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Piano Performance Injuries and Preventions

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SENIOR THESIS APPROVAL

This Honors thesis entitled

“Piano Performance Injuries and Preventions”

written by

Kristin N. Cordell

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requirements for completion of the
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meets the criteria for acceptance
and has been approved by the undersigned readers.

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Introduction

Strength, flexibility, coordination, and determination are all words that come to mind when describing an athlete. Not only do these words apply to athletes, but also to musicians, especially pianists. Each of these characteristics must be found within a pianist in order to achieve success. Although musicians may not look like athletes with large, bulky muscles, they should be considered musician athletes as well.

Just as athletes can become injured during practice or performance, so can pianists. The difference is found in the methods of training each use. Athletes often undergo extensive training to prepare their bodies for intense performance. Before they engage themselves in their sport, athletes usually begin with exercises to warm up their muscles and get their blood flowing. Also, many are involved in strength training to help build up and sustain their muscle strength. While athletes take the time to condition their bodies, many musicians do not. For serious pianists, the reason may be that time is limited, due to the fact that they may practice five to eight hours a day. Others may not see the importance of conditioning the muscles related to playing the piano.

Another difference can be seen in the strategies used by athletes and pianists in the days leading up to a big performance or game day. Athletes tend to taper their training days before, while pianists increase their practice. Athletes do this to save energy, so they can perform their best when it counts the most. Pianists, on the other hand, tend to try to perfect everything possible in hopes to perform perfectly. When doing this, often times injury occurs due to repetitious practice and an increase in practice time. Increasing practice is not always the best method to prepare for before a big performance.¹

Athletic trainers are usually available and nearby to watch over and instruct athletes when training. They are able to correct athletes and provide advice when needed. Musicians usually see their teachers once a week. Teachers help instruct their students on proper technique and posture in lessons, but if the student does not apply this to their everyday practice, bad habits could be learned and become almost impossible to break. This is why it is important for pianists learn about and understand their bodies, especially the upper extremity, since this is the part of the body used most in playing the piano. Knowing how and why certain injuries are caused can help make performers aware of how to practice and also help them avoid serious injury to their bodies.²

Causes of Injuries

Around seventy-five percent of musicians have reported an injury related to their musical careers. Of the injuries encountered, the majority include injuries to keyboard and string players, and women also experience a larger number of injuries than men.³ Many demands are placed upon musicians to obtain perfection in their performance. These demands, both physical and emotional, can result in fatigue, stress, and unnecessary muscle tension within the performer, causing problems with posture and possible injuries related to overuse.⁴ Most performance injuries can be traced back to three causes: sustained muscle contractions, strange postures, and emotional stress.⁵

Striving for perfection requires hours of practice and endurance. When practicing for a long period of time, I often experience tension or pain caused by the constant stress I place upon my body, especially within my arms and shoulders. Every individual has a point at which their muscle tissues can no longer be stressed without hurting.⁶ If this pain is ignored, serious damage could possibly occur. Pain is a person's response to injured

body tissue, and its intensity varies among individuals. There are several ways to interpret pain depending on the types of tissues that have been injured. Injuries to muscles and tendons are often described as an “ache, sore, spasm, or a knife-like pain.” Nerve tissue pain feels more like a burning or numbing sensation. If both tendons and nerves are irritated, a combination of these symptoms can be felt.⁷

Muscular pain is often caused by the absence of oxygen in the tissues of the muscle. This lack of oxygen is called ischemia. Long hours of practice without rest does not allow the muscles to relax often. When a pianist plays with tense, sustained muscles this lack of oxygen can easily occur. To work correctly, muscles require oxygen for any activity. Blood carries oxygen to muscles, and if all available oxygen is used, chemicals are released. Areas surrounding the injured area will also become sensitive due to these chemicals irritating the area and creating the sense of pain.⁸ This ischemic pain is considered a warning sign for a pianist’s body. Naturally, to avoid pain, the body begins to move differently. When this happens, new muscles begin to be used, and oxygen is allowed to return to the injured area through blood flow.⁹ Playing techniques requiring the repetition of octaves and large chords often create tension, reducing blood flow. Muscles become strained, causing pain and fatigue throughout the shoulders, wrists, and arms.¹⁰ If this pain occurs often and is not relieved or treated, more serious problems, such as tendinitis or chronic inflammation, can occur.

