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AN APPLICATION OF THE PRINCIPLES OF ANATOMY, PHYSIOLOGY, AND NEUROLOGY TO THE BALANCING AND PLAYING OF THE FLUTE

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AN APPLICATION OF THE PRINCIPLES OF ANATOMY, PHYSIOLOGY, AND NEUROLOGY TO THE BALANCING AND PLAYING OF THE FLUTE

A DOCUMENT APPROVED FOR THE SCHOOL OF MUSIC

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ABSTRACT

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Flutists encounter significant physical problems in the course of their everyday playing of the instrument and are frequently not given the detailed and accurate scientific teaching and training that would prevent the problems in the first place. The purpose of this study is to investigate the prevalence and scope of performance-related problems among flutists and then to provide science-based teaching about how the body organizes itself to play the flute. Physical difficulties related to playing the flute are analyzed through a large-sample online survey and personal interviews with six prominent flutists. The second half of the document is a scholarly application of the scientific knowledge of anatomy, physiology, and neurology to the physical action of flute playing.

The survey data encompasses the combined responses of 181 respondents with results indicating that a majority of flutists experience pain related to their playing yet have little training in prevention. The dramatic stories of performance-related injuries by the selected interviewees serve to underscore the need for more education for musicians and research by scientists in the field of performance arts medicine.

Applying the facts and principles of anatomy, physiology, and neurology to the playing of the flute presents today's flutists with many new science-based concepts to consider while they are practicing or performing. Because of the asymmetrical body position required to play the flute and the unstopped arrangement of our embouchure, flutists must put more emphasis on achieving a healthy posture and balanced stance for playing that supports the active respiratory demands of the instrument.

CHAPTER ONE

INTRODUCTION TO THE STUDY

Purposes

The purpose of this document is two-fold: first, to investigate the physical difficulties of playing the flute through a large-sample survey and interviews with several prominent flutists and secondly, to apply the scientific knowledge of anatomy, physiology, and neurology to the physical action of flute playing. Different schools of thought exist among flutists concerning how to properly set up the flute and the body in order to play the instrument. The aligning of the joints of the flute is a much discussed issue as well as the position of the flutist's hands, upper torso, and overall stance of the body. The survey and interviews will cover these issues as well as other questions relating to the physical aspects of playing the flute, including postural problems and other physical difficulties of flutists. A thorough discussion of functional anatomy as it relates to balancing and playing the flute will conclude the work.

Need for the Study

A multitude of opinions and a general lack of consensus concerning the way in which the human body organizes itself to play the flute exist in the music world today. Dissemination of these ideas, whether good or bad, is both rapid and far-reaching in large part because of the world-wide web and its ability to offer virtually instantaneous communication. On a local level, teacher-to-student transmission of knowledge via the centuries-old apprenticeship model has served us well; but if teaching about how the human body is used during flute-playing is incorrect or lacks solid evidence in the scientific literature, faulty ideas begin their inexorable path up the flutists' family tree. Unsuspecting flutists end up being the recipients of unproven concepts of body use, with the very real possibility of establishing the bad habits that later prove so hard to eliminate.

Most young flutists begin music instruction in a school setting at approximately the fourth or fifth grade. They are taught by busy band directors who must also teach other students how to play different instruments during the same class period, which is typically less than an hour. Learning to play the flute is at first very difficult and awkward, due in large part to our markedly asymmetrical playing position. Even getting the first sound can be extremely frustrating. Once the student has chosen an instrument, parents tend to 'wait and see' if this new hobby will 'take' before they are willing to front the cost of private lessons. So the young flutist is left virtually on her own to try to balance her flute and get a decent sound with her smaller not-yet-grown-up body.

An additional complication arises when the young flutist takes her seat with her fellow band members in a large ensemble setting. The concert band set-up is not conducive to a good playing posture as flute players are usually seated in the front row. Even though they need extra room to accommodate their instrument sticking out to the side, flute players end up having the least amount of room of all the members of the ensemble. More bad habits in posture and playing position are the result. Another complication occurs later in high school, as the correct playing posture for flutists during marching band season requires the flute to be held in a horizontal position in the same plane as the body – an extremely awkward and uncomfortable position that strains the spine, neck, shoulders, and arms. If continued during concert settings, both during and after marching season, this poor playing set-up is not only uncomfortable and tiring, it also limits the flutist's developmental potential and sets them up for musculoskeletal problems. Bad habits can go unchallenged even as far as the university level.

Inaccurate and incomplete information about the body as it plays the flute is frequently accepted as true by unsuspecting flutists who are anxious to do anything they can to get better. A few anonymous examples are in order. I have personally observed flute teachers in either private or public settings or in print give all of the following questionable instructions. Flutists have been told to "breathe from the bottom of your lungs first," an impossible task in that the lungs fill from the top. For years, flutists have been instructed to use their diaphragms to initiate vibrato, another impossible task as the diaphragm cannot possibly fluctuate as quickly as vibrato does. Vibrato in flutists is the result of oscillations in the vocal folds, the same mechanism used by vocalists.[1] The only difference is that flutists do not produce a sound; they instead moderate the flow of the air stream.

I observed a flute teacher have a student place the embouchure plate on the edge of her lip (where skin of the chin changes to lip tissue), with no instructions to have it rest on her chin. The flutist then began experiencing quivering in her embouchure because she was trying to balance the flute on the thin line of her lip – an impossible task. Conversely, another teacher insisted on full contact with the lip plate and pushed the far end of that student's flute back so far that her right shoulder and arm were obviously uncomfortable

[1] Alan Watson, *The Biology of Musical Performance and Performance-Related Injury* (Lanham, Maryland: The Scarecrow Press, Inc., 2009), p. 129.

and contorted. All flutists, including those in primary and secondary education, need to differentiate this ‘marching band’ position from a standard concert playing stance/sitting position.

Some more examples will highlight this problem even further. The inability to maintain long phrases with proper air support is a common problem among flute students. A cure for insufficient air has been suggested by having the student expand the abdomen during inhalation. Unfortunately, this ignores the role the ribs and spine play in inhalation. A long controlled exhalation merits more emphasis than does an efficient inhalation when considering the playing of long phrases. In addition, breathing techniques given to other wind instruments does not always apply to flutists. We are the only wind instrumentalists that must provide our own resistance to the air flow as we have no mouthpiece to push against when making our sound. Therefore, the mechanisms needed to manage air on the flute are more similar to those used by singers. Flute players and those who teach them need to recognize the difference and have it inform their teaching and playing.

The lack of understanding of how the forearm moves has been suggested as the cause of lateral epicondylitis or tennis elbow – a vast oversimplification. Understanding a standard range-of-motion action for a joint is not enough; finding out what caused the problem is a much more detailed and complicated process.

The number of flute teachers, both private and in the school system, in our country is large. They all have enormous influence over their students and pass along important knowledge. The levels of scientific knowledge of human anatomy, physiology, and neurology vary wildly among flute and music education teachers, affecting how they teach their students. The presentation to flute instructors of research-based scientific principles related to playing the flute will provide the conduit to educate the next generation of developing flutists.

The popularity of the flute as instrument of choice among many students and musicians comes with its own set of problems. Although anecdotal, the following clearly illustrates our problem. At a beginning band class at a local middle school during the fall semester of 2009, all instrument groups were reasonably represented with three to fifteen children in each instrument group. Yet there were *twenty* students in the beginning flute class. The attrition rate will of course reduce these numbers, but as the remaining flutists develop into more seasoned players, they must compete for a limited number of openings and jobs, adding to an already fiercely competitive job market. A strong will and determination to succeed may propel a musician's progress in one respect, but if not kept within the context of accurate teaching and sound physical principles, the very same drive is likely to lead to career-threatening or career-ending injuries. The same conditions that result in world-class performers may inadvertently provide a breeding ground for overuse injuries.

Health Concerns and Need for Prevention

Performance-related health disorders (PRHDs) are potentially career-ending injuries suffered by artists in the fields of music and dance. The rate of injuries among musicians is reported as being as high as 87% yet the healthcare consultation rate remains low.[2] A study of 340 wind instrumentalists in Lebanon who were experiencing physical

[2] C. Guptill, "Musicians' health: applying the ICF framework in research," *Disability and Rehabilitation*, 30:12-13 (2008), pp. 970-7.

problems revealed an average age of only 28.5.[3] The prospect of years of intense practicing and performing only to be sidelined by an injury can have not only dire professional and financial effects, but severe psychological ones as well. The stakes are truly high.

Unfortunately, the relationship between musicians and the medical community does not have a particularly stellar history. Musicians tend to seek out alternative methods of healing, probably in part because of the low and inconsistent pay of their career and the expense of modern medicine. A lack of understanding among traditional medical practitioners of the demands of a musical career can leave hurting musicians seeking a more sympathetic ear elsewhere. Approaches such as Feldenkrais, Chiropractic or Alexander technique are all examples of alternative or complementary medicine,[4] and have been the beneficiaries of this rift.[5]

Different disciplines under the umbrella of complementary medicine have their own terminology which, while helpful in its own context, can cause confusion when used in discussions and consultations with other health care professionals and the general public. Terms such as 'lengthening and gathering of the spine, 'body mapping,' and 'primal control' are self-evident to users of those methods but are unclear and foreign to the language of the scientific community. On the flip side, medical jargon has completely confused and alienated many a patient whether he or she was a musician or not. A

[3] M. Sayegh Ghoussoub, K. Ghoussoub, A. Chaaya, G. Sleilaty, I. Joubrel, K. Rifaï., "Orofacial and hearing specific problems among 340 wind instrumentalists in Lebanon," *The Lebanese Medical Journal* 56:3 (2008), pp. 159-67.

[4] Alternative medicine includes methods for the prevention, the diagnosis, or the treatment of disease that are not generally accepted by regular physicians. Complementary medicine is a synthesis of standard and alternative methods, using the best of both.

[5] See Theresa Mitchell, "Alternative Methods for Resolving Wrist and Hand Pain in Woodwind Players," DMA diss., University of Miami (2003).

scientific but clear explanation of the terms used in all health care disciplines would improve the dialog between musicians and the medical community.

A welcome addition to the alternative/complementary versus traditional medicine debate is the publication of the first scientific study of the Alexander technique.[6] This study concluded that six sessions of massage, a prescription for exercise, nurse counseling, and lessons in the Alexander technique helped with back pain and functioning at three months. In addition, the Alexander technique lessons still had a beneficial effect on pain and functioning after twelve months. Finally, the study found that the six lessons in Alexander technique followed by exercise prescription are nearly as effective as twenty-four lessons; therefore, patients can be confident that with six lessons they will learn all they need to know. Even though this study was dealing with low back pain, it is still significant that scientific research is being done on a complementary discipline.

In summary, I do not mean to imply that these examples of alternative and complementary medicine are not valid; however we certainly need to consider known scientific facts and principles and design relevant research studies in order to address the health issues of musicians. Alternative treatments should not be dismissed out of hand, but they should also be able to stand up to the scrutiny of clinical research.

PAMA (Performing Arts Medical Association) is a 25-year old organization of musicians and medical personnel dedicated to the health and healing of musicians and dancers. The organization encourages research, education, and networking to make good

[6] S. Hollinghurst, D. Sharp, K. Ballard, J. Barnett, A. Beattie, M. Evans, G. Lewith, K. Middleton, F. Oxford, F. Webley, and P. Little, "Randomized controlled trial of Alexander technique lessons, exercise, and massage (ATEAM) for chronic and recurrent back pain: economic evaluation," *British Medical Journal* 337 (2008), p. 884.

healthcare readily available for injured artists. It boasts an unusual blend of medical physicians, osteopathic physicians, occupational therapists, physical therapists, chiropractitioners, professional musicians and dancers, arts educators, and students of all these disciplines. This unique make-up of membership is truly unprecedented in most professional arenas.

The 2006 Health Promotions in Schools of Music Conference, held at the University of North Texas and jointly promoted by PAMA, was a seminal event in the drive to highlight the unique medical problems of students training to be musicians. Its four main recommendations were to adopt a health promotion framework, develop and offer "Occupational Health" courses for all music majors, educate students about hearing loss as part of ensemble-based instruction, and assist students through active engagement with health care resources.[7] These recommendations have created an impetus among academic and professional organizations to address health issues for musicians. Position statements of health issues for musicians have been drafted and published by major music organizations such as the Music Teachers National Association (MTNA)[8] and the National Association for Music Education (MENC).[9] A significant number of other national organizations and universities have also begun working on these recommendations.

Reaching and educating teachers of music about health issues is crucial in order to improve the training of the next generation of professional and amateur musicians. Promoting standards of health for all musicians, flutists included, speaks to quality of life

[7] Ralph Manchester, ed. "Promoting Health in Post-Secondary Music Schools," *Medical Problems of Performing Artists* 21:3 (2006), pp. 95-6.
[8] See <www.mtna.org>.
[9] See <www.menc.org>.

issues as well as information that directly relates to playing their own particular instrument. Overall fitness levels must be brought into the discussion not only because of the visual component of our art, but because it has a direct bearing upon the ability to perform well and live a long and productive life. And musicians must feel free to seek help for their physical and mental problems without fearing the loss of their job.

The need for a bridge between musicians and the medical community is self-evident. Much research is currently being done on topics of direct importance to musicians, yet the distribution of the conclusions of these same studies to the average musician is slow. Another issue is the complicated language typically used in scientific writing which is difficult for the lay person to grasp. On the other hand, the medical community needs to have a better understanding of the demands of a musician's career. A strong first step would be for all musicians to become more familiar with the scientific terminology used to describe the body and its actions. But most importantly for musicians, having a good understanding of basic human anatomy, physiology and neurology can create a strong platform from which to build. It has been said that musicians are athletes of the small muscles and it is time to take this viewpoint more seriously.

