

MUSCULOSKELETAL HEALTH:
A REVIEW OF LITERATURE

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Abstract

String musicians can experience pain while playing their instruments. In fact, research indicates that the majority of string musicians suffer from constant pain and musculoskeletal disorder. This can happen to all string musicians, from beginner students through professionals. Therefore, a review of literature was needed to help teachers to better understand the musculoskeletal system of a growing student and how to provide instruction so that pain and injury can be avoided. Research suggests that musicians should see a physical therapist, physician, and/or a chiropractor to prevent pain and musculoskeletal disorder. Adding exercises such as weight training, cardio conditioning, yoga, and stretching on a regular basis will help prevent overuse of muscles. In children, the musculoskeletal system is continuously growing and teachers need to ensure the students are sized correctly and are shown the proper set-up for their instrument. Proper set-up throughout a students' growing period along with exercising and stretching before, during, and after practice and rehearsals can help students avoid injuries during their school and/or continued music career.

Keywords: Musculoskeletal Disorder, Pain, Set-up, Physical Therapy, Yoga, Exercise

Musculoskeletal Health: A Review of Literature

Musculoskeletal disorder can plague a musician for a short time or can ruin a career. The purpose of this capstone project was to develop a document that examined the literature related to the musculoskeletal system in children and adults in order to better understand how to prevent pain while playing an instrument. This document will help teachers to recognize when a student is starting to compensate for pain or discomfort and provide guidance on how teachers can re-evaluate and help reposition the instrument for perfect playing set-up. In addition to the review of literature, I examined and suggested warm-up and cool down exercises that can be used in the classroom or practice room prior to playing. These tasks are informed by the literature and include physical activities such as stretching and conditioning.

The research questions for this project were:

1. What is the musculoskeletal system?
2. How can teachers put students into the proper playing position and instrument set-up so as to prevent pain and injury?
3. What preventative measures should be taken and what can be added to the daily routine in order to maintain musculoskeletal health when playing an instrument?

Musculoskeletal Disorder

One might associate pain with a professional string musician who has been playing their instrument for over 20 years, logged hours of practice sessions, and engaged in multiple performances in one season; however, beginning string students can also experience pain and discomfort. Much of this pain can be caused by musculoskeletal disorder, a disorder in which muscles and tendons in the human body become overused from repetitive motion, as well as the static load on muscles from holding a string instrument for long periods of time. Manchester

(1988) explained that tissues, bones, ligaments, and the nervous system work together to enable movement in the body. All of the communication comes from our brain down to where the muscle needs to move something specific. Without this system we could not move to participate in everyday life, let alone play an instrument. Interestingly, “some young instrumentalists are more likely than their elders to be bothered by these painful conditions” (Dawson, 2006, p.36). Johnson’s (2009) book *What Every Violinist Needs to Know about the Body* points out, “When bones do not stack up on balance according to design, the automatic postural patterns are not available to aid in making support and movement feel effortless. In the absence of the bony balance and the APPs [automatic postural patterns], muscle groups not designed for the task at hand start compensating. This leads to all sorts of muscle discomfort and strain” (p. 7).

Research on Musculoskeletal Disorder

There are multiple studies on the pain of adult musicians. Additionally, some researchers have investigated this issue in younger musicians. Brandfonbrener (2009) looked at 350 freshmen entering college; out of 350 students, 79% had a history of pain from playing their instrument. That is a staggering number for a freshman class to report pain while playing their instrument. Brandfonbrener (2009) used a 22 question survey for his study to look at age, gender, the instrument and the years studied on the instrument, as well as the habits the string musicians have every day. There was still a significant amount of students who dealt with pain on a daily basis.

Just as Brandfonbrener (2009) looked at college age students, other researchers went a step further. Barton (2008) surveyed college age music students as well, but with two different types of questionnaires: the DASH (Disabilities of the Arm, Shoulder, and Hand) survey and a descriptive survey that looked specifically at the activities string musicians were doing. In the

DASH survey, the participants were asked to identify the pain and the region where it was located, and to describe what type of activities they did on a regular basis. There were two different modules from which the string musicians could pick. Each one had four specific questions that related to the module picked. In the descriptive survey students were asked about their physical make-up and habits they had while playing their instruments. Barton (2008) found that 64.9% of students reported dealing with pain while playing their instrument.

When we see young musicians playing in band and orchestra at school, we are aware of what they accomplish musically and the discipline that comes with learning an instrument. What is not readily visible is the fact that learning a string instrument is not easy and students can be affected by pain. In professional musicians “the reported prevalence of playing-related musculoskeletal disorders...ranges from 39 to 87%,” (Wu, 2007, p. 43). Although there are no reports on the percentage of students who either report or complain to their teacher about pain when they are playing, the percentage could be very similar in the school setting. Brandfonbrener (2009) and Barton (2008) have found that college-age students reported suffering from pain at the secondary school level.