If the problem with ischemic pain is the lack of oxygen, then the solution is simple: re-oxygenate. Massaging and rotating the irritated area helps increase blood circulation, bringing oxygen back to the irritated. Although the area is refreshed, this should be done periodically to decrease tension and the occurrence of pain.

A second cause of performance injuries is due to poor posture. The skeletal system is designed to work efficiently, using the least amount of energy possible. When an individual's joints are positioned incorrectly, this efficient movement cannot occur.¹¹ For example, sit slouched, and try to raise both arms over the head. Then, do the same movement of the arms while seated erect with correct posture. When sitting correctly, the arms should be able to obtain a larger range of motion because the joints are in a more efficient position. Another example of inefficiency can be found within the wrist. With the hand, form a strong fist. It is important to notice the position of the hand and wrist. Now try to make a fist while bending the wrist downward toward the forearm. When this happens, the tendons cannot function correctly, and a strong fist cannot be achieved.¹²

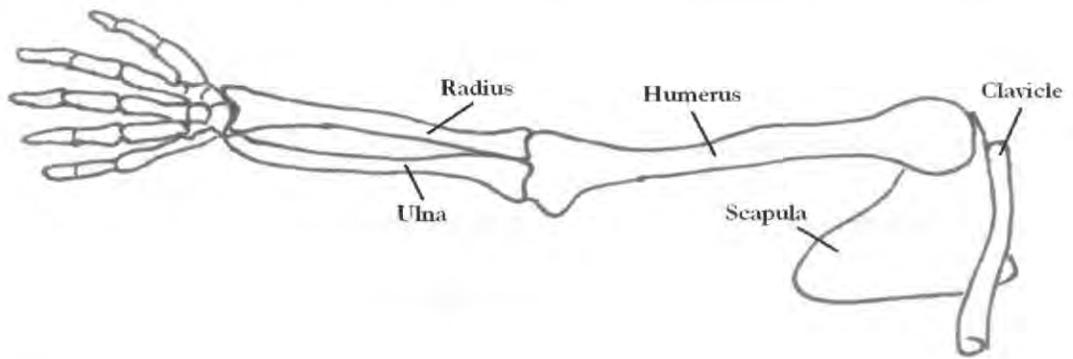
Two forms of muscles are used in referring to posture: postural and non-postural muscles. Postural muscles are designed to keep the body upright and resistant to gravity, while non-postural muscles are not as gravity resistant. Each individual has a certain limit that can be put on muscles before they begin to tire and become painful. When a postural muscle works outside this limit, it is no longer working efficiently, causing strain and tension. Non-postural muscles then begin to work to bring the postural muscles back within their original boundaries. Since these muscles are less resistant they tire easily, causing the sense of pain and irritation. Since the stress limit has been broken, tissues within the muscles can become either stretched out and weak or shortened and tight.¹³ When pain occurs regularly, performers often adapt new positions in an attempt to avoid pain. These new positions become habits, but they do not use energy efficiently. Tiring easily, the body enters a continuous cycle of tension, fatigue, and pain. Often, pianists adapt to an inefficient posture, forgetting how normal posture should feel.¹⁴ When made

aware of this error, it is often very difficult to relearn correct body positioning. From my experience, it is much easier to take the time to learn correct techniques and postures from the beginning. Not only does posture affect the muscles within the body, but also the technique and tone used to play outside the body.

Emotional stress is a third factor that plays a part in causing injury to a performer's body. The burdens put on performers seem endless, especially when one is in a cutthroat environment. It is clear in seeing the stress often experienced by students competing and performing in music schools around the world. The desire to perform well at lessons, competitions, juries, and recitals as well as the pressure of knowing a grade will be given in the end and their work will be criticized all contribute to emotional stress. Often, practice times are increased seeking perfection that will never appear, making the body susceptible to possible injury. Performance anxiety is another factor of emotional stress. The fear of performing in front of an audience can definitely affect one's performance and also their playing technique. All these items cause unnecessary tension throughout the body, paving way for possible injury down the road.