These pressing concerns indicate a need for solid teaching of relevant anatomical, physiological, and neurological information to the general body of flutists and flute teachers, if not all musicians. The procuring of this knowledge will in turn inform their teaching methods and thus the next generation of flute players. Scientific literature and the scientific community's body of solid research and education are more than adequate to produce evidence-based medical care for today's 'athletic' musicians. Most career-ending injuries can be avoided, but only through education and a careful individual application of solid principles of health body mechanics. The goal of my effort in this document is to gather information concerning the current state of affairs within the flute community through a survey and interviews and secondly, to provide correct and accepted scientific knowledge about the body as it applies to balancing and playing the flute.

Why Unique

This document will provide a direct connection between human anatomy, physiology, and neurology to the act of playing of the flute. It will take into account the asymmetrical nature of our body position during playing and will educate flutists with specific details relevant to what their bodies do as they play the flute. In support of this material, a survey of relevant questions and highlights from personal interviews is summarized and wound into the discussion. The goal of this document is to apply medicine's detailed study of the human body specifically to flute playing and to build a bridge between flutists and the art of medicine.

This study is particularly unique because of my background as a physical therapist. This document will speak from the scientific or traditional medical point of view but with the inside knowledge of the music world. The works by Barbara Conable and Leah Pearson are excellent first steps in the movement to educate flutists about the human body.[10] The primary goal of my document is to take the next step and tie in detailed scientific knowledge to the human body as it plays the flute.

[10] Reviews of works by these authors are found in Chapter Two.

Why Worthy

This document will provide helpful information to all levels of flute-playing - professional flutists, students, teachers, as well as amateurs. Particular emphasis on body awareness and the physical mechanics involved in flute playing will bring a new focus to health issues, giving the next generation of young flutists more information on how to avoid injury and stay healthy. This benefit alone has far-reaching effects. In addition to health maintenance, a balanced set-up for playing the flute creates a platform for good playing. This may seem self-evident, but if the student is set-up properly to play well at the onset, there is a stronger likelihood that they will perform with a solid tone and good technique.

Procedures/Methodology

The first section of this DMA project is composed of two phases. Phase One is an online survey of approximately forty questions that address physical issues related to playing the flute.[11] Included are topics such as the specifications of the participant's flute, how they align the joints of their flute, their stance and method of hand placement, their practice/performing habits, experiences of pain relating to playing and so on. The vehicle for this survey was Survey Monkey, an online password-protected service that allowed great efficiency in obtaining a large sample with confidentiality. The flute studio at the University of Oklahoma was used as a pilot group for the survey.

Phase Two is comprised of telephone interviews to prominent, successful flutists and again, focused on issues relating to their hand and body positions as they play the

[11] See Chapter Three and Appendix A and B.

flute as well as any injuries or physical difficulties they may have had.[12] A summary and discussion of the data will conclude these two phases of my project.

The last section of this work is a written study of an application of scientific knowledge about the human body to the playing of the flute.[13] Basic human anatomy, physiology, and neurology are explained within the context of flute playing. The asymmetrical nature of our stance will be addressed as well as topics such as finger independence, postural concerns, and the mechanisms involved in breathing.

Appendices will include the survey questions and detailed results, the personal interview questions, a diagram illustrating methods of flute joint alignment, a sample of songs for the left hand, and recommendations for books on exercise and fitness.

[12] Chapter Four and Appendix C.
[13] Chapters Five through Ten.

CHAPTER TWO

REVIEW OF THE LITERATURE

Flute Pedagogy

Lea Pearson's 2006 book Body Mapping for Flutists: What every flute player needs to know about the body, 4th edition, evolved from the author's 2000 dissertation, "What every flute teacher needs to know about the body: A handbook applying the principles of body mapping to flute pedagogy*."* The text, like its forbearer, *What Every Musician Needs to Know About the Body* by Barbara Conable, presumes Alexander Technique as a starting point and uses terminology associated with that discipline. While the majority of the information given about human anatomy is accurate and helpful, the author's application of those facts is limited and at time simplistic. The asymmetrical nature of the flute player's posture is not alluded to and a slight impression is given that if you know the simple facts explained in this volume, you will not have any physical problems. Pearson's book is a good first step in the movement toward emphasizing health and wellness issues of flutists, but much more needs to be done.

The 2008 dissertation *Risk factors for flute-related pain among high school and college students* by LeeAnne Thompson, DMA, University of North Texas, is a survey research project with a sample of thirty subjects with an average age of 20.97 years. Questions regarding pain, type of flute and modifications, ROM (range-of-motion) and strength measurements, practice habits, and general medical histories were investigated.

The study showed that strength, flexibility, pain spots, and exposure were risk factors for flute related pain. This work is a strong contribution to the small number of studies done on flute playing and speaks to the need for continued research in this area.

Injury Prevention for All Musicians

Janet Horvath's book *Playing (less) Hurt*, 3rd edition (253 pages), is a fairly comprehensive book written for all musicians. Ms. Horvath is the associate principle cellist with the Minnesota Orchestra, so the text is written from the viewpoint of a professional musician. Adaptations to the flute as well as advice concerning hand and neck position are presented, but not much is included on total body posture or set-up of the shoulder girdle for flute-playing. The resources in the back of the book include books, websites, organizations, and businesses. Ms. Horvath also offers a set of six cardstock pages of stretches and healthy playing reminders for musicians.

The Musician's Body: A Maintenance Manual for Peak Performance by Jaume Rosset i Llobet and George Odam is a shorter work (118 pages) also aimed at musicians in general. An international collaboration of Dr. Llobet, a physician from Barcelona, and Professor Odam, a music educator from London, this text is more succinct than Horvath's book, yet it does an excellent job of covering relevant issues through its colorful layouts and many drawings and figures. One page is devoted solely to the flute and highlights one of the flute's most problematic design flaws: its tendency to roll backwards towards the player's right palm when in the open position. Some fingerings require the depression of only a few fingers; fingering a C#/D-flat requires only the depression of the right little finger. During these notes, the flute's balance is more precarious as the rest of the fingers cannot help stabilize it. The authors' solutions to the problems inherent in playing and balancing the flute are ergonomic platforms and spacers that clip on to the instrument. No mention of hand or flute position is made. Excellent references are given to several websites that offer new designs in flute-making – both the head-joint and the entire flute. These sites also offer other ergonomic adaptations and equipment. Again, the only flaw associated with this text is the lack of detailed information of the flutist's particular posture, especially the shoulder girdle.

The Musician's Survival Manuel: A Guide to Preventing and Treating Injuries in Instrumentalists (1993) is another short but concise book addressed to all musicians, but with a little extra information for flutists as the author, Dr. Richard Norris, a physical medicine and rehabilitation physician as well as performing arts specialist, is also an amateur flutist. Dr. Norris allocates an entire chapter for flutists in which he describes the neck, shoulders, and hand problems that result from holding the instrument. His solutions include an angled headjoint for neck issues, and ergonomic thumb and finger rests for the hands. Again, these are helpful, but preventative measures as well as other postural solutions are neglected. In addition, many other adaptations have been designed for the flute since the publication of this volume.

The Athletic Musician: A Guide to Playing with Pain is a 1997 volume by Canadian physical therapist Barbara Paull and Christine Harrison, a freelance violinist and teacher. The viewpoint of the authors, while not disrespectful of alternative and complementary disciplines such as Alexander Technique, Yoga, Feldenkrais, etc., comes from a traditional medicine perspective and focuses instead on a clear presentation of anatomy and the problems caused by the atypical postures and repetitive motions of musicians. The solutions they offer are in a more traditional vein. Many helpful anatomical drawings and photographs of various musicians demonstrate equipment and/or exercises. The authors' recommendations for exercises are extensive but not without problems. The need for abdominal strengthening is disregarded while stretching to increase spinal extension is emphasized instead. Certainly not all physical therapists and other health professionals would agree with this opinion. In the area of flutists, the information is scant and at times incorrect. One photograph of the 'proper' posture for flute-playing demonstrates the infamous 'marching band' posture that is certain to produce pain in the right back, shoulder and arm. These problems aside, there is much to be lauded in this volume as good information for musicians on issues of physical health.

What Every Musician Needs to Know About the Body by Barbara Conable, subtitled *The Practical Application of Body Mapping to Making Music*, is a 96-page book that is an application of the Alexander Technique to anatomical issues most relevant to musicians. The diagrams and fonts are large and the explanations are somewhat simplistic. "Body mapping" is a term coined by William Conable, a cello professor, and refers to "the congruence of students' movement in playing with their reports of their notions of their own structures."[14] This term might also be called proprioception, a designation long used by medical personnel to refer to the sensation of awareness of movement and position of the body parts without actually seeing them. Kinesthesia is another similar term, although it places more emphasis on movement; Conable does use this term in her book. So "body mapping" is really nothing new. The premise of the book is that as a musician refines his "body map," he will evolve into a more natural, pain-free

[14] Barbara Conable, *What Every Musician Needs to Know About the Body* (Chicago: Andover Press, 2000), p. 5.

player. The knowledge supplied by this volume is indeed helpful but limited to rudimentary anatomy. Playing the flute is mentioned once in the section covering shoulder movement, specifically the sternoclavicular joint. All other information that would be applicable to flutists is covered under instructions to musicians as a group and so is therefore limited.

You Are Your Instrument: The Definitive Musician's Guide to Practice and Performance (1997) by Julie Lyonn Lieberman, a free-lance violinist, is a 150-page book that covers the mind, breathing, muscle awareness and balance, music medicine, and other challenges in the life of musicians such as sight-reading, fast tempos, etc. The book contains illustrated exercises and a glossary of health care disciplines. Traditional medicine and alternative approaches are both presented with a slight bias toward the latter. The anatomical material is brief, as the emphasis of the book is helpful advice not instruction in anatomy. Very little instrument-specific information is given and there are no references to the flute at all.

Muscle Management for Musicians and *Health Practice for Musicians* are two volumes both written by Elizabeth Andrews, a British musician, chiropractor and kinesiologist. Her texts contain a large body of self-help remedies which address not only the physical problems of musicians, but also other salient issues as well. Nutrition, emotional stresses, and environmental forces are just a few of Andrews' helpful topics. Neither volume specifically deals with individual instruments, so there is no information directed solely to flutists. Andrews references Alexander Technique, acupuncture, and chiropractic methods in both books, making a point to avoid medical jargon. A moderate bias against traditional medicine is in evidence in both texts, yet they contain much helpful information for the hurting musician.

Musicians' Injuries: A Guide to Their Understanding and Prevention by Nicola Culf is a short (106 pages) but concise book written from the perspective of the musician. Culf studied guitar at the Royal College of Music in London and at the Banff Centre for Arts in Canada. She sustained a playing-related injury which eventually led to the writing of this book. Culf's approach is quite balanced with respect to traditional versus nontraditional forms of medicine. Stretching exercises and total body warm-ups are given along with specific advice for guitarists. Flute-playing is mentioned in only one paragraph with the same problems noted before, but no specific solutions are proposed.

Two medical texts, while written in a detailed format for medical personnel, are nevertheless helpful for the layman in exploring the injuries musicians face. *Performing Arts Medicine* (1998), second edition, and *Medical Problems of the Instrumentalist Musician* (2000) are both comprehensive volumes with chapters written by various medical professionals representing a variety of specialties. Patient cases, educational text, and numerous pictures and diagrams are found in both volumes. A third edition of *Performing Arts Medicine* is scheduled for publication in the near future. Both of these textbooks are from the viewpoint of traditional evidence-based medicine and are extensive in the material they cover.

Fit as a Fiddle is a publication partnered by the National Association for Music Education and its author, Dr. William Dawson, a retired hand surgeon. Dr. Dawson is a symphonic bassoonist and maintains a private studio as well, so he is doubly suited to deal with the physical problems of professional musicians. This text focuses primarily on hand and upper extremity problems and comes from a traditional medical point of view. Explanations of medical terminology and procedures are given and Dawson devotes an entire chapter the importance of teachers in the role of prevention. Several allusions are made to flute-playing, but solutions are general and no reference is made to our asymmetrical posture. Although short (158 pages), this text is concise, direct, and offers a clear explanation of traditional medicine's view of musicians' injuries and treatments. Dr. Dawson gives helpful advice to the musician and includes a glossary of medical terms.

Indirect Procedures: A Musician's Guide to the Alexander Technique, by Pedro de Alcantara is a 313-page volume in which the author discuss the theory, principles, and application of Alexander Technique as it applies to musicians. Discussions particular to flute-playing include the stance, the use of the jaw and the over-all position of the upper body as it holds the flute. Clear answers are not given as the author infers that one need not twist the neck to play the flute. This is just not true; the head has to be rotated to the left or the right shoulder and arm will be forced back beyond their normal position.

Dr. Alan H.D. Watson has added a significant work to the body of science-based literature concerning musicians with his 2009 book, *The Biology of Musical Performance*. An amateur flutist and French horn player, Dr. Watson is a senior lecturer in anatomy and neuroscience in the School of Biosciences at Cardiff University in Wales, England. The 396-page text also includes a compact disc with color versions of all the figures in the text, video files, PowerPoint animations and sound presentations, and a musical extract. The ten chapters cover basic anatomy, posture, problems of the upper extremity, breathing, the voice, the embouchure, structure and organization of the brain, effect of music on the brain, hearing, and performance-related stress and its management.

Dr. Watson hopes that the addition of this text will encourage the teaching of courses in music biology in institutions of higher learning.