Young musicians start learning an instrument in school while they are still growing and developing muscularly. Rardin (2007) says, “Without proper care, the complex and repetitive physical movements that are so fascinating to watch on stage can endanger a string player’s ability to make music” (p. 1). Those repetitive movements include the side to side motion of the bow arm and the left hand fingers that play the notes. Each time a student grows, his or her violin, viola, cello or bass must change with them. Students will grow into the next size or there will be small adjustments made with the current instrument if they are not ready for the next size up. When a younger student moves up to the next size, the teacher has to make sure the student is

ready for the next size. It may be safer to keep the student on the smaller instrument for a few months before moving on to the next size because the smaller instrument will not elongate tendons, whereas the next size up may cause the student pain if the change is made too fast.

Poor set up of the string instrument can also be a cause of pain. The set up of a string instrument entails how the student places the instrument on the shoulder, between the legs, or how the instrument leans against the body. When playing a string instrument the body becomes asymmetrical; however our bodies are made to line up perfectly so we have free movement and no restrictions. Each student will have a slightly different set up for their instrument to be in a comfortable playing position.

For string musicians, pain can be an indication of misalignment in the body. Fransson-Hall, Gloria, Kilbom, and Winkel (1995) brought computer technology into their study to find out the areas in which string musicians feel pain. They studied a number of occupations including musicians, collecting data about posture and how the body performed during everyday tasks of playing a string instrument. The researchers went on to attach wires to the participants, which were connected to the computer in order to collect data. Through analysis of this data, the researchers found when a shoulder is at a high angle for too long, shoulder pain was experienced by many of the participants, specifically string musicians.

Foxman and Burgel (2006) gave out a survey to musicians to see what risk factors were associated with musician's pain. In the first survey, the musicians were asked simple questions regarding their primary instrument and the basic set up of that instrument. They also asked if any of the musicians experienced performance anxiety, stress from their job, fatigue, wrist or hand pain, ringing in the ears, and for woodwind and brass players, dental problems. Based on the data they collected, Foxman and Burgel (2006) gave the musicians information on improving their

current pain situation by modifying their practice sessions. The musicians were given ten minute breaks after every half hour to forty-five minutes of practicing. Foxman and Burgel (2006) noted musicians also have to keep their muscles warm, especially in the hands, because playing without warming up may cause an injury within the hand or the surrounding muscles that assist the hand. Zara and Farewell (1997) used a survey as well for a portion of their study;

The 36-page Playing-Related Health Questionnaire included five categories of questions:

1. Physical and Demographic Variables
2. Psychological Variables
3. Practice Behaviors and Other Playing-Related Variables
4. Non-Music Related Variables
5. Instrument Groups (p. 294).

Zara and Farewell (1997) noted that string players were more likely to suffer from musculoskeletal disorder compared to a non-musician. Additionally, females were at a higher risk than males to experience pain and musculoskeletal disorder. In their study, Zara and Farewell (1997) did not explain why females are more likely to suffer from musculoskeletal disorder than males, but it was mentioned that the body structure between male and females are different. Although Zara Farewell (1997) do not give reasons for pain between genders, string players are set up in an asymmetrical balance where muscles are in a static position for a number of hours and perhaps this can lead to the higher number of females suffering from musculoskeletal disorder.

String musicians often feel pain in the upper half of the body, including the back, neck, shoulders, arms, hands, and fingers. Leaver, Harris, and Palmer (2011), found that musculoskeletal pain was very common among string musicians who participated in their study,

particularly in the lower back, neck, and shoulder. String students may complain of pain in similar areas. Hagber, Thiringer, and Brandstorm (2005) stated “music students playing the violin or viola had a fourfold increase in right forearm pain and twice the risk for neck pain, right shoulder pain and left forearm pain compared with pianists” (as cited in Foxman & Burgel, 2006, p. 310). Playing a string instrument requires a lot of static load that causes the muscles to become fatigued and over used resulting in injury. As Zara and Farewell (1997) noted there is a higher risk of being in an awkward playing position resulting in overuse injury of a string musician.

Hagberg, Thiringer, and Brandstrom (2005) observed 36 music teachers over an eight year period. They looked at tinnitus, hearing loss, and musculoskeletal disorder. From their findings they concluded:

Among the musculoskeletal symptoms the highest incidences per 1000 years of instrument practice were found for pain in the neck and in the left shoulder, with a rate of 4.4 and 4.6 disorders per 1000 years of instrumental practice, respectively. There was a 2.4 times incidence for musculoskeletal disorders in the right hand/wrist and a 2.2 times incidence for musculoskeletal disorders in the left elbow/forearm for musicians who practiced for 20 h[ours] or more per week before the onset of disorders compared to those who practiced fewer than 20 h[ours] per week when controlling for age and gender (p. 582-583).