The Upper Extremity

Playing piano involves four important joints within the upper part of the body. These joints include those located at the shoulder, elbow, wrist, and fingers. The hands, and of course the fingers, are the most obvious body parts required in playing the keyboard. Precise neuromuscular control is needed to correctly execute technique and artistry. Not only do the hands and fingers need this control, but also the wrist, elbow and shoulders. To help understand how injuries occur, pianists should be familiar with the four major joints and their functions when playing the piano.¹⁵

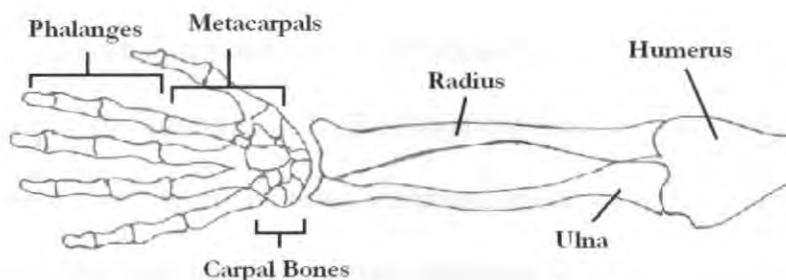


The area around and including the shoulder joint is termed the shoulder girdle.

The humerus, or the bone found in the upper arm is included in the shoulder girdle and is supported by the clavicle and scapula, or collarbone and shoulder blade respectively.

This strut structure, made up of the clavicle and scapula, allows for the movement of the humerus. The shoulder girdle is held together by ligaments which identify unwanted or unusual movements. Muscles work together with the clavicle and scapula to control the movement of the humerus and the shoulder joint. Shoulder movements allow the hands to be placed on the keyboard and provide support for rapid passages and complex techniques. The shoulder moves in three basic ways: 1) by flexing and extending, 2) by abducting and adducting, and 3) by internal and external rotation. Flexion and extension deal with the up and down movement of the arm in front of the body, while abduction and adduction refer to the up and down movement of the arm to the side of the body. Internal and external rotation refer to the movement of the arm to and away from the body, usually with the elbow bent. The trapezius muscles keep the scapula in place, allowing for the proper alignment of the humerus. The scapula can be moved out of place by incorrect posture and even by the lack of an improper amount of exercise. If this were to happen, the trapezius muscles could weaken causing the misalignment of the humerus. Its movement can then cause irritation, pain, and can lead to possible tendinitis.

Moving distally down the arm, the next joint encountered is the elbow. Three bones: the humerus, ulna, and radius, join at the elbow joint allowing the arm to bend and straighten. The radius and ulna lie beside one another and allow the supination or pronation of the arm, which is rotating the hand palm up and down, respectively. They also provide protection for nerves, vessels, and tendons.



The next joint encountered down the kinetic chain is the wrist. It includes both the joint joining the wrist and forearm and the joint connecting the wrist and hand. Eight small round bones, called carpal bones, make up the wrist. Ligaments connect each of these bones with one another as well as with the radius, ulna, and fingers. These eight carpal bones form the carpal tunnel, which protects tendons and nerves running from the forearm into the hand. Movements of the wrist include flexion and extension (up and down), pronation and supination, and ulnar and radial deviation (side to side). A “neutral” wrist provides the hand with the control it needs to function correctly and efficiently when playing the piano. A neutral wrist is one that is not overly extended in any direction.¹⁶ If the wrist is not in a neutral position, unnecessary stress and tension are placed upon tendons, and as this occurs over a long period of time, they will tire. For example, if the wrist is bent toward the fifth finger, the tendons will not work efficiently. When a pianist repeatedly uses this position to play, the tendons will fatigue quickly.¹⁷ If

the tendons are not rested, tissues become damaged and inflammation could occur as well as possible tendinitis as discussed earlier. In dealing with the carpal bones, carpal tunnel syndrome is also a possible result of damaged tendons.