Stability with Mobility, Vol. 2, Exercise Program to Promote Freedom of Movement for Musicians is a recently produced DVD by Ginette Hamel, a Canadian physical therapist. The program contains strengthening, stability, and stretching exercise, as well as self-massage techniques. Ms. Hamel has extensive experience working with musicians and dancers and provides the rationale behind each exercise along with clear instructions. Additional equipment required is resistant elastic bands, a three-foot long half foam roller and a 65 cm exercise ball. A bonus is the background soundtrack provided by the famous professional brass chamber group, Canadian Brass.

Injury Prevention Program for Musicians is an educational and demonstrational DVD that features Jon Kabance, a kinesiotherapist, and Janet Horvath, a cellist and author of *Playing (less) Hurt.*[15] This program requires the use of two unique pieces of equipment – the 'WOW,' a hand-held fitness tool, and the 'Re-Set glove,' a strength training apparatus. The exercises are simple, fast, and focus solely on the upper extremity. Directions are clear and extensive educational segments covering the injury risks of musicians are included. The WOW exercises are light resistive exercises and have promise, but whether or not the extensive strength training of the Re-Set glove is helpful for flutist is uncertain. Both devices provide excellent opportunities for research.

[15] Reviewed on page 14.

Further research is warranted

Research on the actions of flute playing has only just begun.[16] The University of North Texas dissertation surveying the injuries of flutists has been noted, but as it only surveyed thirty high school and college-aged flutists, it needs to be repeated with a larger sample. Motions studies of different practice methods are being done with other instruments, particularly piano, and need to be done with the flute. The effect of general fitness levels on performance is a subject recently studied in Michigan[17] and needs to be repeated with a larger sample. Many motor learning studies have been conducted with musicians, again mostly with pianists and violinists. Within this growing field of research, the flute is under-represented and incorrectly so, as the popularity of the instrument demands more investigation.

[16] See bibliography for articles on research related to flute playing.

[17] Kristie Kava, "Trunk Endurance Exercise and the Effect on Instrumental Performance: A Comparison of the Pilates Method and a Trunk and Proximal Upper Extremity Endurance Exercise Program," paper presented at the Performing Arts Medical Association (PAMA) Conference in Aspen, CO, June 2008.

CHAPTER THREE

SURVEY METHOD, DATA, AND DISCUSSION

Method

The "Survey on the Physical Aspects of Playing the Flute" was offered online on the Survey Monkey website[18] during February and March of 2009. Designed to be completed in approximately ten minutes, the forty-one questions had to be succinct yet informative. Recruiting was done primarily through personal and professional acquaintances, college and university websites, flute society members in Oklahoma and Texas, and at workshops given in Chicago and Tennessee. One hundred eighty-one individuals responded and although they did not complete every question, every respondent did complete the survey. Many individuals emailed me separately, expressing enthusiasm and support for the project as well as interest in the results.

The questions covered topics such as flute joint alignment, hand and body position, practice and performing set-ups, experience and location of pain, amount of education in health issues, and overall fitness levels. Most of the questions were multiple choice; some included open-ended questions that were to be completed with short answers. One major problem with the survey was the omission of questions covering demographic information, such as gender, age, training, and background. The exclusion

[18] <www.surveymonkey.com>.

of this data was primarily due to inexperience on my part; it was unfortunate and would have enriched the results of the study.

Survey Data and Discussion

The following paragraphs will summarize the results of the survey questions according to content and will also discuss any relevant cross-tabulations with other questions. In-depth statistical analysis will not be attempted as it is beyond the scope of this project.

Headjoint

The majority of respondents indicated that they used the classical alignment of the headjoint on their own flutes (64.6%) and when they taught (54.5%).[19] Only 6.2% used the Rockstro position and 23.6% used the modified Rockstro position. These questions were asked in order to ascertain whether there was any cross-connection between the use of the Rockstro alignment and an increased incidence in pain in the right back and upper extremity. The percentages remained roughly similar except when asked about the exact location of pain. 60% of Rockstro alignment users complained of neck pain, while only 32.5% of modified Rockstro alignment and 43.4% of classic alignment users did. Due to the small number of Rockstro users, only eleven in all, this discrepancy may not be

[19] See Appendix D for diagrams of classic and Rockstro headjoint alignment.

statistically significant, but the difference between the three groups is nonetheless striking.[20]

The range of different headjoints owned and used by flutists was quite extensive, with Powell, Miyazawa, and Muramatsu garnering the most respondents. The majority of headjoints were solid silver (66.1%), but a significant number of flutists had solid gold headjoints (25.1%). A wide variety of headjoints speaks to the individuality of each flutist, both in their search for an aesthetically pleasing sound and a headjoint that works well for them physically.

The Flute Itself

As expected, most of the flutists in this survey had open-holed flutes with .016 mm wall thickness and a B footjoint. Forty-five point six percent of the respondents had flutes with in-line G keys, while 54.4% were off-set. In that off-set G keys have been a relatively recent option on professional flutes, the preference for them will surely increase as time goes by. The responses to questions concerning pain and other problems showed no major differences whether the flute was in-line or off-set. Perhaps all the flutists that had experienced problems with in-line G keys no longer have them and had already switched to flutes with off-set G keys.

A slight majority of respondents had a C# trill key. Questions about added mechanisms were included because they increase the weight of the flute; C# trill keys and off-set G keys are two common examples. The addition of these mechanisms did not

[20] A discussion of functional anatomy as it relates to headjoint alignment is found in Chapter Eight, page 238.

seem to increase the incidence of pain, but more thorough research would be needed to make a more definitive conclusion.

Hand Position

A surprising majority (51.4%) of players bend the thumb of their left hand while playing, a mechanically disadvantaged position since extra tension is required to maintain the flexed joint. Another surprising response was that the majority of flutists slightly raised their elbows (53.9%), an act which increases the workload of the shoulders and neck. The amount of bend in the left wrist varied between slightly bent (51.1%), bent (25.6%), and straight (23.3%). In that some extension in the wrist is a part of its functional position, the fact that over 75% of flutists played with their left wrists extended should not be a problem. Only six of the 181 respondents (3.3%) indicated that they had any trouble with hyper-extending the right little finger. 14.4% kept it straight with the vast majority (82.3%) bending it slightly.

Practice/Performance Set-up

When asked about their sitting position, an overwhelming majority of flutists indicated that they angled the chair to the right with the flute remaining parallel to the stand. Stand heights were adjusted in order to see the conductor but remain as low as possible. In the standing position, several flutists used different heights for different times: higher for practicing and learning new music, lower for memorizing and performing. In both positions, many flutists kept the stand as low as possible. While this is certainly understandable, flutists must also take their overall posture into account, and not inadvertently set the stand so low that they would be more prone to slump with a forward head while they are playing.

One hour of practice a day is the most common amount of practicing done by the flutists who took this survey, but 30 minutes, 1½ hours, and 2 hours were also very close. Only 10.6% of the respondents practiced more than 3½ hours per day. These results might serve as a motivator to those who think everyone else is practicing more than they really are. But it is disconcerting to note such a high incidence of pain and physical problems in a group of musicians that may play as little as one hour a day.

Although some flutists do use mirrors, very few use video-taping, which does require a financial outlay and a certain amount of time to learn how to use the technology. Perhaps this is an area we as players and teachers could improve.

Only 1.1%, or two, of the respondents said they never moved while playing; 9.0% said they moved a lot. Thus most flutists are moving some or just a little, an excellent response. A static position might indicate tension whereas an excess of movement might create balance problems. When describing how they moved, most shifted their weight from back to front (82.1%). Head and arm movement are done by a smaller group, about 43%. Bending and straightening the spine was reported by almost 40% of flutists, even though bending forward decreases the abdominal cavity, compromising breathe support.

The most problematic keys to remain covered by the fingers are, in order of severity, the right fourth finger, the left fourth finger, and then the middle fingers equally. Sixty-two point five percent of us wear glasses while we're playing. Only 7.2% wear an earplug while playing and 43.1% do so sometimes. That leaves 49.7% of flutists, roughly half, that never wear ear plugs. With the implications of noise-induced hearing loss, those are not good numbers. Playing the flute may not expose the ears to too much sound, but playing the piccolo and /or sitting in front of the brass section is certainly hazardous.

Pain

Over half of the flutists that took this survey sometimes or always experience pain while playing. This large percentage is not only less than encouraging, in truth it is alarming. Only 14% said they never experienced pain at all. But of this later group, 64% practiced one hour or less per day, so the flutists with the least pain were mostly those that played less than a hour a day. Two flutists in the pain-free group practiced three hours a day, but there were none playing longer than that without pain.

Table 1. – Flute Survey Results: Incidence of Pain

Area of Pain	**Experienced by the following percentage of respondents**
Neck	41.0%
Left Shoulder	29.2%
Left Upper Back	28.6%
Right Shoulder	26.7%
Right Wrist	25.5%
Right Upper Back	24.8%
Left Wrist	21.2%
Right Hand Thumb	15.5%
Lower Back	14.9%
Right Hand Pinky	14.3%
Jaw	13.0%
Right Forearm and Left Hand Thumb	11.2%
Left Hand Index Finger	10.6%
Left Forearm	8.7%
Right Elbow	7.5%
Left Elbow	6.8%
Left Upper Arm	4.3%
Right Upper Arm	3.7%

Fifteen and one-half percent of the respondents indicated they experience pain in "other" areas but most of these were combinations of the same areas listed in the chart. Note that flutists could mark more than one of these answers; the percentages do not all add up to 100.

A higher than expected number of flutists indicated problems involving muscle coordination. Trembling of the lips was experienced by 58.1% and trembling of the chin 16.3%. Almost 40% of flutists noted a loss of muscle coordination in the fingers and 22.1% experienced it with the embouchure. These numbers are significant because this lack of coordination could be a prelude to more serious problems such as focal dystonia.[21] The occurrence of hypermobility, also called double-jointedness, can be inferred by the 25.6% of the respondents who reported temporarily locked joints.

Many flutists have made modifications to their flute including the use of key extensions, mole skin, PVC piping, and devices to hold the right thumb and left hand further away from the flute. Others have changed their joint alignment or bought a new flute with off-set G keys. Several flutists talked about what they did to modify themselves rather than the flute. They mentioned efficient practicing, core muscle strengthening and disciplines such as ballet, Pilates, and yoga.

Education

An amazing 49.7% of the survey respondents have consulted with a health care professional about something related to their body and flute playing. This statistic alone speaks volumes about the need for research and education into the health and wellness issues facing flutists today. Eighty-two percent point eight percent of the flutists had studied anatomy at the college level, which seems an incredibly high percentage Perhaps the question was unclear and the respondents thought that any course that included anatomy counted. My intent was to see how many had taken a course that focused on and covered only human anatomy. Only 7.5% had ever taken a course on health issues for musicians, a dismal percentage.

[21] Focal dystonia is condition involving abnormal involuntary and uncontrollable muscle contractions.

Fitness

Most of the flutists practiced yoga (73.2%), with Alexander Technique (54.5%), and Pilates (30.9%) following. Others wrote in responses such as Tai Chi, body mapping, and ballet. Most felt they were in good or average shape; self-reporting of fitness levels has its obvious disadvantages.

Only 18.8% of the survey respondents indicated that their teachers had pointed out to them the asymmetry of the flutist's body position during playing. This omission is something flute instructors must address.

The complete survey and responses are included in Appendix A and B.

Summary

Prior to receiving any data from this survey, I had expected to see participants indicate pain in the hands, forearms, and perhaps the right shoulder. The results however showed that the neck was by far the worst problem area. Keeping in mind that pain is a symptom and not a diagnosis, I inferred that flutists might be having trouble stabilizing the neck and core muscles of the body in order to support and balance the flute against gravity. Perhaps they might not realize the pronounced effect that distal actions and positioning (further down the arm) have upon more proximal (nearer the center of the body) structures.

As stated earlier, one of the goals of the survey was to ascertain whether Rockstro alignment users had any more physical problems than did the flutists who lined up the joints of their flute in the more traditional way. With only eleven Rockstro users responding, any conclusion is cautionary, but six of these individuals did complain of neck pain. And that percentage does raise a red flag.

As most of the participants did not practice more than one hour a day, although they may be playing more than that, it is still noteworthy that so many were experiencing pain. These results informed the investigation of functional anatomy during flute-playing found in Chapters Five through Ten. The position taken up to play the instrument may involve turning the head left and/or tilting the head to the right. In addition, both arms are holding the flute up against gravity in an asymmetrical fashion for a prolonged period of time. A better understanding of what is happening inside the body will hopefully shed light on why playing the flute has turned out to be for many people a pain in the neck.

CHAPTER FOUR

INTERVIEWS

Introduction

The next section of this project involved a small number of personal interviews with prominent flutists. The focus of the interviews was a discussion of the flutist's own hand and body position during playing, as well as any physical difficulties they had confronted with during their professional career. Requests were sent out to approximately twenty well-known flutists via email; seven replied affirmatively. One interview candidate fell through because of scheduling problems, but six others were conducted over the telephone and recorded with a device. The interviews were transcribed by the author and edited by the interviewees. Four of the participants had significant problems dramatically impacting their musical careers; the other two have had few if any physical problems related to flute-playing.

Description of the Interviewees and Interview Summaries

The candidates who agreed to be interviewed were Mr. Robert Dick, Professor Bonita Boyd, Ms. Katherine Borst Jones, Ms. Florence Nelson, Dr. Adah Toland Jones, and Dr. Amy Zuback. Mr. Dick, Professor Boyd, Ms. Borst Jones, and Dr. Adah Jones all have academic appointments as flute professors at various universities. Dr. Zuback has also taught at the university level and currently maintains a large private studio. Ms.