String musician’s necks and shoulders became the main focus of Hagberg, Thiringer, and Brandstrom’s (2005) study. These areas of the body are where the majority of the load for the violin and viola player holds static for hours during personal practice, rehearsals, and performances. For the cello and bass this area may become overused as the shoulder joint is the one of the main pivot points for bowing as well as being static.

The Effect of Pain on Students

Young students are still developing physically when they begin to learn an instrument in school. The size of an instrument, particularly larger ones, and playing position can cause students to hyper-extend joints. Larsson, Baum, Mudholkar and Kollia (1993) found that students with hypermobility were more likely to suffer from pain than those who did not have hypermobility. Hypermobility is where a joint extends past the normal range. According to Larsson et al. (1993), hypermobility can be an asset or a liability depending on what joint is hypermobile.

Specifically, subjects who played instruments requiring much repetitive motion were hypermobile than if they were not hypermobile... subjects with hypermobile joints not involved in repetitive motion but subjected to stress during the activity more often had symptoms than those with joints that were not hypermobile (Larsson et al, 1993, p. 1081).

The weight of an instrument can also play a role in contributing to discomfort and pain a string playing student may experience. Multiple factors are in play when it comes to musculoskeletal disorder. Dawson (2006) gives three reasons why students may develop an overuse injury while playing. First the body is taking on more than it can handle, such as overuse during an intensive event like band camp. Second, students may not be properly set up to play their instrument. Third, students with hypermobility may also end up with a performance injury.

Larsson et al. (1993) looked at the benefits and disadvantages of being hypermobile. They found adult musicians who have hypermobile joints were more likely to have pain than those who do not have hypermobility of the joints. Although Larsson et al. (1993) looked at adults, young students can be very hypermobile. Hypermobility can cause a person to be stiff in the joints that can be hyper extended. With hypermobility, students can struggle with their bow

arm at the elbow joint as well as keeping the left hand fingers curved while playing the instrument. Besides being hypermobile Hagber, Thiringer, and Brandstrom (2005) also found “a high load on the neck and shoulders for violin players had been reported” (p.582). A majority of string instruments are not positioned properly and/or the shoulder rest and chin rest are not the correct height that will cause pain in the neck and shoulders.

Within the classroom “some music teachers maintain that improper technique is the major culprit, but the technique that works well for most students and for the teacher may not work at all for another student” (Manchester, 1988, p. 150). Every student is different in growth rate and height. When students grow at a rapid rate muscles cannot keep up with the demand that is expected in an instrumental classroom (Dawson, 2006). This may cause muscles to become overused or may result in tendinitis.

Some string musicians do not view playing their instrument as a physical activity, neglecting physical warm-ups and cool-downs as part of their daily routine. Russell (2006) conducted a study with middle school string students to see if warm-ups had an impact on eliminating any discomfort. He found that “warm-up frequency had no significant impact on overall discomfort” (Russell, 2006, p. 99). From this study, warm-ups had no true impact on younger students in the present; however, over time students may start to feel the impact of not doing any warm ups before playing their instrument. When a string musician ignores doing a warm up, the muscles may become more quickly fatigued. Doing a warm up at the beginning of a practice session will reduce the risk for pain.

Russell and Benedetto (2014) conducted a study that focused on middle school age students. The students were in their first to third year of learning a string instrument and they implemented a warm-up schedule to be added to the start of the rehearsal. Russell and Benedetto

(2014) state it is important for young string players to practice healthy habits, especially while practicing to reduce risk of injury, and that teachers are to watch and take an active role in making sure their students are not playing with pain. Teachers, need to make sure their students are set up for success in every aspect of playing an instrument. Often teachers are not trained in what to look for in making sure their students have the proper set up. Russell and Benedetto (2014) stated:

If it is the responsibility of the institution to educate future music teachers in injury prevention, it follows that those music teachers are responsible for using their expertise to help their students develop healthy practice habits, prevent pain, and avoid injury. In this endeavor, a teacher's first step may be to identify and better understand what pain his or her students experience and what practices may best mitigate pain (p. 260).

By providing a class for future instrumental music teachers on the human body and what to look for in the proper set up of a string instrument could be very beneficial. Teachers would learn to correct the students physical and instrumental set up to reduce the risk of injury.