Finally, the last area of the upper extremity encountered is the hand, which is made up of nineteen bones and seventeen joints. The metacarpal, or finger, bones allow for very mobile movement of the joints. These bones are connected by ligaments organized in such a way that allows the relaxed hand to take an arch-like form. Movement of the fingers includes flexion and extension. Two types of muscles control this motion, extrinsic and intrinsic. Extrinsic muscles are found mostly within the forearm. These nine muscles are used with more forceful movements of the hand, such as grasping an object, or in the case of a pianist, the force used to weight the hand for a louder, more forceful sound on the keyboard. Intrinsic muscles are the nineteen small muscles located within the hand, and they deal with the fine movements of the fingers. There are also six muscles that control the movement of the wrist.¹⁸

When looking at the movement of the fingers, it is easy to recognize that some fingers move more independently than others. For example, the index finger moves much more independently than the fourth finger. This is a result of the way the muscles are connected. Some muscles do not connect with other muscles, allowing for a more independent movement. Those fingers with more independence carry out a larger number of fine motor activities. Others, do have these interconnected muscles, causing fingers move with one another, one dependent on the other, such as the third and fourth fingers. The degree of these interconnections varies among each person, so some may have more independent ability than others. Often, overuse injuries related to the fingers

involve these interconnected muscles. When a pianist constantly works to make each finger independent of the other, tension is placed upon the muscles, causing damage and injury.

Blood vessels running from the neck through the arm sustain the muscles within the upper extremity. Nerves run along side and control these blood vessels. When the arm is moved, nerves, blood vessels, and muscles will stretch and lengthen to allow the freedom it needs. When movement occurs, the nerves move closer to the bones they run beside. Certain areas of the arm create more exposure of the nerves than other parts, such as the funny bone. The nerve running along the funny bone also runs very close to the skin. When this nerve is hit, pain occurs and injury could derive. Other areas with this type of exposure include the carpal tunnel, shoulder girdle, and the neck. When the wrist is involved in repetitious motions, the median nerve begins to stretch to allow this motion to continue. When this happens, the nerve becomes trapped in the carpal tunnel causing pain in the hand. The same thing can happen with poor posture of the shoulder or neck, sending pain throughout the arms. When exposed tissues are irritated, they tend to adhere to one another, reducing mobility, damaging tissue, and causing pain. As this happens, muscles do not receive the nutrients needed to function properly, and they will begin to deteriorate. An example can be seen in a person who has a long-term case of carpal tunnel syndrome. The intricate muscles within the hand do not receive the nutrients needed, so they deteriorate, leaving the hand looking skinner than it would with healthy muscles.

Common Injuries

A common side effect of tissue damage is inflammation. As discussed earlier, in cases dealing with ischemic pain, or lack of oxygen, tissues become damaged and weakened. Histamine, the chemical released when pain is felt, causes blood vessels around the tissue to dilate, thus causing an increase of blood flow to this area. When this happens, inflammation begins to become obvious through signs of redness and swelling.¹⁹ Inflammation of the tissues can last several days to weeks. This amount of time depends on the degree of damage inflicted upon the tissues as well as the amount of inactivity given to the tissues. It is important that pianists allow inflamed tissues time to rest and recover. If a performer “plays through the pain,” chronic inflammation could occur.²⁰ After tissues become injured and inflamed, they must be repaired. Blood sends repair cells to damaged areas to remove broken down cells and create new tissue in its place. As this takes place the tissues are restored, returning blood flow to normal, and ending signs of inflammation.