Florence Nelson enjoyed a celebrated career in the New York City opera scene and later became an influential union officer. She is currently president of the Chicago Flute Club. Mr. Dick and Professor Boyd travel extensively giving solo appearances.

Biographical sketches of each candidate will precede a brief synopsis of their interview, followed by the interview transcript itself. Each interviewee edited and approved the transcript of their interview.

Interview with Robert Dick

Robert Dick lives in New York City and teaches flute as a faculty member at New York University. He holds a B.A. from Yale University and an M.M. in composition from the Yale School of Music. As a composer in the classical world, Robert Dick is one of only two Americans ever to be awarded both Composers Fellowships (twice) and a Solo Recitalist Grant by the National Endowment for the Arts. He has received a Guggenheim Fellowship and multiple commissions. At the 1999 National Flute Association Convention in Atlanta, Dick premiered his *Concerto for Flute/Bass Flute, Strings and Percussion*. His performances typically include all members of the flute family as well as his invention, the Glissando Headjoint.

As one of the flute world's most respected masterclass teachers, Robert Dick has been in residence in literally hundreds of universities, colleges and conservatories throughout the US, Europe, Asia and Australia. Mr. Dick also teaches through extended residencies at universities and music schools. His discography includes over twenty compact discs of original solo and chamber works and collaborations. Mr. Dick has authored and published books on contemporary flute technique that are the acknowledged standard in the field.

Flute and Hand Position

Robert Dick owns and plays two different flutes: a stainless steel Sheridan flute and an Oston-Brannen Kingma system flute. The Sheridan flute has an off-set G key, a set-up that Dick heartily recommends. The only other adjustment he has made on this flute is to have the B-roller raised.

Mr. Dick also performs on a special flute that Brannen Brothers Flutemakers built for him, a radically expanded version of their Kingma system model. The design of Brannen's Kingma model offers a full quartertone scale as well as complete multiphonic venting. In addition to the standard Boehm mechanism, there are six extra keys. Because of the extra trill key, this flute has a hand rest built onto it to protect the added mechanism and to provide a place for the left hand to support the flute. Mr. Dick has also had several of the other keys on this flute redesigned to be more ergonomic. His attitude toward making adjustments on flutes is summed up in the following statement:

> The flute is re-buildable. It's not some sacred object and Moses did not bring it down from Mount Sinai. It can be changed. It's something that people make.

Dick uses the standard classic alignment for the joints of the flute with the exception that he turns the headjoint out slightly.

Body Position

Dick stands with his left foot slightly in front of his right with his body at about a 45 degree angle to the flute. He keeps his elbows slightly away from his body and both his wrists “pretty straight.” Dick turns his head slightly towards his left and while keeping his neck straight, he allows his flute to angle down slightly.

Physical Challenges

Dick sustained a significant injury to his left forearm after years of playing with an extremely awkward arm position. His teacher had required him to play with his elbows up in the air and his wrists extremely broken, i.e. extended, similar to the infamous drawing of a bewigged Baroque flutist. Faced with injections and surgical intervention, Dick instead found eventual healing through the study and application of the Alexander Technique.[22] He continued to study and learn more about the body and other ideas about ergonomic ways of movement. For example, the methods of the Dorothy Taubman, a physiological approach to piano technique,[23] are used by Dick in his own playing and studio teaching.

Dick had a “guilt-free practice method” where-by his students get credit for practicing when they exercise, listen to recordings, attend concerts, etc. He recommends swimming, particularly the backstroke, to his students.

Robert Dick Interview

FAIN: I know this is late for you and thank you so much for being willing to participate in my DMA project.

DICK: You’re most welcome, so fire away.

[22] Alexander technique is an alternative and educational discipline which focuses on body coordination and awareness.

[23] See <taubman-institute.com>.

FAIN: First of all could you just share with me what kind of flute you are currently playing on?

DICK: I currently play on two different flutes. I have a Sheridan flute which is a very light-weight instrument. The body tube is actually made out of stainless steel. It's an incredible instrument. The tube is extremely thin and steel is a lightweight metal. It's got enormous power and response. I also have an Oston-Brannen, Kingma system flute with a silver .016 mm wall.

FAIN: Is the reason you picked the stainless steel wall because of the sound or the weight?

DICK: For the sound.

FAIN: So you weren't concerned about having a flute that was too heavy for you.

DICK: Oh, no. No.

FAIN: How long have you played these two flutes?

DICK: I've had the Sheridan flute since 1985 and the Brannen since 1996.

FAIN: OK, so you're very loyal.

DICK: I have good and unique instruments, so I'm just playing them.

FAIN: So, other than those how many other flutes have you owned in your career? Tons? [*laughter*]

DICK: Oh, I don't know about tons, but how about a bushel? [*laughter*] Before the Sheridan flute I played on a silver Powell, an old Powell which had been made for James Pappoutsakis. That flute just had a wonderful resonance but it was the old scale and with old Powell flutes there was always something going wrong. You needed a relationship with a repair person like a therapist and I was really tired of that. Until I played on Dana

Sheridan flutes there just wasn't anything that I played on that had the resonance of the Powell. When I did try a Sheridan flute I knew that's what I wanted and there's a whole other story about how I arrived at wanting a stainless steel flute and he agreed to make it.

FAIN: I'll be honest with you and say I've never heard of that before. So you may be the only person I know of with a stainless steel flute I'm sure.

DICK: To my knowledge there is one other, which was made by Albert Cooper a very long time ago. It was made for a publicity thing for a steel company in England.

FAIN: Of the flutes you've played, in terms of how they fit your hands and the ease of how you're able to work the mechanism, is there anything that you would change to make it work better for you?

DICK: Well, the Sheridan flute is basically a conventional instrument but it is off-set G. I'll never consider playing on an in-line G flute again.

FAIN: It really works well for you then.

DICK: Yes. The in-line G was invented by Louis Lot and the purpose for it was that it required making less parts which meant that he could actually have the flutes built more quickly and get more flutes out the door every year. Did wonders for his bank account but why flutists today still have to have their hands screaming because some dead French guy – admittedly a remarkable dead French guy -- made more money is kind of a mystery.

FAIN: Good point. What about the footjoint mechanism? Does that work well for you?

DICK: Yes. I had the D roller raised. Sheridan originally had these very beautiful - not cylindrical, but tapered on either end – they looked wonderful but you had to actually run your finger right down the middle of the roller to get it. I had them replaced with my old straight rollers

FAIN: I have those, too. They're very helpful.

DICK: On my Brannen flute there is a hand rest built right on to the flute for the left hand.

FAIN: The flute that you play? Is it silver as well?

DICK: Yes. It's hollow, it's tubing, it looks big but it weighs virtually nothing. It is there to protect a piece of mechanism that is not on most flutes. The Brannen flute has three trill keys on it, not two. But what it does do is that it brings the left hand away from the flute in a similar way to a BoPep but it's customized to fit my hand, so it's bigger. And it's really wonderful. I also had him change the shape of some of the Kingma system keys. Things that are now standard. They just weren't ergonomic so I did slightly redesign the thumb cluster, because there are four thumb keys, not two on the Kingma system.

FAIN: So you've had quite a bit of work done on your flute to fit your hands. Considering the amount of time you play that makes a lot of sense. I'd rather you put money into your flute than giving it to a doctor.

DICK: Exactly. It's something I learned a long time ago. The flute is re-buildable. It's not some sacred object and Moses did not bring it down from Mount Sinai. It can be changed. It's something that people make.

FAIN: Let me ask you how you line up your headjoint with the body and the footjoint of your flute. Do you use the standard traditional alignment or modified Rockstro?

DICK: No, no, no. The Rockstro is idiotic. The whole Rockstro thing is as illogical as one can get via it's based on this conception of which way gravity goes – you know, the flute as a lever. Did you ever read Rockstro's book?

FAIN: Yes, actually I just turned it in. I've not read it cover to cover but…

DICK: It's unreadable from cover to cover. But Rockstro's big passion in life was to debunk Boehm. Now if Boehm had come up with the Rockstro position, then the Rockstro position would have become the standard position we use today.

FAIN: Right. He was just being ornery.

DICK: Totally. But it's nonsensical. I use a pretty standard alignment. Basically the center of the embouchure hole is in line with the center of the keys. It's turned out a bit from there.

FAIN: You mean the embouchure hole is turned out in relation to the keys.

DICK: A bit but not dramatically. I do play the flute turned out a bit more than most people do.

FAIN: Perhaps that's more related to where you blow.

DICK: I have the flute lower under my lower lip instead of on it.

FAIN: Can you explain to me how you set your body up to play when you are going to perform or practice? How you line your flute up with your feet, that sort of thing?

DICK: I generally practice standing and play standing. To be honest, when I play sitting, my posture is dreadful. [*laughter*] It means I'm tired, just slumped over. I don't actually perform sitting very much. I don't play in any orchestras and so it's kind of rare that I actually need to be sitting when I play. When I stand basically my left foot is a little bit in front of my right, my body is at an angle to the flute. It's somewhat along the 45 degree angle that one sees in that Roger Mather book. I try to keep my elbows away from my body but not drastically so. I keep both wrists pretty straight.

FAIN: What about your neck? Do you end up tilting toward one side or the other?

DICK: No, I don't tilt. My neck is turned a little bit toward my left shoulder.

FAIN: So you're able to play with your neck basically straight even though it's rotated.

DICK: Yes.

FAIN: Then your flute would be angled down somewhat, correct?

DICK: Yeah.

FAIN: What else have you done besides all the mechanical things you've explained to me, to keep yourself from becoming injured throughout your career? Have you done any exercising, stretching, that kind of thing?

DICK: Back in 1983, I had a terrible injury to my left forearm, which was related to how I was playing. If you look in the original Taffanel and Gaubert, you know the complete two-volume thing, there's that poor guy playing the flute in the opening pages with his elbows up in the air and his wrists extremely broken – that's how I was taught to play.

FAIN: Oh, my gosh.

DICK: Yeah, in retrospect, it was just mindless, but that's how I was taught to play. And the logic I was told was that it was easier for the blood to get up into the hands if your arms were already sort of parallel to the ground.

FAIN: Oh, my word! I had no idea!

DICK: And I've never heard it from anyone else but that's what my first teacher who was a student of Barrere said. I don't know what Barrere's comment on that might be. I have no idea. It makes no sense at all. And of course, if you're not serious, it doesn't really matter. But for those who are serious, it's just a matter of time before some major physical fuse blows. And for me it was the left forearm. Alexander Technique is what led me to change, to learn about physiology from a completely new point of view. From the body to the flute, not the flute to the body. And it helped me to heal without any kind of actual surgical intervention. The first medical people I saw were talking about injections and surgery. And I knew that was wrong even though my hand was killing me. I had heard of this really famous diagnostician in New York and I went to go see him and he sent me to a really wonderful Alexander teacher who said, "Look, I don't know exactly what it is that you've done to yourself playing the flute but this is clearly something you've been doing wrong for a long time. Now go and learn how to use your body correctly and it will heal. If six months from now this problem is still persisting, then we can investigate other alternatives but frankly I don't think that's going to happen" and it didn't. So that led me into a whole journey to learn more about the body, to learn about others who have developed ideas about technique and other ergonomic ways. Do you know about Dorothy Taubman?

FAIN: Yes! I had a roommate who was learning all about the Taubman approach because she had wrecked her hands playing Rachmaninoff.

DICK: Yes, but it wasn't Rachmaninoff's fault.

FAIN: No, no, of course not. [*laughter*] Well, she was only about 5’2” and she had little hands and just blew them out trying to do that. She had to totally relearn how to play.

DICK: The ideas of Taubman are wonderful and I use them in my flute teaching, too. Things about playing the footjoint by rotating the right wrist instead of trying to reach those keys with your pinky actually. But to understand that the pinky is just an extension of the palm which is an extension of the wrist which is an extension of the forearm and arm. So exercise is a very regular part of my life.

FAIN: Wonderful.

DICK: [*unintelligible*]…along with the fitness club I go to. It’s a total body awareness. So the physical side of playing – you’re using your whole body. And I think just about all of those body disciplines are pretty much excellent whether one does chi gong or tai chi or yoga or… I find again and again when I have students who complain about problems, my prescription is to send them to the college’s swimming pool twice a week and make sure while they’re in there that they do the backstroke as well as the crawl and the breast stroke. But make sure to include the backstroke. And it’s amazing how physical problems just go away.

FAIN: Right. A little bit of balance – literal balance – in the muscles that you use.

DICK: The thing is that in most students and in most professionals, in terms of just addressing the demands of our daily life, we find ourselves not moving our bodies through the full range of motion. And if we restrict the range of motion, then problems develop.

FAIN: Yes, exactly.

DICK: And so you've just got to go through the full range of motion and kick that body into higher gears a couple of times a week. Everything you read about it in health says the same basic things. Andrew Weil's books also talk about the importance of maintaining your health through, he says, "Sweat those toxins out of the skin a couple times a week." Obviously someone has to do something so that that happens.

FAIN: Exactly. And I'm really thankful that you're making this point because in our busy lives, it just seems that that's one of the first things that gets thrown out the window.

DICK: Yes. And what I do with my students, I introduce them to the idea of the guilt-free practice system in which practice is defined in a much broader way. When you are exercising, you are practicing.

FAIN: Oh, I like that.

DICK: Practicing is not just playing on the flute. Practicing is everything that you need to do to be the best you can be and so it includes exercise, it includes listening to music, it includes thinking about music, and it all counts as practice. You know, if you need to take a longer trip to buy really good fresh food instead of eating crap, count it as practice. And at the end of the week, you can end up with a really big number and it's delightful!