Relieving Pain in Young Musicians

There are several treatment options for students playing with pain related injuries, including doctors who specialize in working with these specific types of injuries. Alternative medicine can also be added to what the physician prescribes. Although surgery can help in certain circumstances, physical therapy or seeing a chiropractor can usually alleviate pain and discomfort. When surgery is needed, it is important for the doctor and physical therapists to communicate with one another to make sure the healing process is going smoothly.

Physical Therapy

String Musicians have a lifetime prevalence of performance-related musculoskeletal disorders (Chand, Driscoll, & Ackermann, 2012). When an injury happens, string musicians often will visit their regular physician or a therapist, who are not trained in instrumental injuries, but try to give the best care they can for the musician. However, sometimes the treatment and/or diagnoses of the injury can be wrong. Over the past few years, medical clinics have opened to serve the injured musician (Manchester, 1998); however, medical practice for musicians is new, but musicians can educate the doctor and therapist about what is involved while playing their instrument (Quarrier, 1993). Quarrier (1993) found that a regular physician had a low success rate in treatment, whereas the physical therapist had a higher rate of success in working with the injured musician. These inconsistencies suggest that a specialized clinic for musicians could provide the care needed to heal and prevent further injury.

Although string musicians typically see physicians and physical therapists when a problem arises, another type of doctor, the chiropractor, can also provide effective care. The chiropractor looks at every aspect of the musician's bone structure and determines the best possible healing and realignment for that musician. Through manipulation of the musculoskeletal system, the chiropractor is able to make adjustment to ensure everything is properly aligned.

Keeping the back and spine healthy is very important for string musicians. When the spine is compressed, the nerves that run all of the information need to be subluxated to make sure the signals from our brains reach the certain part of the body that has to do a specific task. Depending on age and the wear and tear that a musician has put on the body will determine what needs to be done so no further damage to the spine and other joints continue. Either within weeks or over a few months a person can feel the difference in their physical health and overall health.

Dr. Timothy Jameson is a chiropractor who created a website called Musicians Health and founded a network of chiropractors throughout several states that specifically work with musicians. These chiropractors ensure the musician's musculoskeletal health is getting the best adjustment as an alternative or extra assistance to the care they are already receiving.

Practice is one of the primary ways musicians improve their technique and playing style, and prepare for concerts. Along with practice, exercising is another way to prepare for playing an instrument. Quarrier (1993) stated most musicians are not properly trained in exercises and stretches; however, a physical therapist can educate a musician on stretches and exercises that help to avoid injury. For instance, when a player is injured during a sporting event, the medical staff immediately tends to the player, starts working in that area and the relating areas to start the healing process and, if needed, start physical therapy. Just as "when a tennis player is injured, she has her form and stroke analyzed by her coach. The injured musician also needs her technique examined by her instructor" (Quarrier, 1993, p. 92). Li and Buckle (1999) suggested using videotaping, self-assessment, and pen and paper to help musicians, doctors, and physical therapists to diagnose the injury.

Every musician should be doing a self-assessment of some sort at home while practicing. When musicians self-evaluate while playing, they are learning what hurts and when to make an adjustment to stop the pain. A musician can videotape themselves and evaluate the tape later with a doctor, physical therapist or the chiropractor to see what adjustments can be made. I have personally videotaped myself to see what I needed to adjust to relieve pain in my shoulders. Practicing in the mirror and making adjustments along the way will improve the playing quality and help to prevent injury. Mirror practicing is great for young students as they can see what they are doing and make the minor adjustments in placement of their instrument on the shoulder,

between the legs for cello, or how they stand with a bass. Mirror practicing also gives the students a chance to see what their bow arm is doing and make the adjustments needed. My students do mirror practicing in order to learn what adjustments are needed to their body, instrument set up, etc. Teaching young musicians the tools to succeed while learning to play their instrument is necessary.

Exercises and Stretches

Exercises can be a tedious task and are often left out of the musician's daily routine. A workout routine should be added to a musician's schedule. When a musician adds a workout, it not only improves the health of the musician, but strengthens the areas that are put under a lot of stress when playing an instrument. By doing a regular routine of cardio and strength exercises, a musician can prevent injury while playing their instrument; however, the musician has to be aware of the proper technique in working out as well. "Strengthening, as with the athlete, should consist of basic progressive resistive exercises and endurance conditioning" (Quarrier, 1993, p. 93). Musicians, do not put in enough time for physical conditioning for the long hours of playing. Without conditioning the muscles, an over use injury of a muscle can occur. Pacelli (1989) interviewed a violinist from the New York Metropolitan Opera Symphony, who said, "musicians have no tradition of regular exercise, despite the significant strength required to play certain instruments and maintain posture during practice and performances of up to several hours" (as cited in Quarrier, 1993, p. 93).