Many overuse injuries pianists encounter fall under the category of Repetitive Strain Injury, or RSI. A study by Naotaka Sakai, conducted in 2002, supplied the following criteria to define an overuse injury: 1) the beginning of the symptom occurs while practicing or right after practicing the piano, 2) there is no other medical condition, 3) symptoms recur often during practice or performance, and 4) practice is difficult enough to develop an injury.²¹ RSIs arise from prolonged repetition of the hand in awkward positions or movements. Bad posture, along with stress, can also play a part in causing this type of injury due to the unusual positions learned from poor posture. If done improperly, the repetition of certain hand movements can result in damage to the

upper extremity and cause weakness, pain, and possible loss of motor control.²² When hand movements are repeated several hours a day, for several months, or even years, the muscles, as well as the tendons, of the hands and forearms, are strained, producing microscopic tears. When this happens, unnecessary stress is put upon these muscles. Sheaths covering the tendons begin to use more lubrication because they are unable to relax. The tendons and their sheaths begin to wear, running out of lubrication and causing pain and numbness or tingling.²³ It is not uncommon for individuals to have five or six different RSIs at the same time.²⁴ RSIs can affect “neighboring” tendons or nerves, causing problems for both the neighboring tendons and nerves as well as those being used in the repetitive motions.²⁵ RSI, also defined as cumulative trauma disorder (CTD), can be divided into three categories of disorders: those affecting muscles and tendons, those affecting nerves, and those affecting the neurovascular system.²⁶

One example of an overuse injury is a sudden increase in the amount of time spent playing the piano. This could occur when one returns from a long break, such as summer, or when there is an increase practice time to prepare for a competition or performance.²⁷ Breaking from practice for a long period of time causes loss of both strength and muscle mass. When pianists begin practice again, tendons and muscles are more vulnerable to wear and tear.²⁸ To help avoid this, players should increase their playing time in stages suitable to their individual needs.²⁹ When this is done, muscle endurance will be built up allowing for longer practice time without damage to the body. Those who strive to learn pieces too quickly are also susceptible to injury due to prolonged practice sessions.

A change in repertory in which a performer must use muscles and tendons not normally or previously used can also cause injury.³⁰ Muscles work in groups of two, where as one group contracts, the other expands. To work properly, each group of muscles should have muscular strength nearly equal to its partner group of muscles. When the strengths are unequal, an imbalance could develop, leading to possible damage. The stronger muscle may suppress the weaker muscle. In the short term, cramping will occur, when over time technique can be lost. An example of this can be found through partnership among the muscle groups of the thumb and fifth finger. If the thumb is overworked, the fifth finger is likely to suffer due to the muscle imbalance.³¹

Muscle tension also causes damage to the body. Stress plays a major role in creating excess tension within the muscles and is usually difficult to control. Each pianist each has his own stress level that varies according to personal and unique factors. These stress factors lead to both physical and muscular tension. When muscles are unable to relax from tension, fatigue sets in. This result is more likely to be found with unconditioned and overused muscles than those that are conditioned and have built up an endurance to long periods of playing time.³² A pianist should be aware of his mental state in order to control the number of bad stress factors affecting his playing. The less stress a player has, the lower the risk of damage from muscle tension will be.

Muscle and tendon disorders include tendinitis and tenosynovitis. In the previous explanation of RSI, the tiny tears resulting from stress on tendons are defined as tendinitis, while the loss of lubrication and wearing of the tendons and sheaths is defined as tenosynovitis.³³ Tendinitis not only occurs in the hand, but also can be seen in both the shoulder and forearm. Bicipital tendinitis appears where the biceps connect to the

shoulder joint. Poor posture, due to a keyboard at an incorrect height for the pianist, can increase the risk of bicipital tendinitis. The inadequate height of the bench can also cause rotator cuff tendinitis, which is caused by “winged” elbows that extend away from the body.³⁴ Incorrect set-up and posture play a major part in putting unnecessary strain on the shoulders and upper back. A common forearm tendinitis is flexor tendinitis, developed from prolonged motion of the fingers.³⁵

The most common occurrence of chronic tenosynovitis is found where the thumb and wrist are joined and is termed DeQuervain’s Disease. This disorder creates pain from the movement of the thumb.³⁶ It develops by using the thumb with too much force or possibly by crossing the thumb over or under other fingers with incorrect technique and improper use of the upper extremity.