FAIN: Right, yes! Thank you so much. You've said so many of the things I've wanted to say, even better. I think really that that's all the questions I have, Mr. Dick and I really appreciate you taking the time to talk to me.

DICK: Well, sure. And I'm sorry for the delay. But anyway here we are and I'll meet you in a couple of weeks.

FAIN: That's right; I'll be there in April.

DICK: All right, if you need anything else just let me know. I hope this is something in the end that you can actually publish because it really is important. It astonishes me that very often a masters student comes into my studio and the first thing we do over the first couple of weeks is to redefine how to hold the flute.

FAIN: And it's a smart thing that you do that. It's incredibly important.

DICK: It's completely irresponsible not to. My teachers didn't. You know, Henry Zlotnik had all these wrong ideas. I mean he really worked at getting my hand position into this dreadful place. But for example when I studied with Baker, he never said a word about any of that stuff whether he was cognizant of somebody being on the highway to hell or not. Nyefinger also had very little to say. Nyefinger was sort of modified Rockstro-ish person; getting into those ideas in essence are just dumb, I think. The emphasis is that gravity's pulling down and the main purpose of holding the flute is to keep it from falling on the floor when you play it. Put Newton down for the simplest reason why you're holding it. It's that. The flute is not going perpendicular to you and flying to the nearest wall and sticking there. It will fall onto the floor. So, we have to get under the flute to hold it up, not alongside it.

FAIN: Yes, amen!

DICK: So all these ideas about putting your thumb on the back of the flute and things like that…the amount of extra strain that puts on the hand is consequential. At any moment it might not be too much but repeat these motions millions of times and big things happen.

FAIN: Exactly. Well, thank you for talking and I really do look forward to meeting you next month.

DICK: OK, thanks, Susan. Take care.

FAIN: You, too. Bye-bye.

DICK: Bye-bye.

Interview with Professor Bonita Boyd

Bonita Boyd served as principal flute with the Rochester Philharmonic (1971-1984), Chautauqua Symphony (1971-1977), and Filarmonica de las Americas, Mexico City (1977). She was a faculty member of the Johannesen International School of the Arts (1987-1996). An Eastman faculty member since 1977, Professor Boyd is also currently a member of the artist faculty of the Aspen Music (1996-present) and the Aria International (1997- present) festivals, and is co-principal flutist of the Aspen Festival Orchestra. Her teachers included Maurice Sharp of the Cleveland Orchestra; Roger Stevens; and Joseph Mariano, former principal flute of the Rochester Philharmonic Orchestra and legendary pedagogue at the Eastman School. Boyd succeeded him in both posts – becoming the youngest woman to hold major academic and orchestral appointments. Boyd has premiered numerous works, toured extensively and has made numerous successful and innovative recordings. She tours regularly with guitarist Nicholas Goluses.

Flute and Hand Position

Professor Boyd currently plays a 14K- gold Lafin headjoint with an older silver Powell body. She uses the classic alignment of the headjoint and because she has long fingers, lines up the rods of the footjoint slightly forward from the center of the keys on the middlejoint. Boyd began her musical training on piano, becoming a highly developed player before switching to flute. She uses a lot of principles of finger technique from her piano training in her flute playing and teaching:

> …the position of the fingers, keeping the fingers curved and relaxed. The weight of the finger is then enough to depress the key. You don't need any extra force coming out of your hand.

Boyd goes on to say that she envisions the flute as a keyboard to be played and not something to be gripped. She teaches her students to keep their fingers very close to the keys. When teaching about balancing the flute, Boyd refers to three points of balance – the chin, left index finger and right thumb – and says that the flutist should be able to use any two of those points at one time. So for example, if the chin were taken away, the flute would still be securely held by the left index finger and right thumb. With all three points of balance in place, the flute should be very secure, leaving the fingers to play freely as if they were on a keyboard. Boyd also recommends gentle, curved fingers.

Body Position

Boyd has worked hard to keep her shoulders "uninvolved, like a singer." In the standing position, she plays with her feet even and her weight balanced between them. Angling her flute down and slightly forward, Boyd's neck is straight and her spine is slightly rotated to the left. In the seated position, Boyd keeps her chair straight to the music stand.

Physical Challenges

Boyd describes herself as a very relaxed player. She has had no significant physical problems related to playing the flute. She teaches flute as though it were voice and instructs her students to eliminate tension and enhance phrasing by singing through passages. For the past decade, Boyd has been doing simple calisthenics and walking for exercise.

It is interesting to note that Boyd could remember only two fellow students with playing-related injuries during her earlier years of training for the musical profession. Students arrive in her studio at Eastman with a history of physical problems – and these are only college freshmen! She suggested that the marked increase in these overuse type injuries might be due to the amount of time today's younger generations spend on the computer.

Bonita Boyd Interview

FAIN: I really appreciate you doing this for me, Mrs. Boyd. You've had such a great, successful career and being the flute professor at Eastman is certainly going to… having your thoughts and words in my dissertation is going to be a really big help and I really appreciate it.

BOYD: Oh, that's nice.

FAIN: So, first of all, what kind of flute, headjoint and footjoint do you use?

BOYD: At the moment I have a La Fin gold headjoint, 14K gold on an old Powell which I love.

FAIN: Is it a B footjoint?

BOYD: Yes, a solid silver Powell.

FAIN: And how long have you been using this particular set-up?

BOYD: I've been playing on the Powell for maybe seven years and I got the headjoint four years ago.

FAIN: So, in your career how many different flutes do you think you've owned?

BOYD: Let me count up quickly. I could tell you exactly. One, two, three, four, five, six. Yes, six, I think it's six.

FAIN: So is the set-up you have now your favorite?

BOYD: I certainly love this; I just changed from time to time. I probably learn different things from each instrument and then for various reasons move to a different metal.

FAIN: What difference does it make with what metal?

BOYD: I've had a platinum flute and two gold flutes. And three silver. Let me see, did I get this number right? There must be seven. The platinum was very unique and I learned a fantastic amount playing on it. It was a Goosman platinum flute, maybe the only one he made actually. It was a fantastic instrument. I tried it in the orchestra; I especially liked it in the orchestra. The carrying power of platinum is really, really fantastic but the fact that it carries like that and has that stability also means that it's a little less flexible because of the density of the metal so you have to kind of go out of your way to create colors and nuance on it. There's always a plus and a minus on the same property of metal in this case. Since it's so dense, it holds pitch really, really, really well so you can over blow and it's really hard to go sharp on it. But then the opposite thing is obviously that it doesn't mold as easily so on that instrument I felt like I had to really relax more. I learned a lot about having a more relaxed air stream, going for fullness in a natural way, not forcing, that kind of thing. I really had to learn to not be tense at all otherwise this flute didn't respond very well. You know, it would be very cold.

Fain: Didn't you ever notice how heavy it was?

Boyd: Jack Goosman had put silver keys on it and that made a tremendous difference. I could be wrong on this, but my recollection of what he said was that ⅔rds of the weight of the flute was in the keys. So that would make a really big difference.

Fain: So with the keys made of silver, it just made it not as heavy.

Boyd: I think it did. I never really thought about it. Actually I had gone from a gold flute to the platinum; it was gold keys and gold flute and 14K gold. After I played the Goosman I also played another gold flute. Maybe I didn't notice it for that reason either.

Fain: So the gold is heavier than silver?

Boyd: Oh, yes.

Fain: So would they put silver keys on a gold flute?

Boyd: They sometimes do. Platinum is much heavier though. It really is.

Fain: So, on what you are playing now, is there anything that would change about where the keys are placed, the mechanism?

BOYD: I don't think so. It's my very favorite combination of all. Just in general, it's a silver tube with a gold head. Jack Goosman was a really brilliant man and he once said that you have to have a denser metal in the headjoint to power the body. So if you were to put a silver headjoint on a gold tube then that really wouldn't work very well. And a gold headjoint on a platinum tube wouldn't work very well either. But people have platinum headjoints on silver tubes occasionally. A gold headjoint on a silver tube, there's a certain kind of brightness in the silver and a kind of mellowness from the gold. That's why I like the combination of the gold and silver.

FAIN: So do you like the way you have the C# trill, the D# roller, etc?

BOYD: The only thing on this one is the B roller. There's nothing else because it's an older flute. It's old scale.

FAIN: Do you have any problem with where your pinky goes to the D# trill key? Do you wish it were turned a little bit or does it work well for you the way it is?

BOYD: I think it's fine.

FAIN: Have you ever experienced any pain due to the way the flute was manufactured?

BOYD: I actually haven't.

FAIN: I think you may have hit upon some good practice planning if that were the case. So how do you line up the joints of the flute?

BOYD: The embouchure hole I have pretty much in line with the C key and on down the line of keys. And then the footjoint – if you were envisioning the E-flat key and then the D key on the end of the tube, the e-flat key is turned down slightly, somewhat, but not as much as some people do.

FAIN: So you don't have the rods of the end joint in line with the keys?

BOYD: The e-flat key would kind of be rolling back toward my hand a bit. It's not exactly lined up with the D key; it's rolled back toward my hand a little bit. Does that make sense? Just very slightly. It's very slight; it's not a lot.

FAIN: The way I was taught was to have the rods of the footjoint be in the same line as the embouchure hole and the center of the keys of the body. And what you're saying is that that would be rolled way too far in for you, right?

BOYD: I think maybe, yeah. I have long fingers though; I'm pretty big.

FAIN: That makes sense. Were you taught that way as a student or did you just figure that out on your own?

BOYD: I just always did that. I think that it was just suggested to me; somebody suggested having the hole lined up with the line of keys. I like it not to be rolled in too far when I play, of course.

FAIN: Ok, now I have some questions about how you get your body set up to play. So when you practice or perform, what kind of stance do you take when you're about to play your first note? What do you do with your body to get yourself ready for playing? Do you have one foot in front of the other…or do you ever think about it? I guess it might be something you do naturally.

BOYD: If I'm standing for a solo, I have my feet sort of spread apart, sort of naturally, not way apart, so that my weight is really balanced between them. My feet are the same; one foot is not in front of the other.

FAIN: Would you say that your flute is in the same plane as your body? Or does it angle forward?

BOYD: Pretty close. It might angle a little bit forward but not a lot.

FAIN: And when you sit down and play – in orchestra, that's a pretty good example – would your chair face directly straight to the music stand or would it angle one way or another?

BOYD: That's a good question. It's straight. I've always had it straight; I've never thought about it.

FAIN: Have you ever used one of those wedges that the cellists use? Or do you just sit on the chair the way it is?

BOYD: I've never used a wedge.

FAIN: And how far away from the music stand do you usually play?

BOYD: Just a normal amount. I'm not way back. I couldn't see it if I was back so far. I have to be able to see the conductor too, so I wouldn't want to get too close to it.

FAIN: Do you wear glasses when you perform?

BOYD: Not any more. I've had lots of eye problems. I've had lots of eye surgeries. I've had detached retinas in both eyes related to nothing. I'm at a high risk because I'm near-sighted and I think most of those affected are near-sighted. They've never figured out any reason– I'm not diabetic or anything. They were really early on. The first one happened when I was in my thirties and the other eye went not terribly long ago. It was exactly when Marianno was having his birthday celebration. And then cataracts usually come as a result of that surgery. It's a well-kept secret. So I've had to get all that done. Five or six surgeries at least. The bonus on the cataract surgery was that they put in lenses so I don't have to wear glasses anymore. So I've got long distance focused vision. It's really, really, really nice. So now I don't wear glasses.

FAIN: That's wonderful. The next question I have is when you're holding your flute, could you describe to me where it presses against your left index finger?

BOYD: It's right on the soft part of my hand between the joint that's in my hand and the first joint of the index finger. It's right on the inside directly.

FAIN: So it's not on the crease but between them. Is that what you're saying?

BOYD: Right. And on the side, of course.

FAIN: If you could do the same with your right thumb? Describe to me where you put your right thumb.

BOYD: Do you mean where I put it on the tube or where the tube hits my thumb? It's between the F key and the E key.

FAIN: Do you put your thumb totally under the flute or do you press forward a little bit with your thumb?

BOYD: It's under the flute; it's on the soft part of the thumb, the first part of the flesh. It's not on the side of my thumb; it's on the real thumb. But not completely obviously.

FAIN: When you teach your students how to hold the flute, how do you talk to them about balancing the flute or holding it? Do you discuss equal handedness or do you talk about Rockstro or modified –Rockstro? How do you teach your students how to balance the flute when they play?

BOYD: Well, first of all I should say that I'm usually fixing problems and not starting people. I never start people. I was a pianist, a highly developed pianist before I really made the decision to go to flute instead professionally. I learned a lot from piano, the position of the fingers, keeping the fingers curved but relaxed and how the weight of the finger is enough to depress the key. You don't need any extra force coming out of your hand – all the things pianists use. And staying very close to the keys instead of way up in the air some place; almost up on the keys, staying really, really close. The pianist does not hold the keyboard up! So I've always envisioned the flute as a keyboard, instead of gripping the tube, so the three places that the flute rests (on your chin and the two places we were talking about), all three work to rest the flute on. Any two of them could work so you could rest it on your hand and your chin or your other hand and your chin. You could take one away and you still would have the flute secure there. So all three should be a really nice balance and should free your fingers to play like on a keyboard. That's what I teach.

FAIN: I love that idea of the flute being like a keyboard.

BOYD: It works really well for me.

FAIN: Super. OK, almost done. If you have students whose right pinky gets locked or if one of the joints hyperextends, do you know what I'm talking about? Do you deal with that?

BOYD: Yes. I want them to curve their fingers gently and not have something straight like that when the first joint caves in.