Stretches

Besides going to the gym and keeping physically fit, stretching is a very important for a musician. A string musician should include stretching in their warm-ups routine before every practice, rehearsal, and performance. The upper body is the main focus in stretching for a string

musician. An article from the magazine *The Strad* provided excellent information of eleven stretches that string musicians should use. For instance, standing tall, you let everything relax as you breathe in and out while standing tall. This will allow you to set up properly and have your head in the correct position. When standing tall, think of a string pulling you up from the crown of your head and allowing your upper body to become limber and relaxed.

Stretching the arms and fingers is important for string musicians. For example, to stretch the arms and fingers, hold your arm straight out in front of you with your palm up. With your other hand, gently pull down all of your fingers, including the thumb. Gently push your fingers down and towards your body bending your wrists. You will do the same process for the other hand. You can also do this stretch by pulling your fingers up as well; this will start with the palm facing the ground. After stretching out the hands and arms, string musicians should proceed to stretch out the oblique's and back through oblique's and roll downs. For roll downs you will reach down to the toes and slowly roll back up extending your arms over the head will open the spinal cord disks back to position. Obliques are side muscles of the torso and part of the abdominal structures. To stretch the oblique's you will reach one of your arms over the head and bend to the side and then to the other. Musicians do not realize that they use quite a bit of their back muscles while playing their instrument. Doing stretches at the beginning and end of playing your instrument will prevent pain and overuse in the long run.

Yoga

Yoga can be beneficial for string musicians as it provides stretching, and promotes relaxation and flexibility. Khalsa, Shorter, Cope, Wyshak, and Sklar (2009) performed a study at Tanglewood during the eight-week summer program where musicians were invited to participate in a Kripalu Yoga and meditation program. Faulds (2006) stated Kripalu is a classic yoga

practice that includes breathing techniques and meditation (as cited in Khalsa et al., 2006).

Khalsa et al. (2006) discussed that in an eight week period yoga showed and proved that it can reduce stress and performance anxiety.

Yoga can improve core strength, as many of the positions require a lot of balance. YJ (2013) suggested different yoga positions that a musician can easily learn and do at home or in the yoga studio, including positions for the arms, like Warrior I and II, Cow-Face Pose arms, and few others. These positions can help regain all of the motion in the arm. For the back, doing poses like the Cobra, Sphinx and the Locust position help the back from becoming rounded, especially for string musicians where the back is rounded while playing their instrument. All of these poses also include the legs, where the legs are elongated through stretching. This is very helpful for someone who sits while playing the majority of the time. Although many yoga poses can be done at home, attending a class lead by a yoga instructor can ensure that the body is properly aligned as poor technique can be a cause for injury.

Weight Training

A weight lifting routine can be done by using free weights or weight machines to build muscle. When using a weight machine, follow the displayed instructions. Begin with a weight that is light, but that will challenge the targeted muscle. When the weight becomes too light to feel the workout, start slowly increasing the weight. When using weight machines, musicians must work out all muscles involved in the movement. For example, if a musician uses an abdominal machine, he or she should also use a machine that focuses on the lower back. Working out the front and back muscles of the abdominal section will ensure evenness and stability. While using free weights, musicians have to use the proper amount of weight and the correct stance for the best results. Trainers are available to work with you on any machine and/or free weights.

While working out, the musician can do two to three sets of 10 to 15 repetitions with one minute of rest between each set. The one minute rest gives the muscle time to fully recover. Som (2004) wrote an article for Body Building stating that the 60-90 seconds of rest is optimal for the muscle to make a full recovery. Som (2004) also stated when a person waits too long between sets they will lose the drive to continue; whereas, if there was not enough time, then the person will become fatigued a lot faster. Resting in between also helps prevent injury, whether using the weight machine or free weights, this is crucial in making sure the muscle recovers before continuing with the next set. After working on a particular section of the body, musicians must give the area 48 hours to recover and heal. During this time, the musicians may work on another area of the body. Rotating muscles groups is very important in reducing injury and overuse of the muscles that are worked on.

By establishing an exercise routine that includes stretching before and after exercising, string musicians can enable themselves to play for a longer period of time. Stretching before, during and after practicing, a rehearsal and a performance, will keep the musicians' musculoskeletal system healthy and injury free. This goes not only for the professional musicians, but for students at every stage of playing a string instrument. Their exposure starts in the classroom, so setting the example that stretching before, during and after everything they do to play their instrument will continue on with them as they grow in their playing.

