at all in the fingers. Rather, “forearm muscles connected to the tendons in your fingers enable you to move your fingers. Your forearm, in turn, is supported and carried by your upper arm. Your fingers do not move alone, but as a part of the larger complex.”

Cellists who understand this simple anatomical fact will naturally play with less finger tension.

Fast playing requires a neutral hand and arm position and a relaxed thumb that rests gently on the back of the instrument’s neck: “for fast playing, you will be the most tension-free if your hand and forearm are in line–in a neutral position.” The fingers will also be slightly more rounded when playing fast than when playing slow. “This equalizes their size and allows for a lighter, more facile touch.” In his book New Directions in Cello Playing, Victor Sazer suggests the following exercise cellists may use to explore the technique of rapid left-hand fingering:

Step 1. Simulate fast playing on your right hand by holding as many fingers of your left hand down as you can;
Step 2. Simulate fast playing by tapping the fingers of your left hand downward against your right hand, one at a time;
Step 3. Simulate fast playing by wiggling your fingers in their freest path of motion. Allow your wrist to lift and your forearm to rotate as you move your fingers;
Step 4. Move your fingers as in step three but do no let your wrist or forearm move; and

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38 Ibid., 120.
39 Ibid., 137.
40 Ibid., 137.
Step 5. Simulate playing fast notes on the side of a string. Use a finger of your right hand as an imaginary string. Which steps are the most effortless? Which steps interfere with your breathing? Which steps allow you to breathe most freely?\textsuperscript{41}

When approaching slow fingering, cellists should take the time needed to assess their hand and arm balance. Slow fingering often “allows for sufficient time to adjust your arm and hand to the optimal alignment for each finger…. If your hand and arm are free, needed adjustments can occur naturally.”\textsuperscript{42} In the application of both fast and slow fingering, it is important to keep in mind the most natural way in which the arm can approach the neck of the cello. Evangeline Benedetti, long-time cellist of the New York Philharmonic and author of \textit{Cello, Bow, and You: Putting it All Together}, recommends the “hand leading the movement of the arm and the arm moving the hand.”\textsuperscript{43} As the hand leads the arm and the arm moves the hand in passages of music requiring slow to moderate fingering, cellists will find their left hand motion will feel much more easy and balanced. Cellists should also look for opportunities to make finger motion more efficient—for instance, keeping the fingers close to the string and releasing tension from fingers not in use will enable the left hand and fingers to move with ease and will require less effort. Since there are no muscles in the fingers but there are muscles at the base of the thumb, most finger tension can be released by relaxing the thumb and letting it gently graze the neck when fingering and shifting.

\textit{Shifting}

\textsuperscript{41} Ibid., 138-139.
\textsuperscript{42} Ibid., 137.
All shifts, unless a purposeful gliss or audible slide, should be a form of physical release in the hand and arm. On this topic, Sazer posits that “pressing a string down when you shift is like dragging your foot on the ground when you ride a bicycle.” Although this is sometimes done purposefully to create an audible effect, cellists should only shift audibly when the decision is artistically driven or marked in the score (i.e. glissando). Habitually keeping left arm weight in the string during a shift makes intonation less reliable in addition to preventing natural release of tension during the shift. Finding as many opportunities as possible to incorporate physical release when playing will encourage both fluidity of movement and good musculoskeletal health. Breathing from the diaphragm is a simple way to naturally cause release of tension in physical movement. “Like bowing, [shifts] are always lifted or pulled in response to your body’s impulses. They are never pushed.” Similar to other motions discussed in this chapter, shifting motions should be natural, rounded motions. Expanding upon that concept, Sazer describes the motion of a shift as being very similar to “throwing a ball.” He continues, “your upper arm is the first part of your arm/hand unit to move. It is followed by your forearm, hand and fingers, in that order—always shift from the heavier to the lighter part. This natural sequence occurs when shifting in either direction.” The momentum of the shift comes from the upper arm, with the rest of the hand and arm following through. Cellists struggling with tense or jerky shifts may find success in relating shifts to their breath and exhaling through the shift.

Vibrato

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45 Ibid., 150.
46 Ibid., 151.
While vibrato is often viewed as difficult and complex, it is built upon hand and arm movements that are quite simple. Although there are various types of vibrato that can be created by adjusting both the speed and width of the vibrato oscillation, the movement itself comes from a simple foundation that builds upon the previous principles of arm weight and arm motion. Rather than starting in the fingers, vibrato motion originates in the forearm and requires a tension-free hand and fingers. As Victor Sazer states, “when your whole arm is free, your vibrato can flow more evenly and easily from one note to the next.”