FAIN: Good, I'm glad to hear that. When you practice on your own, do you typically sit or stand?

BOYD: I think it's really a mixture. If I'm feeling lazy, I might be sitting. Many times I'm standing.

FAIN: At what angle do you hold your flute? Is your flute parallel to the ground?

BOYD: Pretty close, parallel. It's not leaning down much.

FAIN: So do you keep your neck straight?

BOYD: Yes, supposedly.

FAIN: How about your right shoulder, does it elevate a little bit or is it able to stay down in a neutral position?

BOYD: I don't think it elevates much.

FAIN: It must be those long arms of yours.

BOYD: And that's another thing I've really worked on and that's keeping the shoulders uninvolved like a singer. And that's really important actually.

FAIN: When you play is your spine rotated at all or is it straight? Do you turn to the left a little bit when you play?

BOYD: There must be a slight rotation because I'm not pushed back so that there's a tension created by pushing back with the right arm. I do have one student who's really rotated a lot and she's really comfortable. She's been playing that way for years. She seemed to be fine with it. I've seen people who are very rotated.

FAIN: What have you done in your career, especially considering the demands of it, to avoid being injured?

BOYD: I guess I could say absolutely nothing. Nothing whatsoever that's conscious. I've always just played. I think I'm a pretty relaxed player; I've heard that from all over the place. Physically relaxed. I teach flute as though it was voice. I have people sing all the time so that the whole body can let go and relax. It's an overall body relaxation, obviously, relaxation is not flaccid, because then you'd drop the flute, but where the muscles are able to work at their optimum because they're not tense. I'm a person who tries to eliminate the tension and I think singing things….I sing things to my students all the time in my studio. And I'll sing things to myself to improve what I'm going to do lyrically and so that's done an awful lot for me just in the whole delivery, feeling just more in contact with what my body is doing. I practice – now this is just for relaxation not to prevent injury – I practice against a wall sometimes to just feel the spine being lined up. I haven't done anything consciously for the purpose of avoiding injury.

FAIN: Everything you have just described to me works toward that end.

BOYD: It does. I think everything I am trying to do does work toward that end. I never even realized it. But in terms of injuries, when we were students – this performance injury business? It was close to unheard of. I knew one violinist with tendonitis problems and one pianist, it turned out to be bursitis that was really due to his backpack. And nothing else. *Nothing.* And now it's rampant. Tendonitis and performance problems, I don't think it's flute. I really feel very strongly about this. I think it's computers, honest to heavens. We were also under stress and we practiced a thousand hours too, but people did not have these problems that I see now. And we have more and more. The other thing that tips me off is that the secretaries all have the same problems. They're all wearing splints and they have the same problems. I think it's this keyboarding, this hunching over the computer and the posture and the fatigue and all these things. I just had to say that.

FAIN: That's OK.

BOYD: It just doesn't make any sense. The flutes aren't any different. I can't see any reason for this. And the kids have got problems *already* before they even enter college. They've already been having problems in high school. So what could that *be*?

FAIN: Part of it could be the posture that they are required to do in marching band which is a much bigger business than it was a while ago.

BOYD: Maybe. The students I get have avoided that. They're the arrogant ones who've said they wouldn't march in a marching band.

FAIN: That's true. [*laughter*] The last question is what do you do in general just to stay in good shape? What's your own exercise regime?

BOYD: Oh, you mean physically?

FAIN: Yeah.

BOYD: Well, ... for years…well, nothing. As you get older, you start to realize that your body is not going to improve by itself. In fact it's definitely going to get worse. So that's when I kind of woke up. It was about ten years ago so I started doing sit-ups and push-ups in the mornings, just real exercise, and just tried to walk a lot more. So those have been the main things. Just that kind of exercise. Like I do about a hundred sit-ups in the morning and things like that.

FAIN: OK, well, that's all I have to ask. You've been just very helpful. I really appreciate your time.

BOYD: Oh, you're more than welcome. That was easy.

Interview with Katherine Borst Jones

Katherine Borst Jones has been teaching flute at Ohio State University (OSU) since 1985 and has served as chair of woodwinds, brass and percussion since 1999. She was awarded the Distinguished Teacher award in 1995 and the Scholar award at OSU in 2008. She is a founding member and co-principal flutist of the ProMusica Chamber Orchestra, a member of the Columbus Symphony Orchestra and principal flute of the New Sousa Band, which has toured Japan and the US. In 1976, she created the annual

OSU High School Flute Workshop which continues to this day. Professor Jones conducts the OSU Flute Troupe, and has served in many roles for the National Flute Association, including president, vice-president, and 1992 convention program chair. She has performed at eight conventions and was a member of the NFA delegation to the Soviet Union in 1989. Professor Jones studied with Keith Brion, Robert Willoughby, Kyril Magg, Donald McGinnis, and Julius Baker. She has performed with symphonies, chamber groups and festivals around the world and made numerous recordings. Her flute, viola and harp trio, COSMOS has commissioned works from Libby Larsen, Stephen Paulus, Andrew Boysen and Steven Main.

Flute and Hand Position

Jones plays a gold Brannen flute with a B-footjoint. The body has silver keys, which decreases the weight of the flute significantly, an important feature considering the heavy weight of a gold flute. She uses the Brannen C# extension mechanism for the index finger. Jones uses the modified Rockstro position for headjoint alignment in that she turns in the headjoint, but 'just a little bit' and turns out the middlejoint. The keys are flat to the ceiling and the end of the flute angles down.

Body Position

In standing, Jones keeps her left foot forward and her right foot back, facing her trunk to the right at about a 40 degree angle. She replicates the same angles in her sitting position. In working with her students, Jones keeps a watchful eye:

> I try to be smart to not turn them off to body position or posture but to just give them suggestions. I listen carefully to whatever they're saying, but I really do look to make sure that they are looking natural number one, relaxed and comfortable and then, what I've studied, trying make sure they're not bending in funny ways. You can usually see tension and see problems. But I listen to what they're saying, how does it feel, are you hurting in any place, anything I need to know that happened this week?

When asked whether she intercedes when flutists have a collapsed joint in the right hand little finger during playing, Jones replied,

> I might mention it, but I don't make a big deal about it. I've seen too many really great players. Chris Norman was here just the last two days and his pinky is pretty straight and yet the rest of him is so relaxed. It clearly hasn't caused him any problems. I think with some people it's just not going to look perfect. Everyone's body is different. I have heard of people who have played for a long time in a way that doesn't look or seem right and then they've changed and then they've had real problems. So I think we have to be really careful not to do a one-size-fits-all approach, but to look at the individual body type and try to evaluate from listening to the student and looking. Because you can't always tell just by looking.

Physical Challenges

Jones has not had any significant problems related to playing the flute. An avid athlete, she is a seasoned tennis player and for exercise walks and has regular sessions with a personal trainer.

Kathy Borst Jones Interview

FAIN: So I have some questions. Some of them are the same as the survey but I wanted to talk to people in positions such as yours to get a little more detail on how we hold the flute, setting our bodies up to play, and injuries and how we've dealt with them. So that sort of is the thrust of my project and to start with, can I ask you what kind of flute, headjoint, and footjoint do you use?

JONES: I play a Brannen flute with a Brannen headjoint. It's a gold flute with silver keys and it's a convertible B/C footjoint. But I play the B most of the time

FAIN: So when you have a lot of stuff in the stratosphere, you use the C joint?

JONES: No, I really don't. I might use it if I play baroque music.

FAIN: Oh, that's true. That would work, too.

JONES: But I tend not to mess with it.

FAIN: So, for how long have you used this particular set-up?

JONES: A long time, since '85 I think.

FAIN: So, in your career how many different flutes have you owned?

JONES: Four, if I don't count my student flutes. I'm starting when I got my first professional flute which was a Powell in high school and I had a couple more Powells. I guess three other Powells before I got the Brannen.

FAIN: And you obviously like the Brannen the best.

JONES: Yes, well, the Powells were very good while I had them but when I got the Brannen, I fell in love. [*laughter*]

FAIN: You were just in lust before and now you were in love.

JONES: Right. [*laughter*]

FAIN: So what wall thickness is your flute?

JONES: You know, it's whatever gold is.

FAIN: Oh, do they just make it in one thickness?

JONES: I think they do.

FAIN: I bet it's .016.

JONES: That's my guess, too.

FAIN: Do you have any extra gizmos on it like the C# trill or the…

JONES: No, the only thing I have on it is one of those plastic things for your left hand first finger and I don't know what they call it.

FAIN: Oh, a little extension?

JONES: Yeah.

FAIN: And you added that yourself?

JONES: I bought it from them. Again it was, I just tried it at a convention and it felt really good and it seemed to make it more comfortable and I thought why not, so I've had that for quite a long time.

FAIN: Did you have problems with your index finger before that?

JONES: No, it was just one of those things where I thought let's see what this feels like and it felt better so I went to it.

FAIN: When you were choosing which flutes to buy, did you ever consider the entire weight of the flute as a consideration? Or did you ever not even think of that?

JONES: I didn't worry about it and it didn't strike me as something important at the time. I chose the flute blindly. I was in a position where I had a whole mess of Brannen flutes and I closed my eyes and just picked on up, played it, put it down, picked up another one. I picked up this one and played it and I knew instantly this was the one.

FAIN: This is off the track, but what do you think – in terms of finding the flute that matches you, I've heard some people say that they think that part of it is the way the air vibrates in your upper respiratory track somehow matches the flute? Have you ever heard that?

JONES: No.

FAIN: I'm just trying to figure out and it would be interesting to know why…

JONES: Why we choose one?

FAIN: Yeah. I mean, how did you *know*? I mean what are the physiological or acoustical reasons why that flute matched you so well?

JONES: I knew very quickly because I knew that the sound was what I was looking for, it felt comfortable, I could change the color of the sound in a way that I hadn't been able to, so there was just a comfort level. It was a little bit like when you sit in a new car and it just feels right?

FAIN: I've never done that. [*laughter*]

JONES: But sometimes you sit in a car and oh no, this isn't comfortable. You just know it isn't comfortable. It just doesn't fit. It's sort of a funny analogy, but…

FAIN: But I understand what you are getting at.

JONES: And I was pretty experienced by that time and I had played a lot of flutes and none had struck me like this one before.

FAIN: So, when playing the flute as a professional have you ever experienced any pain that was due to the way the flute was manufactured?

JONES: It's hard to know. I think the complicated thing about all this is that we age and we do others things in our life besides play the flute. I'm a tennis player and have been an athlete all my life. I've been in and out of shape and I notice that when I'm in good shape overall, I feel better playing the flute. And if I'm out of shape, I might have some little aches and pains. I've really been wondering how much balance between muscle groups…if opposing muscles, one set of muscles is really strong, the opposing set isn't, it seems to me that's when I've had issues of some sort. Nothing horrible enough to stop me but just those aches and pains you get if you overdo a little bit.

FAIN: Right.

JONES: Like what I get if I play tennis too much if I haven't been.

FAIN: Are you right-handed?

JONES: Yeah. When I've exercised, and when I've specifically strengthened my chest muscles, the flute playing was a lot easier.

FAIN: When you exercised your chest muscles, are you also talking about strengthening your upper back?

JONES: Well, maybe.

FAIN: Because when you play the flute, you're using all those forward muscles. The ones in the back can get weak and stretched out. So in terms of having a good balance…

JONES: Maybe I was doing both. I was working with a personal trainer who took a look at me.

FAIN: I'm sure that they had you do…

JONES: …different things.

FAIN: Right.

JONES: And it made a huge difference. And I'm doing it again now.

FAIN: Good.

JONES: And it does help.

FAIN: Excellent. Excellent. Yeah, and I'm sure we can't be weekend athletes.

JONES: Right. [*laughter*]

FAIN: Now, how do you line up the joints of your flute?

JONES: I turn in the headjoint just a little bit. I guess you call it modified Rockstro. It's really not very much. I'm going to look at it right here. It's just a little bit turned in. And then I turn it out with my hands. The footjoint is lined up perfectly the way everybody tells you to do it.

FAIN: When you hold your flute, are the keys – I don't mean parallel to the floor, but are the keys flat? Or do they angle down a little bit in the front?

JONES: They're up to the ceiling pretty much.

FAIN: And also, the end of the flute, does it droop down a little bit or do you keep it straight?

JONES: Oh, it droops down a little bit I'm sure.

FAIN: Good. OK. How about your neck? When you play, do you keep your neck straight? I'm not talking about rotating right or left, but rather do you tilt your neck to the right when you play?

JONES: Hang on a second. You know it's hard to say. I think I do a little bit but not maybe the same all the time. I move some but I don't move a lot. I'd have to video tape it and look at it very carefully to see how much I tilt it but I do tilt it a little bit.

FAIN: But I would think that if you're not sure, it mustn't be a lot.

JONES: Sure. It's not much.

FAIN: Do you think that both of your shoulders pretty much stay down?

JONES: Yeah.

FAIN: Can you describe to me how you would stand while practicing?

JONES: Left foot forward, right foot back. I'm faced to the right about 40 degrees and then I turn my head to the left to see the music. I do sort of what Hotteterre did. And when I sit I do the same thing with the chair.

FAIN: So you turn the chair a little bit to the right?

JONES: Yeah.

FAIN: On your left hand, where does the flute actually touch your left index finger, where the finger joins the palm? Can you describe to me where it touches?

JONES: It touches not on that third joint, but just off that bone so that's it's on that fleshy part.

FAIN: Is it right above it?

JONES: Right above it, yeah.

FAIN: I think mine ends up doing just about the same thing. And how about your right thumb?