In the classroom

Many teachers are guilty of starting right into the lesson for the day without any type of physical warm-up routine as part of their rehearsal. However, playing with cold muscles can lead to injury. Zara and Farewell (1997) discussed that doing a warm-up and taking breaks should be incorporated into a musician's routine in a rehearsal and practice, as it will benefit the learning

process and will prevent injury. Making sure the hands through the shoulders and neck are warmed up will help them be ready for faster passages and playing for a long duration of time. Without a physical warm-up of some type, playing cold will result in an overuse injury. Throughout the rehearsal taking mini breaks where students put down their instruments will prevent an overuse injury. This will also give the muscles that are static time to relax before playing again.

Sizing Instruments

Ranelli, Straker, and Smith (2011) found that students complained the most about their back, wrists, hand, forearm, elbows, and neck. As teachers, we need to make sure that our students are having the best musical experience in the classroom. This not only includes the type of instrumental curriculum that is taught for the school year, but our students' physical health. One way we address students' physical health is by sizing their instruments from the first day of study.

Violin and Viola. To fit a violin and viola, the left arm will be extended out with the scroll sitting in the palm of the hand for the correct size. Students will constantly change how they set the instrument on their shoulder; to where teachers need to check the height of the shoulder rest and chin rest to insure the violin and viola students are comfortable. The student should not be lengthening their neck in any way to make the instrument properly fit. The student should be relaxed from the neck down through the shoulders with the violin and viola sitting there. Shoulder rests have adjustable feet to make it higher or lower based on the height of the chin rest and the distance between the chin and shoulder of the student. The feet on the shoulder rest can be marked off with permanent marker to let the student know this where the feet of the shoulder rest needs to be at all times, when the feet have changed height positions.

There are different heights, shapes and placements for chin rests as well. The chin rest needs to fit the student comfortably along with the shoulder rest placement. Trying out different chin and shoulder rests takes a bit of time, but once the chin rest and the shoulder rest work together to provide a comfortable fit for the student, the adjustments will be easy from there. Along with the proper fitting of the shoulder and chin rest, Johnson (2009) gives a five point of contact for the violin and viola player to follow: 1) jawbone; 2) collarbone shelf; 3) side of the neck; 4) left hand; 5) friction of bow hair on string. When these are followed the student will be less likely to develop an overuse injury while playing their instrument.

Cello and Bass. Making sure that the end-pin is at the correct length and the students are sitting and standing correctly for their instrument is paramount for cello and bass players. For the cello, students can sit on a foam padded seat that is angled to improve their seated posture. The foam padded seat will also correct the cello students' feet so that they stay flat on the ground and not on their tip toes. With the padded angle seat, the end pin will be at the same length every time. A teacher can also mark off on the end pin that is needed for each student in different permanent marker colors when multiple students are sharing a cello in different classes.

Basses can set up a couple of different ways: standing and sitting. The bass end pin can be marked the same way as the cello, as the basses are often shared from class to class. While in a standing position, the bass will be angled into the student to a certain degree creating a small "A" like shape at the bottom between the student's feet and end pin. The student has to be able to reach for bowing and have the hand width to play the instrument. Making sure they have the correct size bass is critical. As such, most often students are not started on bass until second or third year of string education. The basses can also have a stool if they decide to sit, but the stool has to be at the correct height along with the end pin to make everything work. Students still

have to be able to reach down to bow and finger the notes in first position. Just as the standing bass must be in the correct position, when they are sitting the bass will angled between the legs so the bow arm is able to reach each string. The left foot must be on a rung of the stool that best fits the student with the knee touching the back of the bass. The right lower corner of the C bout point, the curve in the middle of the instrument, will be resting on/or inside the right knee for the extra stability. The end pin may have to come out longer for the bass to be in the correct spot for both the bow arm and the left arm for playing the notes.

Furniture

In making sure that students have the correct size of the instrument needed and are set up properly, the type of furniture in the classroom may need to be adjusted. As teachers we might not think about the height of the stand or the type of chair the students are sitting on. Just as teachers have their own personal preference for their own home practice or in an ensemble of how they set everything up, so do students and the classrooms have to be flexible for everyone. Reel (2005) interviewed Judy Palac of Michigan State University about the healthy habits for students, including the type of chair a student sits in. Reel (2005) revealed that Palac pointed out your knees should not be above your hip joint, resulting from the chair being too low to the ground, rather the knee should be parallel to the ground with the legs at a 90-degree angle. It is important for a teacher to have students help test out chairs before deciding which ones to purchase. Music stand will also need to be adjusted. A student should be sitting up tall with a straight back while playing. In orchestra, students share a stand, and finding the perfect balance between the two students can be difficult. Teachers and students will make the adjustment needed to insure that everyone is sitting tall and can still read the music. No one should be hunched over to play their music.