There are two bones in the forearm: the ulna and the radius. When the arm is in a neutral position (for instance, hanging at one’s side), these bones lie parallel to each other. When the forearm is fully rotated, these bones cross over each other, and the muscles and tendons surrounding the bones have less room to function, which could cause strain if full rotation happens frequently. “In everyday life, the action of turning a key is an example of the smaller radial rotation, while turning a large doorknob” is an example of full radial rotation. The arm motion required in vibrato does not necessitate full rotation. Rather than “turning a doorknob,” vibrato motion is similar to the “turning a key” motion described above. Opinions of cello pedagogues vary on whether there is any arm rotation and how much there should be. Regardless, full arm rotation (and therefore the crossing of the radius and the ulna) should be avoided. Cellists learning vibrato may find it useful to imagine shaking a can or a bottle back and forth; this exercise will help encourage the impetus-release that many cellists use in vibrato. As cellists strive to develop a vibrato that is relaxed and expressive, they will also find that developing an awareness of individual parts of the

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47 Ibid., 121.
48 Benedetti, Cello, Bow, and You, 2017, 143.
hand—especially areas such as the palm, base knuckles, and top of the hand—will aid in the cultivation of a healthy vibrato.

**Thumb Position**

In thumb position, the same sort of principles regarding the arm’s approach to the neck apply. Evangeline Benedetti suggests that in this position, “we employ the weight of the arm as the force to depress the string, not only for the thumb but also for the other fingers.” Since the arm is usually lower when playing in thumb position, “the physical direction of this force is into the cello, toward the player’s body.”

Still, many cellists resort to exerting muscular force in both big and small muscle groups in order to depress the string. Too much string tension or a bridge that is too high will contribute to a cellist feeling the need to use muscular force in order to depress the string. If these issues are alleviated, it is within every cellist’s reach to use only arm weight to get the string down to the fingerboard. Similar to fingerering on the neck of the cello, it is recommended for cellists to lead motions in thumb position with the arm. The hand and wrist should remain relaxed, with a flat wrist. Additionally, the arm should never rest on the side of the cello—this will prevent arm weight from being used to depress the string. Although some arm weight will need to go into the string via the thumb, cellists should resist the impulse to tense the thumb. Maintaining a relaxed and rounded hand shape will help ensure this. Cellists should aim for the same type of ease and kinesthetic feeling in the hand and arm when playing in thumb position as when the thumb is behind the neck. Shoulders should remain relaxed, and

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49 Ibid., 151.
there is no physiological need for the head to be ducked forward or shoulders raised when cellists are playing in thumb position.

*Three and Four-Note Chords*

The key to playing three and four-note chords tension-free is shifting hand and arm balance. When confronted with a three or four-note chord, many cellists instinctively attempt to depress each note equally, which commonly causes unnecessary left-hand tension. Victor Sazer suggests, “allow your arm and forearm to move freely as you move from note to note. … When playing four part chords, it is usually better to place your fingers on notes only as they are needed, rather than holding your fingers on all of the notes at one time.”\(^{51}\) As the bow moves off of a string being fingered, cellists can release that finger and shift their arm balance over to the notes being bowed. For instance, if a four-note chord across all strings is being broken (played as two sets of two notes in the same bow with a break in the middle), cellists could finger only the lower two notes, release those notes when the bow switches to the upper two strings, and finger those notes when they are being played rather than attempting to finger all four notes throughout the playing of the chord.

*Common Ailments and Preventative Pedagogy*

Teachers should note that an abrupt increase of activity has been related to nearly every case of music-related overuse that has led to pain or injury in the studies cited in this thesis. Most commonly, these conditions included muscle strain, muscle/tendon-unit strain, inflammatory

\(^{51}\) Ibid., 164.
problems, and nerve problems. Pain is the most common symptom of any of these injuries, but other symptoms include “loss of dexterity, cramping/stiffness, weakness, tremors, swelling, and clicking.” Cellists experiencing any of these symptoms, even if intermittent, should seek the help of a medical professional. If a student finds themselves in a position where they feel the need to practice significantly longer each day, teachers can help students avoid injury by encouraging them to increase practice time incrementally and take frequent practice breaks. Similarly, if a cellist has taken a break from practicing for more than 14 days for any reason, they should be aware that they may need to slowly build up their practice stamina.

Hand/Fingers

In Dawson’s 15-year study referenced earlier in the chapter, hand pain was one of the most common complaints. Pain in the hand most often indicates injuries such as tendonitis, carpal tunnel syndrome, and muscle strain and inflammation. In the hand and fingers, any undue strain can “inflame or tear tendons, causing painful tendonitis.” The tendons in the hand and fingers have finite abilities, so cellists must take care to stop playing and possibly change their approach when they start feeling strain in their fingers and hand as “tendon damage can be one of the most debilitating injuries.” Tension is the quickest way to experiencing muscle and tendon strain. The most effective way that cellists can prevent overuse of tendons when playing is by avoiding tension and relying on larger muscle groups when possible. As mentioned previously, there are no muscles in the fingers themselves. Students who understand this will

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55 Sazer, New Directions, 2003, 12.
naturally rely on larger muscle groups to move their hand around the fingerboard. In addition, an emphasis on releasing thumb tension “can often help relieve tension in the whole hand.” The following mental exercise suggested by Victor Sazer is a useful visualization for cellists:

Imagine holding the ends of a rubber band between the first finger and thumb of each hand. Stretch and release your imaginary rubber band several times. If you stop flexing but keep the rubber band even partially stretched, it is no longer elastic—it is tense. Your arm and hand react in much the same way. Your hands are most tension-free when your fingers are in a released state….Yet regularly holding your left hand open with your fingers separated creates unnecessary strain. To minimize tension, release your hand as much as possible. Open it only as needed. This principle applies to both hands.