JONES: It's back. I have very long fingers and so the way I could describe it, the hand position is as if I were writing on a blackboard and there's kind of a C between my forefinger and my thumb and so my thumb is on the inside back edge just pushing forward slightly, so that I'm balancing between the right hand thumb and the left hand forefinger and the chin. And that I came to on my own after graduate school. I had trouble with that. My right hand position is pretty calm, pretty relaxed I'd say.

FAIN: So do you think you hold the flute mostly with your left hand?

JONES: No, I balance back and forth.

FAIN: When you practice, do you find yourself alternating between standing and sitting or do you stand most of the time?

JONES: I stand most of the time but I sit some of the time. I have a big yellow ball that I sit on sometimes

FAIN: Ah, a woman after my own heart!

JONES: Yep. Especially if I'm tired or if my breathing doesn't seem good. I have a ball in my studio at Ohio State, so I use a ball quite a lot.

FAIN: Two more questions. In terms of injuries, have you had any injuries related to playing?

JONES: Not really. I've had things happen that have affected my playing but not because I played.

FAIN: You've already answered this sort of, but what do you do to keep your body in shape for being a good flute player? What's your exercise...?

JONES: For years, I walked. A mile and a-half every day. For twelve years I did that because I had a dog. I try to take the steps. I do this personal training stuff. I do walk. I play tennis. I've gotten one of those *wii console* things. And I garden.

FAIN: Oh, do you like that?

JONES: Yeah. It's fun. I'm trying to get into that. So I consciously try to get exercise.

FAIN: I want to ask a selfish question about tennis. I had a big gap in flute-playing when I had five children so after that last one got out of diapers, and I had a life again, I wanted to pick up tennis again along with playing flute. I ended up giving up tennis because it conflicted so much with my right hand. How do you manage the two?

JONES: Oh, it causes no problem at all.

FAIN: You must just have a lot of residual strength built up.

JONES: Well, I'm a good tennis player. I think I might have started playing before I started playing the flute actually and I used the whole arm and I turn my body and use the strength of my whole body when I swing.

FAIN: Oh I never had tennis lessons. That's probably my problem.

JONES: You could get in real trouble I think if you don't turn your body when you go to hit a forehand. And you know how we lean into the stand as flute players; well, you have to lean into the ball as you swing. You have to make sure you hit the ball forward of your body and you step into it, then you use the whole arm to swing. If you're using your whole arm, it won't cause you any problems.

FAIN: The last question I have is…what do you do with your students, do you spend a lot of time talking about hand position or body position with them?

JONES: Yep. I'm always keeping a watchful eye for it. I try to be smart not to turn them off to it but to just give them suggestions. I do talk about it specifically in their first year and then from that time. I listen carefully to whatever they're saying, but I really do look to make sure that they are looking natural number one, relaxed and comfortable and then, what I've studied, trying to make sure they're not bending in funny ways. You can usually see tension and see problems. But I listen to what they're saying, how does it feel, are you hurting in any place, anything I need to know that happened this week? I also ask them to ready different materials about flute playing including the Kujala *Flutists Progress* and I encourage them to take Alexander Technique which is offered as a course at Ohio State, as is performance enhancement which also gets into relaxation and concentration techniques.

FAIN: I do have one more little detail question and I promise this is the last one.

JONES: No, and I've got something really important that I need to tell you.

FAIN: When you have a student that has a collapsed pinky, you know what I'm talking about?

JONES: Yep.

FAIN: Do you deal with that?

JONES: Not much. I might mention it, but I don't make a big deal about it. I've seen too many really great players; Chris Norman was here just the last two days and his pinky is pretty straight and yet the rest of him is so relaxed. It clearly hasn't caused him any problems. I think with some people it's just not going to look perfect. I have heard of people who have played for a long time in a way that doesn't look or seem right and then they've changed and then they've had real problems. So I think we have to be really careful not to do a one-size-fits-all approach, but to look at the individual body type and try to evaluate from listening to the student and looking. Because you can't always tell.

FAIN: Right.

JONES: The thing I need to tell you is that I've been at Ohio State for twenty-four years where Bill Conable, the Alexander Technique guy who invented body mapping is. And his former wife Barbara Conable was here and I took a few lessons with her so I've been kind of aware of body mapping and Alexander for a long time and two of my graduated DMA students are Amy Likar and Lea Pearson who are both doing all of this Andover Educator stuff.

FAIN: Oh, right. I didn't get that connection.

JONES: But they've gone much further with it than I ever wanted to or whatever, which is great. That's fine for them. So I kind of follow what they do and I did go to one of their retreats and I think they're on to some good things but I think there's more to it. From what Pat George told me about what you're doing; I think that approach is really important, too.

FAIN: Well, I think we can all work together to increase the body of knowledge can only be helpful.

JONES: Exactly. And now with computer imaging and all sorts of things we're going to be able to have at some point. I'm sure it's there, it's just not easily available. It sure would be nice to be able to say more accurately what is happening rather than, we have to rely on analogy and images so much.

FAIN: That was one of the things than compelled me, because I had so many teachers say things like, "Oh, just play it like you're playing it from your nose" and I didn't know what in the world they were talking about, because of the way I think. I just needed to know, OK, so you want me to raise my soft palate, *that's* what you wanted. That means a lot more to me…

JONES: And yet, other people you say soft palate" and they say, "Where in the heck is the soft palate?"

FAIN: And I'm hoping to show them where it is.

JONES: I think that is one of the really important things to realize that people learn so differently. That whole Vaark survey: visual, aural, kinesthetic and reading. I've had some miraculous things happen when I invoke a different sense; we use aural and visual so much. I had a student that I used an image that was olfactory and it was just incredible what happened! Yeah, nothing else worked and I used this image and it was like this total change. So clearly, we're very complicated beings.

FAIN: We are. [*laughter*] The good side of that is that there are a lot of different ways to skin a cat; I hate to use that image, but…

JONES: I know what you mean.

FAIN: …to solve the problem.

JONES: And I think that as a teacher, that is the most important thing, to stay open minded, keep learning, keep listening, and keep trying things.

FAIN: Excellent. I agree. I couldn't have said it better. Well, it's late, I'll let you go, Kathy. Thank you so much for taking the time to talk with me.

JONES: Absolutely. And I'll be real curious to look at your results.

FAIN: Thank you so much.

Interview with Florence Nelson

Florence Nelson recently moved to Chicago from New York City, where she spent more than 25 years as a flute and piccolo player with the New York City Opera playing with celebrated soloists such as Beverly Sills. In addition to being a busy freelance musician, Nelson also served as first-call flute/piccolo substitute at the Metropolitan Opera during the late 70s and 80s. Her flute teachers included William Hebert, Robert Willoughby, William Kincaid, and Marcel Moyse. Nelson taught flute and piccolo extensively, and many of her students are currently professional musicians in New York City. As a union activist, she served as Vice-President of AFM Local 802, NYC, Treasurer of ICSOM (International Conference of Symphony and Opera Musicians), and co-founder of the AFM Organization of Professional Women in Music and the Long Island Flute Club. She was appointed Director of the Symphonic Services Division of the AFM in 1994, and in 2001, was elected International Secretary-Treasurer of the American Federation of Musicians. In her administrative roles within the AFM, she negotiated contracts, counseled musicians, led organizing seminars, and lectured at music conservatories. Her music degrees are from the Oberlin College and the Manhattan School of Music. In 1961, Nelson won first prize at the International Mozart Competition in Salzburg, Austria.

Flute and Hand Position

When Nelson started studying the flute at the age of eight, her first flute teacher began her flute training by tying her hands together so that her wrists were "curved enough." The left hand and wrist were totally under the flute and the fingers of the right hand were to go up and directly over the keys. She was required to keep her hands tied together during practicing until her teach felt that they would stay close enough to the flute.

Nelson aligned her flute with the embouchure hole in a direct line with the first trill key, which would place it a little turned in with respect to the remainder of the keys of the middlejoint. The keys were kept flat, parallel to the floor. Nelson played with her left thumb bent and rocked it back and forth across the B and B-flat keys as needed.

Nelson played on a gold flute, with an extra G# trill key that could be facilitated by the right hand and a low-B footjoint. The keys were silver, which would serve to mitigate the heavy weight of the instrument somewhat. Nelson had Lillian Burkart create the headjoints for both her flute and her piccolo, asking that they be as similar as possible with respect to the width of the inner wall of the embouchure hole.

Body Position

Nelson spent the bulk of her time performing in the seated position in a pit orchestra setting. She did not have to angle her flute down because of space considerations. She played with her chair and body at an angle to the stand and her back never touched the chair. Nelson reports that she was not a stiff player and moved quite a bit during her playing, much to the chagrin of her teachers.

Physical Challenges

By the end of high school, by which time Nelson was already winning competitions, problems in coordinating her fingers were already starting to show in that the G/G# trill, which is manipulated by the left little finger, was abnormally slow. During her years at the Oberlin Conservatory, numbness in both the 4^{th} and 5^{th} fingers of the left hand developed; Nelson was told to practice more. Eventually she had a key added so that she could play the G# key with her right hand. With the incredible demands of playing opera and free-lancing in New York City, Nelson's physical problems eventually spread to her neck. Doctors diagnosed her with carpel tunnel, and she was given splints. An embarrassing loss of thumb control during an orchestral performance sent her back for more medical help. Nelson's husband worked for Burkart and he created devices for her flute to enlarge the space between her left thumb and index finger. Whenever these two digits would get close enough to hold the flute, they would wiggle uncontrollably. Nelson's husband made a similar attachment for her right hand so that those fingers would have the same distance to travel. Nelson was ultimately forced to see another surgeon who recommended that she look for another job. Crushed, Nelson received a phone call that very evening offering her a new professional avenue working with the musician's union. She was only forty-five years old.

Florence Nelson Interview

FAIN: To start with, if we could review your career. Now I know that you've played at the Met and I know that you've been active in the Union. But beyond that I don't know. So could you tell me your education and then what you did in your career as a flutist?

NELSON: And if I am getting too specific or not enough, please interrupt me. OK?

FAIN: OK.

NELSON: I started the flute at age eight. I grew up in Cleveland, Ohio. My first teacher began my flute playing by tying my hands together so that my wrists were curved enough. I'm looking at them so that I can explain it to you. By the time I got to Maurice Sharp and then Bill Hebert, my wrists were trained to bend significantly.

FAIN: So they were extended.

NELSON: I guess you would call it that. They were certainly at an angle to the flute. My fingers of the right hand were to go up and directly over the keys and my left hand and the wrist had to be under the flute. That string had to be on for a long time until I could get my hands away from being too far away from the flute. By the time I was at the end of high school, I was already winning competitions; my problem was already starting to show in my left hand in my pinky. I had a very slow trill for the pinky, G to G#. The whole concept through my years at Oberlin were well, you've got to practice more. And that's what went on. This was the 1950s and the early 1960s. So we were practicing more, doing trills with metronomes, I was doing scales with metronomes, double-tongued at 178 mm, all the Moyse scale passages and all that stuff. By this time now my left pinky and fourth finger were getting numb. Again I was told that I was not practicing enough and I needed to practice more. Being a very obedient little girl and not knowing any better and nobody knew any better. We didn't go to doctors in those days for any of that stuff. I was easily a 6-7 ½ hours-a-day practicer. I had been so convinced, for reasons I won't bother this tape with, that I wasn't going to be any good and if I wanted to be good I had to be better because I was a girl. If I won this competition, I had to be better so that I could win that competition. And I did win competitions by kracky. I mean I did all this stuff. I did make all the auditions. But I was already seriously in trouble with my hands and not knowing it. Just not knowing it. I finally had devices made for the flute. I played a Powell and we devised a way for me to trill the G to G# trill with the right hand which needed a key similar to the extended B trill. So that I could trill that. Well that was fine except for the fact that in opera there's a lot of stuff where it's from G# to A#. You're not quite in the key of C in opera. It was always a terrifying thing to me. I won my first job with the New York City opera and that was my day job, meaning that I had guarantee of work with them. We did in those years eight performances and six rehearsals a week so the only time off I had would be Saturday morning and Sunday morning before you'd have two shows. And then all day Monday. Monday then became the day where I did freelance work. I was a freelancer; I was known for my piccolo playing. So when I wasn't playing at the opera, at the state theater, I was playing at Carnegie Hall, and then became one of the subs at the Metropolitan Opera. That's how my career really was. During the summers when the opera was shut down, I played all the ballets that came into the Metropolitan Opera House. So I was constantly playing, there was no rest for the hands. By this time my neck was starting to really give me trouble, my hand was giving me trouble and I went to the Miller Clinic in New York City. At the Miller Clinic they would put my head into traction but they did it with hands, they didn't do it with a machine at that time. This was again in the 70s and 80s. They tried to get me to tuck my chin in more. They did the nerve conduction test which was horrible. Absolutely horrible. It showed that I had carpel tunnel but at that point they said because of that I had to have braces. So I had a wrist cock or whatever you call it…

FAIN: … a splint?