The most commonly known nerve disorder is carpal tunnel syndrome. It falls under the category of tunnel syndromes because bones, tissues, and ligaments form a “tunnel” through which nerves pass. Repetitive movements within the hand cause tissues to swell, causing pressure to be applied to this tunnel. Carpal tunnel syndrome is caused by a strained median nerve, which connects the brain to the arm and fingers. The carpal tunnel is a passageway bound by bone and ligaments located on the palm side of the hand. Nine finger tendons pass through this “tunnel” along with the median nerve. Habitual up-and-down movement of the fingers and constant motion of a flexed wrist creates swelling of the tissues and places pressure on the median nerve. Numbness, weakness, and tingling in the wrist and hands are often encountered.³⁷

The last category of RSI includes the neurovascular system, which involves both nerves and blood flow. A common disorder is thoracic outlet syndrome. Where the

nerves and blood vessels, along with the muscles of the shoulders, are compressed, pain is caused from the neck down to the hand.³⁸ This can be caused by intense strain put on the arms and shoulders, such as muscle tension from incorrect posture.

There are many solutions to help prevent and avoid these disorders. Many problems can be improved simply through rest. If the sheaths of a player's tendons are not given time to rest, pain will arise, and over time could create serious damage. Gerald Klickstein recommends three different techniques to help rejuvenate tired muscles and tendons: active, passive, and diverting. While taking a break, a pianist could actively count a rhythm or analyze chord progressions of a complex piece. Active rest allows the pianist to continue focusing on the music, while resting the arms and hands. A passive style could include actual laying down to rest. The performer is not taking part in any physical activity, but could mentally review what has been practiced and what still needs to be done. Finally, a player may divert their attention to something completely different in order to take the mind off practicing. These breaks can range from a few minutes to a couple of hours. It is suggested that pianists refrain from any activities involving extensive use of the upper extremity.³⁹

Treatments

Warming up before playing is critical in avoiding performance injuries. Warm-ups should include the whole body, not just the hands and fingers. Stretching is a good way to speed up blood flow, release tension, and relax the body. As little as two or three minutes is sufficient and should be followed by a technical exercise on the piano utilizing the fingers, hands, and arms. Once the warm-ups are complete, regular practice or performance may begin.⁴⁰ Cool down is also important. It is recommended that

performers give muscles time to rest after playing. They should avoid computers and anything involving intensive use of the hand and fingers.⁴¹

Technique plays an important role in the avoidance of performance injuries. It is critical that students learn from the beginning how to control both the piano and his body. If pain is present, the body is acting in a way it was not designed to act.⁴² Healthy technique is gained through use of the whole body, not just the fingers and hands. Intensity captured in music should come from the power and weight of the center of your body, not just the limbs.⁴³ It is a combination of both physical and mental aspects. Healthy technique is formed from the correct alignment of the muscles and bones of the skeletal system combined with an alert, attentive mind that directs the movement of these bones and muscles. Pianists must be aware of how the mind and body work together to play the piano properly and without risk of injury.⁴⁴ The mind must not only be aware of its interaction with the body, but also of how the mind itself copes with the preparation of the music. It is important that the mind stays engaged in practice and carefully organizes the method and length of practice time. If pianists have a plan, before ever beginning practice, stress will most likely be reduced, more work will be accomplished, and concentration will be easier to achieve.⁴⁵

Exercise is one of the most useful preventions of performance injuries. A toned body is less likely to be injured than one that is not toned. Here, a toned body refers to one in which the muscles have built up endurance to play for long periods of time without tiring, not necessarily a body with bulky or massive muscles.⁴⁶ Exercise should include strength, cardiovascular, and flexibility training.⁴⁷ Musicians should also be aware that certain exercises could be more harmful than helpful and should find a program suitable

for their individual needs. Yoga and other disciplines have been used by performers to enhance not only their physical fitness, but also their meditation and grace.⁴⁸

Along with these prevention techniques, other simple treatments are recommended such as ice or heat, aspirin, and a balanced diet. It is suggested to seek a doctor only if pain becomes increasingly worse over a period of several days and interferes with daily activities. Surgery is seen as a last resort. Experts advise that surgery be used only if other conservative treatments fail to work.⁴⁹