When attempting to understand the difference between tension and activation, cultivating a mental image of the two can be useful. For instance, both tension and activation could be defined as muscular energy. Tension, however, is energy stopped, held, or stuck in place, while activation is muscular energy flowing freely. Points of bodily tension could be compared to a dam in a river, while activation could be thought of as the river flowing freely, unencumbered. Cellists who can differentiate between the two will be able to understand when muscular activation has crossed into the realm of tension. Activation enables free movement while tension hinders it.

_Wrist/Arm_

Wrist pain was found to be as common as hand pain in Dawson’s study. (This thesis separates them out, but wrist, hand, and arm pain frequently overlap or show up in various combinations.) Similar to hand and fingers, the most common playing-related wrist/arm injuries

56 Benedetti, *Cello, Bow, and You*, 2017, 141.
57 Sazer, *New Directions*, 2003, 123.
include: carpal tunnel syndrome, cubital tunnel syndrome, muscle tears/scar tissue buildup, tendonitis. Since the tendons in the fingers run through the wrist and far up into the forearm, inflammation of these tendons often is accompanied by sharp pains that run the length of the tendons. The wrist joint is different from most other joints because it can bend multiple ways (flexion and extension). It is a relatively small joint, but is complex. In and around the wrist joint are the carpal and cubital tunnels, nerves and blood vessels, tendons, ligaments, and the bones in the joint itself. There are tendons on both sides of the wrist that connect most of the way up the forearm, and they are easily strained—especially at the wrist joint itself. When the wrist is bending in either direction, the tendons on either side are being pulled. Only when the wrist is flat are none of the tendons under pressure at the wrist. Although flexion and extension at the wrist is not an unhealthy movement itself, it is one of the most easily-inflamed places in the body.59 Because of this, cellists should try to keep their wrists flat and neutral whenever possible.

If the wrist must bend for one reason or another, it should not stay that way for an extended period of time or happen very frequently. Cellists should also be aware that “a lowered wrist (wrist extension) is more dangerous than a raised wrist (wrist flexion),” as concluded by Pennsylvania State researchers in a recent study.60 Poor use of the wrist can also affect the muscles “involved with ulnar deviation in the left hand.”61 This is mainly caused by wrist flexion from side to side, “when the wrist bends toward the body's midline.” Too much of this type of

60 Sazer, *New Directions,* 2003, 10.
wrist movement can wear away at cartilage in the joints of the hand, which can lead to ulnar deviation.\textsuperscript{62} 

Excessive muscle strain and muscle tension, especially over time, can lead to the development of scar tissue in the arm. Victor Sazer offers this helpful explanation of the development of scar tissue and its implications, citing research by Drs. Emil Pascarelli and Debrah Quilter:

Muscles are arranged in opposing groups. Motion occurs when one group of muscles contracts while its opposing group lengthens. Excessive tension can prevent a muscle group that should be lengthening from doing so. This happens when opposing muscles contract at the same time. When used in this way, muscles and connected tendons can become inflamed or torn. When muscles are repeatedly torn, scar tissue replaces normal muscle fiber. Even when this occurs in tiny increments, its cumulative effect can be harmful. ‘scar tissue slowly replaces muscle. The scar tissue can impede surrounding muscles, leading to more micro tears and more scar tissue. Eventually, scar tissue dominates.’\textsuperscript{63}

\textit{Shoulder}

Although hand and wrist injuries are the most common left-side playing-related injuries in cellists, shoulder injuries also frequently occur. Issues include inflammation of the shoulder joint or of the rotator cuff, rotator cuff tears, bursitis, general strain, and tendonitis of the biceps tendon or rotator cuff tendons. As Sazer explains, “joints are the body’s hinges and shock absorbers. They are most frequently injured when they are misaligned or forced to move beyond their normal range of motion. Joints can also be injured by excessive pressing or by jolting movements.”\textsuperscript{64} Most of the shoulder injuries listed above happen in the front of the shoulder,

\textsuperscript{62} Abrahams, \textit{The Human Body}, 2017, 139.  
\textsuperscript{63} Sazer, \textit{New Directions}, 2003, 10-11.  
\textsuperscript{64} Ibid., 9.
which indicates too much muscular activation coming from that area of the shoulder. If the principle of leading motion with larger groups is followed with regard to the shoulder as well, most of these injuries can be prevented. For instance, the latissimus dorsi is one of the largest muscles that connects to the shoulder and spans most of the back. When cellists learn to use this muscle to lead movements rather than the biceps, deltoids, or pectoralis major, they will likely avoid overuse of the shoulder tendons and rotator cuff.⁶⁵

CHAPTER FOUR - RIGHT SIDE

Chapter Introduction

Studies of instrument-specific injuries and injury rates in orchestral musicians have found that cellists “have a risk of injury that is equal to or higher than other members of the string family.” Many of these same studies have also found a direct correlation between rate of injury in musicians and hours of consistent playing. A recent study by Logue et al. states, “Cellists in particular are required to perform awkward hand and arm movements. Proper technique for playing the cello requires a constant flow of movement with alternating forearm muscle contraction and relaxation.” The same study states that “repetitive and awkward movements of the arms while playing the cello” puts cellists at risk for injury in the upper extremities.