Classroom stretches

In the classroom, teachers need to make sure the students muscles are warmed up by doing physical warm up activities before starting a rehearsal. This will reduce fatigue during class time. Wilke, Priebus, Biallas, Frobose (2011) give a whole mobility program for musicians to work on in the gym or at home. Students can easily do running, biking and swimming and stretching at home and in the classroom. The exercises and stretches presented earlier can also be done in the classroom. For example, the following stretches can be done in the classroom at the beginning and end of rehearsal:

- Arm circles: big and small, circling forwards and backwards ten times
- The neck: stretching the sides, front and back. Do not roll the neck around. Thirty seconds each.
- Shoulders: circle forward and backwards ten times.
- The back: stretching from your toes and rolling up slowly then extending the arms above right.
- Arm and hand stretches: described later, hold for thirty second each.

Students can benefit from stretching out the chest area. To open the chest area and stretch out the muscles students will have to spread out in the room. Their arms are placed out to the side like they were going to do arm circles. Point the thumb towards the ceiling and reach back to open the chest up; then do the same thing with the thumbs down towards the floor. Another way to stretch the chest is to clasp your hands behind your back.

Chan, Driscoll, and Ackermann (2012) discussed that in a sitting and standing playing posture, the core muscles are used to stabilize and support the musician. Making sure that the abdominal area is stretched out before and after playing is important. The abdominal muscles are

held static while playing; by doing the oblique stretch and the cobra yoga position the muscles will relax. Another stretch for the abdominal muscles is to bend backwards while in a standing position, or doing the yoga pose called the one-armed camel. The one-armed camel starts by kneeling and bending backwards with the right hand touching the ground and the left arm extending behind the body, then switching sides.

Wilke, Priebus, Biallas, and Frobose (2011) looked at ways to prevent musculoskeletal injuries for string musicians; one that they focused in on was motor activity. They looked at endurance and strength as the main factors for string musicians. In the classroom, working on endurance can be difficult. One way to work on endurance is to have students do simple cardio exercises to elevate the heart rate. Students can spread out in the room to do simple jumping jacks, running in place, or walking around in a circle to get their heart rate up and ready to play.

Playing exercises

To keep students on their toes, a teacher should always be changing up the rehearsal so the class is not doing the same thing day in and day out. Students love to lead the stretches and warm ups once they know how the classroom is run. By giving students the chance to run the beginning portion of the class, the teacher has time to walk around and correct students' posture while stretching and playing. There can be a different student every day or a student for the week that runs the beginning of class. Students will be motivated to do the stretches and warm ups in class as well as doing them at home for their own personal practice. It gives them a sense of ownership while the teacher still has control of the classroom.

There are multiple types of warm ups that students can do together as a whole. Scales can help to get the ear in tune with everyone else, and get muscles warmed up even further. Scales should start out slow and gradually get faster. Depending on the level students are at, the scales

will range from one octave to three octaves. Scales should start out as six beats per bow with the quarter note beat set at 60. Students are challenged to use the whole bow in six beats. From six beats the students will play whole notes and all the way down to sixteenth notes still with the quarter note set at 60. This gradually warms up the fingers and gets the student's ears listening to themselves and everyone else. The technique books at every level should be used at the beginning of class. Many of the technique books touch on rhythms, bowing technique, shifting, counting and listening to each other. These not only warm up the students bow arm and fingers, but it also gets them thinking as well. Besides technique books teachers and students can create their own warm up activities by taking a section from their pieces they are working on and focusing on the rhythm in the key the piece is performed in.

During rehearsals students should not be playing their instrument constantly without resting in between. Students, just like adults, need small breaks throughout the rehearsal. Placing in little change ups is critical to keep students focused and a chance to relax. After rehearsing a piece for a period of time, take a couple of minutes to stretch out and shake out the arms and hands. This will get students to relax and a chance to digest what they were just doing before going back and working on a section of a piece. When going back to work on a small section within the piece, start out slow to hit all of the notes and make sure that all fingerings for the passage is correct. By taking passages slow students are memorizing with their fingers where everything needs to be placed. Adding rhythms to a passage of eighth or sixteenth notes in varying ways the student's fingers and bow arm start to memorize the passage. Gradually speeding up the rhythms in place of the passage gets the students concentrating where everything is to go. Taking away the rhythm and playing the passage as is will show improvement and give the students another way to practice.