Conclusion

Knowledge of possible injuries, and especially preventions, is important to performing artists, such as pianists. Without a performer, an instrument makes no sound. When pain becomes unbearable, many pianists feel they must give up their performing careers. Staying healthy and taking care of the body largely helps prevent damage to the body as well as improve performance, which is always the goal of a pianist. Gaining knowledge and understanding of how the body moves and functions can be extremely useful in avoiding pain and possible injury. Not only is this important for performers but also teachers. In learning to recognize techniques that could be harmful to pianists, teachers are better able to help students avoid possible injuries and risks, causing them to be better aware of how the upper extremity moves and functions. Little is known about the serious damage incorrect playing can cause, but with the increased interest of this subject, more pianists will become better informed on how to maintain a healthy, pain-free performance career.

ENDNOTES

- ¹ Nicholas F. Quarrier, *Prevention of Musician Injuries* (Ithaca, NY: N.F. Quarrier, 1996), 3.
- ² Barbara Paull and Christine Harrison, *The Athletic Musician* (Lanham, MD: Scarecrow Press, 1997), 6.
- ³ Quarrier, 2.
- ⁴ Ibid., 2-3.
- ⁵ Ibid., 4-5.
- ⁶ Alice Brandfonbrehner, "The Medical Problems of Musicians," *American Music Teacher* (Jun-Jul 2001): 22.
- ⁷ Quarrier, 6.
- ⁸ Ibid.
- ⁹ Ibid., 6-7.
- ¹⁰ Naotaka Sakai, "Hand Pain Attributed to Overuse Among Professional Pianists: A Study of 200 Cases," *Medical Problems of Performing Artists* (Dec. 2002): 180.
- ¹¹ Quarrier, 17.
- ¹² Ibid., 18.
- ¹³ Ibid., 19.
- ¹⁴ Ibid., 20.
- ¹⁵ Ibid., 36-37.
- ¹⁶ Ibid., 38.
- ¹⁷ Ibid., 18.
- ¹⁸ Ibid., 39.
- ¹⁹ Ibid., 10.
- ²⁰ Ibid.
- ²¹ Sakai, 178.
- ²² Emil Pascarelli and Deborah Quilter, *Repetitive Strain Injury: A Computer User's Guide* (New York: J. Wiley, 1994), 3.
- ²³ Ibid.
- ²⁴ Ibid., 50.

²⁵ Carol Anne Jones, "Music and Medicine: Preventing Performance Injuries," *Teaching Music* (Oct. 2001): 26.

²⁶ *Ibid.*, 49.

²⁷ Gerald Klickstein, "Seven Habits for Healthy Performance: A Practical Approach to Injury Intervention," *American String Teacher* (May 2003): 49.

²⁸ Brandfonbrehner, 25.

²⁹ Klickstein, 49.

³⁰ Brandfonbrehner, 24.

³¹ Kathleen A. Horvath, "Muscle-ship: The Overlooked Foundational Element of Stringed Instrument Performance Technique," *American String Teacher* (Aug. 2003): 71.

³² Brandfonbrehner, 24.

³³ *Ibid.*, 50-51.

³⁴ *Ibid.*, 53.

³⁵ *Ibid.*

³⁶ *Ibid.*, 51.

³⁷ *Ibid.*, 54-56.

³⁸ Jones, 26.

³⁹ Klickstein, 52-53.

⁴⁰ Horvath, 71.

⁴¹ Klickstein, 50.

⁴² Horvath, 24.

⁴³ *Ibid.*, 27.

⁴⁴ Barbara Lister-Sink, "Mind and body; piano technique, plain and simple," *Piano & Keyboard* (Mar-Apr 1999): 22-3.

⁴⁵ Klickstein, 52.

⁴⁶ Brandfonbrehner, 24.

⁴⁷ Jones, 26.

⁴⁸ Klickstein, 55.

⁴⁹ Brandfonbrehner, 23.