Musicians, especially orchestral musicians and college music majors, do not usually have the ability to decide how many hours they rehearse each week or balance their repertoire based on physical demands. However, they can protect themselves from injury by approaching technique in a healthy way and learning about common injuries, injury warning signs, and

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67 Ibid., 71.

playing risk factors. This chapter briefly covers the basic principles of healthy right-side use in
cello playing, in addition to common playing-related ailments and some ideas for their
preventative pedagogy. (As in the previous chapter, the author recognizes that there are many
schools of thought about all aspects of cello technique, but has based the information in this
section on the pedagogical resources cited within this thesis and her personal training.)

**Basic Principles of Healthy Right-Side Use**

*General Approach to the Bow*

With the exception of techniques like pizzicato, the bow instigates and shapes the cello’s sound. It allows cellists to speak and sing as musicians, and the use of the bow is often compared to a singer’s breath. With this in mind, it follows that everything the cellist does with the right hand and arm has the potential to affect their sound. For the sake of both physical health and freedom of sound, “optimal playing technique avoids unnecessary effort and muscle co-contractions.”

Cellists should strive for an arm-weight driven approach to the bow that is as tension-free as possible. The following section addresses specific technical aspects of right-side technique in cello playing, all based on natural, healthy movement: bow hold, the role of arm weight and gravity, stroke and articulation, upbows and downbows, and navigating string crossings and bow changes. (The author recognizes there are countless other bowing and pizzicato techniques, but has chosen to focus only on the most basic aspects of right hand

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https://doi.org/10.1016/j.jelekin.2016.10.003.
technique in cello playing with regard to bowing. The principles outlined in the following sections are a foundation for nearly all other techniques.)

Bow Hold

A good bow hold always starts with a relaxed hand-frame and a healthy setup. A bow hold that is set up improperly can very quickly lead to injury. Developing a consistent, healthy bow hold is key to producing good tone. The bow hold itself should look similar to the natural shape of the hand when it is resting on the cellist’s knee or hanging at the cellist’s side. Each of the knuckles and joints in the hand should be flexible and malleable, including the thumb. When cellists understand that the right hand should serve as a bow guide rather than a way to exert force, they will naturally loosen their grip on the bow. In a healthy bow hand, the fingers and thumb are curved, the pinky is folded over onto the frog, the thumb is placed in the notch where the stick meets the frog, the bow hand is relaxed and flexible, and the palm of the hand is soft.

The pointer finger directs arm weight into the string and allows for specific articulation, the middle fingers hang balanced, the thumb works with the pointer finger, and the pinky adjusts the angle of the bow and supports bow changes and string crossings. The position and spacing of each cellist’s fingers will vary slightly depending on their individual hand. The right hand should be free to pronate and supinate slightly when bow placement and string crossing require it, but the hand should generally face forward (as it does when resting on the arm of a chair or on the knee). Too much pronation in the bow hand could potentially place excess stress on the biceps tendon and rotator cuff, whereas a balanced hand will encourage the use of the latissimus

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70 Logue et al., "Median and Ulnar Neuropathies,” 2005, 70.
dorsi—a muscle much larger and more resilient against injury which also aids in bow fluidity.\textsuperscript{71}

Figure 1 (below) shows an example of a healthy cello bow hold as seen from the front. In this view, notice that the fingers are curved and hang slightly apart, the wrist is in a neutral position, the pinky is draped over the frog, and the hand is balanced and facing forward.

\textit{Figure 1 (front view of cello bow hold)}\textsuperscript{72}

Figure 2 (below) shows a view of the same cello bow hold from the back. Notice that in this illustration, the thumb is gently bent and the thumb is placed in the notch where the stick meets

\textsuperscript{71} Rickert et al., “A Study of Right Shoulder Injury,” 2012, 70.
the frog. The thumbnail is also facing slightly left, so that the point of contact resting in the notch is approximately just above the top right corner of the thumbnail.

Figure 2 (rear view of cello bow hold)

Arm Weight/Gravity

In her book, *Cello, Bow, and You: Putting it all Together*, Evangeline Benedetti said, “A cellist with a so-called good bow arm instinctively knows the effect of gravity on the bow, even

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if he or she has never thought about it.” In cello playing, the string fully supports the bow and the cellist’s arm weight, which is drawn down toward the earth by gravity. The only time the hand holds the bow is when the bow is in the air. Cellists should think of their arm weight going directly into the string instead of into the bow. As previously mentioned, the fingers in the right hand help point arm weight directly into the part of the string which makes contact with the bow. Thumb placement is another key aspect of bow hand/arm balance. The thumb needs to be placed correctly in order to facilitate tension-free transfer of weight into the bow and maintain arm balance throughout the bow. When cellists understand that their body has natural weight and that gravity can work together with arm weight, bowing will become more effortless. In addition, a weight-driven bow arm working with gravity will encourage greater resonance from the instrument, while musccularly pushing into the string with the bow elicits a pressed quality in the sound which is usually considered undesirable. Overuse injuries in the bow arm often start with an over-muscled stroke, so cellists should attempt to find as much physical ease in their bowing as possible to help prevent general arm and shoulder playing-related injuries.