When the notes in a piece are simple, it is a great time to take away the left hand and practice with just the bow arm. This is great for working on a difficult bowings and string crossing. The student's can go into rest position, still sitting with good posture and air bow the string passage. In doing so the students can say the bow movements of up, down, up, a slurred down to a slurred up bow. Teachers are able to see who is not doing the correct bowing or is confused about the bowing. For air bowing this should start out slowly to make sure everyone is on the same page with the bow changes and work up to the tempo of the piece. Another way students can practice bow changes is by placing their bow on the strings. The students will still say the bow changes within the passage they are reading. A great way to practice string crossings, is to have students place their left hand on the shoulder of the instrument and let the right hand do the work. Every student will play just the open strings when working on string crossings, but keep in mind that the students have to keep their bow on the string where the notes are played before crossing over to the next string. These two rehearsal techniques give the students a different pace and some time to relax here and there.

Dawson (2006) stated that for every 25 minutes of practice there should be five minutes of down time or a break. When a high school orchestra class runs for an hour, it is a good idea to take a break where the students sit down their instrument. Here, the teachers can go over a few spots for marking in bowing, fingerings and the road map to a piece. This can also be a time where students reflect and do small journal writing about what they have worked on so far and save some for the end of class before they leave to go to the next class. For younger students who are just starting out on their instrument, breaks should be taken more often. The younger students' muscles are becoming used to holding an instrument and staying static for the 25-40

minute period they are in class. Making sure that younger students understand the importance of taking a break and stretching will be a tool in their tool box for the rest of their lives.

The rule of 25-5 is wise for any string musicians to take small breaks while practicing to reduce fatigue and pain. This regains focus and lets the muscles relax before continuing on. Students can become mentally fatigued as well. Ensuring that there is a break between each piece or during a piece after a hard rehearsal on a specific section, gives the students time to reflect and digest what they have learned and worked on.

At the end of rehearsal, it is important that students cool down so their muscles do not come to a screeching halt. The same stretches and playing exercises that were done at the beginning of class can also be done at the end of class. For playing exercises, teachers can begin a scale with sixteenth notes with the quarter note at 60 beats and working the way back down to six beats per bow. A great way to end out the class is by doing some breathing exercises where student inhale for four counts and exhale for eight counts to calm everything down in the body. This also reduces the stress that was put on the muscles during rehearsal and calms the brain before students continue on with the school day.

Conclusion

Playing a string instrument can be a very rewarding activity for everyone involved; however, pain and injury can dampen that reward. Professional musicians are not the only ones who suffer from pain. Brandfonbrener (2009) noted that 79% of college music students reported playing with pain at a young age. This is a staggering number to think about for college students who already deal with pain. Even though there is no percentage given to beginning students, many of them play with pain just as their adult counterparts in the music profession.

To keep the musculoskeletal structure of the body pain free is to keep the body healthy. Exercising and stretching will help to prevent the overuse injuries that many string musicians encounter. While exercising it is important to remember that strength and cardio will help prevent musculoskeletal disorder. String musicians can exercise at home or in the gym, by doing weight lifting, weight machines, and cardio activities, including biking, swimming, and jogging. When the body has proper conditioning, playing an instrument will become easier and there will be less stress on the body. All string musicians should focus on the upper half of the body, as it holds the most static load from the abdominal section through the back and shoulders. Yoga is another great exercise that works with stamina and strength throughout the body. Yoga can be practiced at home or in a studio where the yoga teacher can correct the positions when needed.

Medicine has come a long way for musicians; many doctors are now specializing in working with musicians. Regular physicians, physical therapists, and chiropractors are forms of medicine that benefit the musician in staying healthy and injury free. Physical therapists work with musicians on stretching and on specific areas to reduce pain and fatigue. Chiropractors can help to alleviate pain when a muscle has become overused. Chiropractors also work within the spinal area to realign the spine. In doing so, the nerves are no longer pinched when adjusted back to the correct position. For both physical therapists and chiropractors, making sure musculoskeletal structure is in the proper position will reduce pain and start to heal with continued sessions.

Students can benefit from seeing the correct doctor when dealing with an injury. They will also benefit from the correct fitting of the string instrument that they are learning. Making sure the instrument has the proper fit for the student will go a long way in preventing pain as they grow. Teachers have to keep a watchful eye on their student's posture and playing position

to make sure that are set up properly to prevent pain. The size of the instrument is also very important and ensuring that each student has the correct size. While in the classroom teachers need to make sure that they are adding physical warm ups at the beginning of class to taking breaks in between pieces or after a hard rehearsal on a particular section. As well as doing physical cool downs to relax the muscles at the end of rehearsal to prevent pain.

It is important that at every level musicians are receiving and doing everything that they can to reduce and prevent pain for future practice, rehearsals, and performances. Musicians need to stay healthy and not let exercises and stretching be put on the back burner. Beginning string students will learn from the start that stretching before, during, and after they are playing will keep their muscles healthy. No musician wants to play with pain throughout their musical career. Doing simple exercises and seeing a doctor on a yearly basis will insure a healthy musculoskeletal system.

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