*Stroke/Articulation*

Stroke refers to nearly anything that can be done with the bow to create or articulate a certain sound. Fast and slow strokes both require a relaxed approach. Cellists will have the greatest ability to be tension-free when playing if their hands and forearms are in line and in a neutral position. Fingers should also be slightly more rounded for fast than for slow playing, which will allow for a lighter, more “facile” touch. Cellists should be aware that studies

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76 Sazer, *New Directions*, 2003, 137.
involving electronic imaging have shown that back muscles are activated asymmetrically in fast bowing. As a result, spending too much time practicing or rehearsing fast and athletic strokes may lead to overuse. There is a greater risk for injury any time muscles are activated asymmetrically for long periods of time. Slow playing allows cellists to be more aware of the shift of weight and balance in the bow hand. Having a free hand and arm will allow the cellist to adjust hand and arm, and most of the time the hand and arm will adjust themselves naturally in slow bowing. Even in slow playing, cellists should strive for constant motion, which will help them release tension throughout the stroke. If something is not working well, the cellist is likely tensing their thumb, first finger, wrist, or shoulder. Releasing tension from these areas will provide ease in slow playing. When attempting to play difficult or complicated strokes, cellists will have more success ridding these strokes of tension if they begin practicing these motions with as little tension as possible. Many times, this will mean slowing down or simplifying the technique to the point that it can be executed without tension, then incrementally speeding up or adding additional elements to the practice. Separating the hands when practicing is a useful practice technique which is particularly effective when practicing difficult bow strokes.

**Upbows and Downbows**

Since the frog of the bow is heavier than the tip and the frog is where the bow is held, there is more weight that rests at the frog than at the tip. This creates a natural tendency to make down bows stronger than up bows. This tendency causes sound to decay as the bow is drawn out toward the tip unless the cellist adjusts their approach to direct arm weight throughout the bow.

77 Afsharipour et al., "Spatial Distribution of Surface EMG,” 2016, 144.
78 Sazer, *New Directions*, 2003, 137.
As the point of contact with the string moves from frog to tip, cellists’ hand-arm complex will likely transition from being balanced across all fingers to pronated in order to facilitate weight transfer to the upper half. Much of the time, string players can use the natural distribution of bow weight to their advantage (i.e. planning down bows on strong beats), but there are times when down bows will be necessary on weak beats or the weight must remain evenly distributed so that the sound does not spike with every down bow. This will also usually require more bow speed at the frog and tip to facilitate the transfer of weight through bow changes. On this topic, Victor Sazer, author of *New Directions in Cello Playing*, recommends the following:

Two arm levels are used on each string. One level is used for up-bows and another for down-bows. When you play consecutive strokes on a single string, therefore, your arm level changes with each stroke. it is released to be lower for down-bows and lifted to be higher for up-bows. This can make a big difference in tone production and comfort. Rounding the ends of your strokes to form figure-eights connects the counterclockwise up-bows.79

This kind of duo-level approach to the string naturally creates a rounded and more fluid approach to bowing, in addition to encouraging release of tension and proper distribution of arm weight throughout the bow. Still, cellists should be mindful that the muscular activation in the back that is needed for bowing and fingering simultaneously is most balanced— for cellists specifically— when playing in the lower half of the bow.80 It is essential for cellists to be able to play full bows and understand how to achieve their desired sound in the upper half, but they should also be wary of spending too much of their practice playing at the tip of the bow; especially extended tremolo playing and other athletic bowing techniques.

80 Afsharipour et al., “Spatial Distribution of Surface EMG,” 2016, 152.
Navigating String Crossings and Bow Changes

The technique required to achieve seamless string crossings and bow changes is a continuation of the previous section, as fluidity in playing involves an understanding of the use of arm weight throughout the bow. In fact, cellists could apply the Sazer quote in the previous section to this topic as well. In addition to adjusting arm weight, fluid string crossings necessitate a different bow angle for playing on each string. This change in bow angle begins in the arm. Bowing on the G string is physically very balanced in the arm—and is therefore a good starting point for developing a balanced arm—while an extreme arm angle is needed for bowing on the A string. Janet Horvath, cellist and author of *Playing (Less) Hurt*, recommends that cellists turn their instruments slightly when playing on the A string “rather than rotating the shoulder or twisting the back.” She continues, “This approach is less theatrical, but it could save your career. Keep the cello mobile with slight knee adjustments for whatever side you are playing.” Cellists should also keep in mind that the thickness of the string affects how the arm should adjust when changing strings. Upper string to lower string crossings require more arm weight when landing on the lower string, and the opposite when changing to a higher string in order to achieve the same level of tone and clarity. Leading the string crossing with the elbow will also prevent overuse of the wrist. When the wrist is bent instead to facilitate a string crossing, there is risk of overuse and a loss of contact with the string. The arm must move to the level of the new string ahead of the hand in order to facilitate fluid string crossings.

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82 Ibid., 80.
Similarly, the arm always prepares for bow changes as well. As the arm anticipates both the bow change and the new direction it will be bowing, seamless bow changes will follow. About bow changes, Sazer posits, “Every act you perform includes preparation. When you throw a ball, your arm moves backward to prepare to throw the ball forward.” Down bow on a lower string followed by an up bow on a higher pitched string requires counter-clockwise motion. The opposite requires clockwise motion. As technique develops, the right arm should continue to be isolated and the technique refined in each new bowing situation. After preparation comes followthrough, which is preparation for the next change in motion or direction. In this way, each motion is a preparation for the next. Cellists can practice monitoring the shape their elbow creates in the air during long, slow bows. Once the basic bowing shape during bow changes is learned, recent studies suggest that athletes and other individuals using tools or objects in a specific manner may have more accuracy and ease of movement by having an external focus when moving an object. For instance, once the fundamental bowing movement is learned, cellists could find more ease and fluidity in bowing by focusing on the sound they are creating or on their bow rather than thinking only of what their arm is doing.

Common Ailments and Preventative Pedagogy

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Of injuries correlated with right-side cello technique, tendonitis and muscle strain are the most common, and neuropathies and shoulder injuries are the most severe. Many of these playing-related injuries, though only bothersome at first, easily become chronic and disabling. After developing from strain to injury, most of these injuries last 2 to 5 years. The ideas of tension-free playing, weight transfer, and using gravity to one’s advantage will help cellists prevent these types of injuries. Similar to playing-related injuries prevalent in the left side, pain, swelling, cramping, numbness, loss of dexterity, and stiffness are all indicators that an injury is present. Cellists experiencing any of these symptoms in any body part should seek the help of a medical professional.

Hand/Fingers

Although the right hand is slightly less injury-prone for cellists than the left hand, the right thumb is particularly susceptible to ligament damage when too much force is continually placed through the thumb. The flexors and extensors of the right hand can be under significant strain when the bow is continually pressed or over-controlled. This can lead to entrapment neuropathies and carpal tunnel syndrome of the digital nerves, but can be prevented as cellists do their best to avoid gripping the bow tightly. Since tendons are not very malleable, they are highly susceptible to injury and can develop “microscopic tears,” which over time can cause the

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88 Horvath, Playing (Less) Hurt, 2010, 60.
“tendon sheath to thicken,” thereby putting the individual at risk for further injury quite easily.\(^{92}\)

Of tendonitis, Janet Horvath said the following:

Tendinitis and other overuse problems in the forearm can be triggered by excessive finger motion and/or pressure... Even at rest, muscle tenderness can accompany tendon pain to the point where muscles are sore to the touch. Unchecked, this inflamed condition can result in scar tissue and can cause nerve entrapments. Chronic muscle tension therefore, creates a susceptibility to reinjury as a result of this scar tissue.\(^{93}\)

In order to avoid this painful condition, cellists should avoid gripping or squeezing the bow.

Squeezing usually happens between the first finger and the thumb, and is a result of the attempt to either over-control the bow when it is on the string or press in order to get sound. Horvath suggests that string players can get “the power to [their] fingers comes from [their] back and arms,” they should “release [their] thumbs when the opportunity exists on a long note” or during rests and string crossings, and that a healthy thumb “should remain slightly flexed at all times.”\(^{94}\)

A thumb that is completely straight does not have the ability to support an instrument or bow with any sort of longevity. When bowing, the thumb should be free to bend and unbend slightly. The thumb will be more bent when playing at the frog and less bent when playing at the tip, acting as a “counterbalance” to the fingers placed on top of the bow.\(^{95}\) Cellists should avoid collapsing fingers when playing, as this leads to “finger pressure and squeezing, rather than arm weight,” which leads to injury.\(^{96}\)

\(\textit{Wrist}\)

\(^{93}\) Ibid., 58.
\(^{94}\) Ibid., 68-69, 86.
\(^{95}\) Ibid., 84.
\(^{96}\) Ibid., 87.
The wrist is a small, complex joint surrounded by vulnerable tendons, ligaments, and nerves. Since there is very little protective tissue around this system of nerves and tendons, it is a common site for playing related injuries; most commonly, “tendonitis, and peripheral nerve entrapment syndromes, such as carpal tunnel syndrome.” In general, the best way to protect the wrist is to keep it in a neutral position and maintain a relaxed hand. Janet Horvath has found in her research that “repetition, combined with poor wrist position” is usually the cause of Carpal Tunnel Syndrome in musicians. She explains, “it is essential, for example, that string players avoid exaggerated wrist motion in the bow arm and keep the left wrist level.” Further, “The hand is much stronger in a neutral position… we lose 50 percent of our strength with a raised or lowered wrist.” Cellists who play with a flat wrist will preserve both their wrist joint health and their wrist strength. “There need not be a dramatic raising and lowering of the wrist during bow strokes. If you minimize thumb pressure, your hand and wrist will be fluid.” Releasing thumb tension and lowering the wrist are keys to protecting the wrist joint and cultivating a healthy bow arm and bow grip.

*Elbow*

Elbow injuries are the least common, but usually occur “about the lateral humeral epiconyle at the elbow.” These injuries usually manifest in cellists similarly to the ways that they show up in athletes like golfers and tennis players. Frequent jolts or movements outside of

99 Ibid., 79.
100 Ibid., 80.
101 Ibid., 85.
the natural range of motion will cause inflammation and injury in the elbow. Tendons that run from the forearm to the elbow joint can become inflamed at the point of connection with too much forearm activation. Nerve compression is also quite common at the elbow, as the median and ulnar nerves are surrounded by less protective tissue at the joints. As cellists work to increase their fluidity of motion and physical preparation for bow changes and other quick movements, they will decrease their chance of developing an elbow injury. Another aspect of applicable technique to consider is the idea mentioned previously of turning the cello slightly to reach the A string—especially with regard to cellists with shorter arms playing in the upper half of the bow. In addition to sharp jerks of the arm, an immobile elbow can also contribute to injury. Cellists experiencing this could practice “X-bows and T-bows” detailed by cellist Pamela Devenport in her book *Cellostart*. This exercise is designed to aid cellists in both developing a straight bow when bowing and encouraging freedom of movement at the elbow joint. To start, the cellist places the bow on the string at the middle of the bow. They then create an “X” shape with the bow and string by alternately opening and closing their elbow while pivoting silently on the string. The cellist continues to open and close the elbow less and less until they reach a point when their bow creates a “T” shape with the string. Although it is recommended that this exercise begins at the middle of the bow, it can be experimented with at any point along the bow.

104 Ibid., 67.
A recent study researching shoulder injuries in student and orchestral cellists came to an alarming conclusion, stating, “a breakdown of instrument injury prevalence has shown that right shoulder injuries are present in 16% of orchestral cellists, placing them in a similar category to other high-risk occupations such as welders, painters and over-head athletes.” Further, motion capture studies on cello bowing found that “cellists adopt similar positions of abduction and flexion seen in these professions.” These types of injuries usually have “very poor rehabilitation outcomes” in cellists: another reason why cellists and cello teachers should focus on prevention of such injuries. This same study found that although orchestral cellists experience the most severe injuries, many student cellists were already exhibiting “deficiencies in shoulder strength and stability.” According to this research, there appears to be a trend among cellists–regardless of whether they are students or professionals–of shoulder weakness or instability that either has led or could lead to a serious shoulder injury.

There are four main types of shoulder injuries, three of which most commonly occur in musicians: impingement, rotator cuff tear, and frozen shoulder. According to Janet Horvath,

We can put the shoulder into approximately 16,000 different positions! The price for flexibility is vulnerability. This joint’s stability depends on muscle balance. A shoulder injury may cause pain in your arm, hand, and neck in addition to your shoulder… Whenever the arm is held out from the body…for long periods of time, the rotator cuff and bursa in the shoulder joint are squeezed.

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106 Ibid., 66.
107 Ibid., 66.
108 Ibid., 71.
109 Ibid., 69.
111 Ibid., 61-63.
Common areas of shoulder tension and pain include the trapezius, rotator cuff muscles, biceps tendons, and deltoids. As stated in the quote above, the shoulder’s stability—and, therefore, its ability to avoid injury—“depends on muscle balance.” When the muscles that contribute to the shoulder joint are healthy and their relative strength is balanced, the shoulder joint is resilient to injury and able to easily perform what is reasonably asked of it.

Research has found that the main area of weakness in the right shoulders of student and professional cellists is usually the scapular stabilizers and the muscles in the rotator cuff. The research study cited at the beginning of this section by Rickert et al. explains:

Tasks that require positions of the shoulder abduction and flexion and use these larger muscles (such as cello-playing) place the rotator cuff muscles and scapular stabilizers under increased load in order to maintain integrity of the shoulder joint. If control and strength of these muscles is not sufficient, this can lead to [shoulder impingement]... If the activity causing impingement is not modified or the underlying muscular imbalances are not addressed, shoulder impingement can lead to a rotator cuff tear whereby the supraspinatus tendon becomes frayed through abrasion against the acromion. This extremely painful condition is seen amongst cello players and can mark the end of a performance career.

According to this and other studies of upper extremity overuse in musicians, the trend appears to be that various combinations of muscular imbalance, lack of scapular support, specific hand positioning in space, and gripping all place significant strain on the shoulder and contribute to and can cause right-shoulder injury in cellists. Additional symptoms of injury and muscular

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112 Ibid., 62.
113 Ibid., 61-63.
114 Ibid., 62.
116 Ibid., 66.
117 Ibid., 66.
weakness in the shoulder includes trigger points (which are directly correlated with right shoulder injury), loss of range of motion, muscular imbalance (commonly 1/3 difference in strength between internal and external rotators), deficient shoulder strength and stability, and unevenness in shoulders at rest (particularly common in orchestral cellists).\textsuperscript{118} In addition, Rickert et al. reported a definitive correlation between playing-related pain and playing with a very active upper trapezius muscle.\textsuperscript{119} Conversely, cellists who were able to play with relaxed trapezius muscles appeared to have greater resilience against shoulder injury and less playing pain overall.

Raising the shoulders or thrusting them forward when playing “results in poor stabilization of the arm, making all movements more difficult,” and causes an imbalance in the scapular stabilizers and between the internal and external rotators of the rotator cuff.\textsuperscript{120} To protect shoulder health and avoid injury, Horvath suggests that cellists should avoid “repeated \emph{fortissimo} downbow passages,” “big arm circles and crash landings” and attempt to always keep the right arm and shoulder relaxed. She also encourages the use of minimum movements, and to “stay near the string and at the frog.”\textsuperscript{121} Cellists prone to muscle weakness could also consider getting involved in some level of basic strength training in order to ensure that they are not at risk for muscular imbalance. Freedom of breath will also encourage muscle relaxation.

In general, cellists will find that the most ease and fluidity in bowing will come from the muscles connecting from the shoulder to the back. The latissimus dorsi is a muscle that is largely

\begin{itemize}
  \item \textsuperscript{118} Ibid., 70.
  \item \textsuperscript{119} Afsharipour et al., “Spatial Distribution of Surface EMG,” 2016, 145.
  \item \textsuperscript{120} Horvath, \textit{Playing (Less) Hurt}, 2010, 66.
  \item \textsuperscript{121} Ibid., 66.
\end{itemize}
underused in string players in bowing. It runs from the back of the shoulder joint and spans most of the back on both sides. Focusing on bowing from the back with this muscle, strengthening the scapular stabilizers, and avoiding activation in the trapezius muscles will help reduce rates of injury in cellists’ shoulders and provide greater ease of movement and bowing stamina.122

CONCLUSION

Musicians are small-muscle athletes whose craft can take a serious physical toll if preventative measures are not properly implemented from the start of learning an instrument. Playing-related injuries affect 8 out of 10 musicians. Approximately 2 of those musicians will fully recover with little to no long-term problems, 5 will manage chronic symptoms or flare-ups, and 1 will be forced to discontinue playing permanently.123 Studies suggest that the best way for musicians to avoid playing-related injuries is through prevention, and that preventative measures are usually effective.124 Cellists, in particular, endure playing-related injuries more than most other instrumentalists, and rates of injury caused specifically by cello bowing places cellists in a high-risk occupation similar to welders and overhead athletes.125 126 These injuries are most often caused by muscle weakness, physical misuse, and overuse—all of which can be avoided with

complete, well-rounded cello pedagogy that includes proper physical setup and preventative strategies.

The most common playing-related injuries in cellists include but are not limited to: tendonitis and bursitis in the hands, wrists, elbows, and shoulders; neuropathies; impingement; muscle strain and tearing; development of scar tissue; and spinal disc problems (including bulged and herniated discs).\(^\text{127}\) The most common of these injuries are muscle strain and forms of tendonitis, and the most severe are neuropathies, impingement, and disc problems. Treatments range from rest and physical therapy to surgery, and recovery can take several years. These injuries are caused by poor posture, body misalignment, muscular weakness or imbalance, repeated unnatural movement, over-rotation of joints, and excess muscular tension. Symptoms of playing-related injuries include sharp and dull pain, numbness, muscle soreness and tightness, tingling sensations, loss of range of motion in joints, weakness, swelling, cramping, development of trigger points, and loss of dexterity.\(^\text{128}\) Cellists consistently experiencing any of these symptoms should cease playing and any strenuous activity until they are able to seek the advice of a medical professional.

In order to prevent overuse injuries, cellists must be proactive in their approach to physical setup and instrument practice. In addition to the study of anatomy and physiology, developing body awareness, engaging in somatic practices such as the Alexander Technique and


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Feldenkrais Method, warming up properly, increasing physical activity, and balancing the physical demands of their repertoire, cellists can prevent overuse injury by:

1. Sitting with the head, neck, and spine properly aligned

2. Finding a foot position that feels the most supportive

3. Playing on an instrument of the correct size and a chair of the proper height

4. Actively looking for moments to rest and release tension while playing (i.e. rests, bow lifts, shifts, string crossings, etc.)

5. Taking playing breaks when muscle soreness or strain arise

6. Avoiding the complete rotation of the forearm (crossing the radius and ulna) and maintaining a neutral wrist as much as possible

7. Default to using larger muscle groups whenever possible (such as the latissimus dorsi)

8. Using gravity and body weight rather than pressing or squeezing

9. Understanding the difference between muscle tension and muscle activation

10. Avoiding sudden, drastic increases in practice/rehearsal time

Cellists and cello teachers must implement preventative measures such as these in order to successfully avoid physical misuse and overuse in themselves and their students. There is still extensive additional research that needs to be conducted in order to determine the exact implications of specific cello-playing techniques, the anatomy of bowing and fingering, and the
level to which certain muscles and tendons require activation for each aspect of cello-playing technique. Until this information can be identified, cellists and cello teachers must be proactively implementing the preventative strategies—though limited—that are currently available for cellists.

Injury prevention is an essential element to longevity of instrument playing, regardless of whether the musician is young or old, amateur or professional. As cellists implement preventative strategies such as the ones outlined in this thesis, they will be able to more successfully avoid overuse, misuse, and playing-related injury. Cellists who strive to give and attain well-rounded pedagogy in their development of instrument technique will increase their comfort while playing and their ability to avoid playing-related injury. This will allow each cellist to find continued enjoyment in musicianship throughout their musical lives.
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