NELSON: Yes. You could get it in the drug store and it had a bar in it. They had me sleep in that they said because they said I practiced so much, that my hands automatically went into a position like I was playing flute even when I was sleeping. So they tried to get me to straighten my wrists when I was sleeping. Then they molded a form that I was to wear all the time when I wasn't playing the flute. These big white things – it was absolutely horrible. I was supposed to put them on between shows on Saturday and Sunday and between dress rehearsals and evening performances. So here I am at Lincoln Center where the whole world knows who I am and I'm to wear these things and walk around? It was ludicrous, defeatist at the worst. It was terrible. Finally I was playing in Saratoga, we were playing outdoors and I don't remember what we were playing but I had to trill a B to C and my thumb stuck. There was nothing happening in the orchestra (that I remember hearing) except the second flute trilling B to C. And my thumb stopped. Well, the conductor looked at me as if I had personally destroyed the whole performance and that the whole audience had left the room. And everybody swung around to look at what happened to Florence. Well, Florence wanted to die, right there on the spot, I just wanted to die. I came back into the Miller Clinic – I'm about to cry because I've never dealt with the tears of all of this – so I came back the following Monday to the Miller Clinic, and excuse the language, but I said, "What the f*** are you doing for me? You give me heat pads, and you give me things to put on my arms but in the meantime my hand is dying." And he looked at me and he ran out of the room and he came back with a book and another doctor. They started reading the book and looking at my hand and then they would touch these trigger points; I didn't know what they were at the time, at which point I would really just really jump out of my skin. "Does that hurt? Does that hurt?" Because I had been working so hard at ignoring the pain. I had no knowledge of what I was feeling at the time I was playing and it wasn't until the flute was not in my hands and they said, "Tell if me if this hurts, if that hurts." At which point they said I'm in terrible trouble. I ended up having carpel tunnel surgery, but this was in 1989. The surgery was not successful. I still had trouble coordinating the fingers. He couldn't understand why I was having difficulty, since all his typists were now doing well, his tennis players were doing well. Again, I looked at this man with death rays and said "They do not know work with fine motor skills. What the hell are you talking about?! I'm a musician." So then my husband and I sat down and created devices to enlarge the space between my thumb and my first finger because the minute I tried to make that space small enough, my fingers would start to wiggle. And then we did the same thing for the left hand so that it would have the same distance to travel. Otherwise my left hand would go down faster than my right hand because it could get to the keys faster. Then we had to do something to the piccolo so that I didn't have that much of a change. We experimented until we learned how much I could move my fingers before the wiggle started.

FAIN: This is perfect; I'm really interested.

NELSON: I then went to a second surgeon who did some more tests and looked at me and sadly said, "I suggest you find another career." And it was that night ironically that the telephone rang and somebody offered me a job at the union.

FAIN: Oh, my gosh. There is a God.

NELSON: There is a God. And I can tell you exactly where I sat because I sat the whole day there crying.

FAIN: Bless you heart; I would have too.

NELSON: Yeah. That's all I had known since I was eight years old, that I was going to be a flutist.

FAIN: How old were you at that point?

NELSON: I must have been about forty-five. That's when I got active in the union. I discovered that I still had hand problems because in those days the keyboards were so sensitive that if I didn't move a finger fast enough, the 'd' would go right across the page. [*laughter*] It's been changed since then so that got fixed. And I slowly but surely gave up the flute. I tried to go back to the flute since then because everybody said "Can't you enjoy it?" That does not work once you've been a professional. When you've played *Rosenkavalier* in the Met you cannot just have a couple of drinks and play flute in your corner. No, it doesn't work like that. And I can't make my thumb stop shaking. I can't make my neck stop hurting. One doctor said, "Well, we can try and operate on your shoulder and see if that would help." And I said, "When you guys figure out what to do you can call me back." I've talked to somebody about dystonia. There's one doctor here in Chicago who might be willing – that might is very long drawn – be willing to try a little Botox into my thumb but they're very inexperienced in it and they don't want to make whatever else I do in my life like my typing to become worse because it might weaken my hand so much that until the Botox in six months goes away, I may really become suicidal. Pat George has given me any number of interesting ideas about how I can try and retrain the mind. I'm at a point where any time I take it out, and I see it, it so visible to see it, Susan, and it's so awful to see the hands shake like that, that I'd rather melt the flute down I think, than go back to it.

FAIN: I can understand that. That would be so hard.

NELSON: [*crying*] I'm sorry.

FAIN: No, no. Don't apologize at all. This was the center of your life for so many years and to have that much time even as a young person practicing so hard and then to have gotten strange advice and no help over so many years and then still to have succeeded in the way that you did. There are not many people that could say that they've had the career that you've had, Florence.

NELSON: No, I understand. And I've had a wonderful career. I toured Europe with Detroit; I've done fabulous things and won fabulous competitions. I played solos with Beverly Sills, you know.

FAIN: Oh, my gosh! [*laughter*]

NELSON: And all those "Live from Lincoln Center" and Carnegie Hall Performances, I'm on many of them. I can't complain for any of that. I tried to turn my energy into education.

FAIN: Yes, and I've seen that. You've done…your experiences can really speak for other people.

NELSON: Yes, and I try to do that. I try to help musicians who find it hard to admit that they are broken! I got very involved with the International Conference of Symphony and Opera Musicians, ICSOM by name. First I was their treasurer, when we worked with symphony orchestra managers about the use of sound baffles on stage. I served as Vice-President of AFM Local 802 in NYC and then I became the director of symphonic services to the AFM, American Federation of Musicians, during which time I tried to guide musicians with physical problems to seek medical help or consider artistic alternates. I felt a part of my job was to educate conductors to the personal and physical properties of being a musician. I'd say, "What's my name?" And he looked at me and he said, "Flute." I said, "No, that's what I play. I am not a flute. I am *Florence*." I tried to educate people that it is acceptable that they admit that they are losing their hearing or control of their hands or lips, that there are people like you (referring to me) in this world, in this country and in Canada who are finally admitting that there is something that can be done, and then working with management to agree that they cannot just throw the musician out because they're in trouble. How many flutists have said that they were alcoholic rather admit that their hand had gone? That to me is shameful.

FAIN: That is shameful.

NELSON: They had to lose their jobs for other reasons that were much more embarrassing than to say that they were physically unable to do what they had to do. Of course, the United States has no retraining for people like this. We are a step higher than dancers, who lose their jobs at the age of thirty. But we've still got a long way to go into what are you going to do with musicians who've got all this experience but can't play. That's probably not in your survey but …

FAIN: Oh, no, that's OK. I know of one flutist at a university that has her teaching post, but the graduate assistant plays in the quintet, because she can't.

NELSON: That's right.

FAIN: And others, they've lost their jobs, and that's just the end of it. They've lost their job and they've got to go, I don't know; sell real estate or who knows.

NELSON: Right. The world that we come from is so much about working with the ensemble, working with the group, has so much in terms of internal organizing and things that we can do together as people, as humans. But we don't know that. They don't know that that's what they're doing every time they pick up their instrument. That's part of why I tried to get people to feel proud of themselves even if their hand didn't work. So that's my story.

FAIN: Thank you for sharing. I know that was not easy. Let me ask you a question. When you line up your to play, how were you taught to line up the different joints?

NELSON: The blow hole went across the first B key.

FAIN: So that would be a little turned in if you were considering the rest of the keys, correct?

NELSON: Nevertheless, the keys had to be parallel to the – I know that you've got labels for it in that survey I filled out – but the keys had to be parallel with the ground, flat, not on an angle. One thing you asked in the survey that I found remarkably different between me and Wally Kujala – my thumb was trained to be bent, my left thumb, and then to rock back and forth. Not to slide, but to rock back and forth so I was just about between the B and the B-flat. Wally's thumb is straight and he moves it right and left like a windshield wiper. And he has no pain whatsoever.

FAIN: Most of the people I come across play with the straight thumb. Now I'm wondering if that might have added to your problems.

NELSON: When I saw that last year at a flute festival, he and I were doing a masterclass on piccolo. I said, "Let me see something. Show me what you do with your left thumb." And then I said, "That's it! I've got too much of an arch and too much pressure on the thumb."

FAIN: Is your flute's wall thickness .016?

NELSON: Yes, I think it is. .014 is light, right?

FAIN: Yes.

NELSON: So it's a .016.

FAIN: And you had a C# trill key?

NELSON: Yes. And a G# trill key. And I had a gold flute. So the gold was heavy, it had silver keys; it was a gold flute with silver keys, so it was a heavy instrument. And it had a B foot. Galway made a big thing about trying not to play with a B foot.

FAIN: So you didn't have the thick, thick wall, but lots of keys added weight to it.

NELSON: That's right. The wall was modified because I ultimately had Lillian Burkart match the wall of the headjoint for my flute to my piccolo, because I wanted them to be as similar as possible, so I would know exactly where I was blowing. So it was adjusted for that but the width of the wall in the headjoint wasn't changed.

FAIN: You did most of your playing in the seated position, right?

NELSON: Right.

FAIN: Could you describe for me, since you're an orchestra player, what was the typical way of setting up to play? It sounds like a lot of your work was done in the pit, right?

NELSON: It was, and we could spend more time arguing space than the animals in the zoo. The harpist put lines on the floor and no one would even think of coming inside her lines. No, I mean it was really quite something. I played at an angle. My back never touched the chair.

FAIN: Did you have to angle your flute down because of spacing?

NELSON: No, no. Fortunately I played in big enough theaters that I didn't have to deal with that.

FAIN: So you really don't think the spacing was an issue for you?

NELSON: No, no. That had nothing to do with it. I was wide open for anything I wanted to do. I was not a stiff player. It drove Bob Willoughby out of his mind. I couldn't sit still or stand still. Kincaid went nuts with it also. I think I was moving around because I was so into the music I was playing. Whether that hurt or helped, I don't know. Anytime that they would line me up against the wall, or put books on my head, that hurt even more.

FAIN: Sounds to me like it would hurt.

NELSON: In today's day, when I heard Pat or you or Kathy Borst Jones talk about moving while playing, it was stressed that it helps to keep the spine relaxed and not stiff. But back then in the 60s, it was considered disruptive to the line of view of the audience.

FAIN: I think you've covered everything so well. I'm looking over the questions and I think that you've answered them all without me having to ask you.

NELSON: One of the things that I did by the way was what I think they call music hardening now or something like that. After I had gotten the cast off following the carpel tunnel surgery. There was no physical therapy at that time, no training, nobody to help me. I'd like to think it's totally different today. I started practicing with five minutes a day and then do that for three days. And then raised it to ten minutes, then did that for three days, you know, and stuff like that. I didn't want to overuse the hand when I went back to it.

FAIN: Well, that was smart.

NELSON: It made more sense than just picking it up and starting to see what I can do. But again, there was no re-training. I'm having physical therapy now because I had had some back surgery in January and I see that there is a whole plethora of things that people do for your hands now that were never done back in the 80s.

FAIN: Well, yes, things have improved. I still think as you have said earlier that we need to work on this bridge between music and medicine because there are still a lot of misconceptions on both sides.

NELSON: Yes. There's a whole world of education. We are so fast to blame ourselves for a problem that we can't control. For the very reason that it would be very easy for me to say "Boy, I don't know how to focus on E. What reason would my E crack all the time?" I could spend hours trying to determine what I'm not doing correctly with my lips or breath support, or I could give the flute to my husband, a flute repairman and say, "Fix the darn thing." And then I'd find out that the key is leaking.

FAIN: Yes! I've done that very thing.

NELSON: The thing is that it's very easy for us to blame ourselves, because suddenly that second finger isn't lifting and we hear the "bloop." And we need a tremendous amount of education to our own people that it's not a shame to know that you've got a physical problem just as much as if you'd got a cold. You have a problem. And the minute you hear these things, this is an alarm that you should go and seek help. It is not something to apologize for, but is a reality of our occupation.

FAIN: Well, you know the Miller Clinic isn't seeing musicians anymore.

NELSON: I know.

FAIN: I read that somewhere and was not happy about it.

NELSON: I haven't seen it recently but about a year ago there was a whole world of emails that were going back and forth, "I'm having trouble with my right arm." "I'm having trouble with my shoulder." "I'm having trouble with my elbow." "Do you know who I should go to get the best hearing aids?" I think that there needs to be renewed emphasis on wellness, prevention, education and where musicians can go for these resources.

FAIN: That's one of the things that PAMA, the Performing Arts Medical Association, is trying to provide. On our website, we are working on a page for referrals. If we could get a national network set up of people and places you could go to if you're having problems. Because of HIPPA, there's going to be confidentiality, so musicians don't need to worry about being found out unless they inadvertently let something slip. I think a lot of the help is there but they don't know how to get to it. And also, Florence, they think they have some kind of musculoskeletal problem when it's a neurological problem.

NELSON: That's true. And there has to be some education for the employers and for the specific teachers. Julliard, Manhattan, maybe Mannes are doing something about Feldenkrais or Alexander, and I hope many other schools around the country are doing the same. I tried to get a program going at Lincoln Center for Lincoln Center musicians during a lunch break. But there are many more things that can be done. As a matter of fact, Alice Brandfonbrener has agreed to come to our Chicago Flute Festival in November.

FAIN: Oh, good!

NELSON: I am so excited. I had written her saying I don't know if she remember me but I worked with her back in the '80s on a research project concerning the physical wellness of symphony orchestra musicians. She wrote back, agreed to meet with me and will address the flutists about her newest research dealing with our choice of instruments and the repercussions on our body.

FAIN: Have you heard of PAMA before?

NELSON: Oh, yes, I have. And I used to get the magazine but I couldn't understand it 99% of it, [*laughter*] but it still looked good.

FAIN: There are some people in PAMA that are very active nationally that are not…yes, most of them are medical, but there are some that are not. Dr. Kris Chesky has an appointment at the University of North Texas. He's a jazz trumpeter, but his job there is that he's in charge of research. He's very active in PAMA and he goes around talking about noise-induced hearing loss and trying to get schools to at least address the issues. To let kids know that at least that they are at a risk of losing their hearing.

NELSON: Yes, exactly. We've got standards in New York City pits now at least for the theaters. But the fight I had with the City Opera to muffle the pit and get people to test how loud it was took devious turns. I physically dragged conductors into the pit and made them sit there. They would say after sitting in front of the brass, or under the stage over hang for about two arias they were ready to do whatever was necessary to help us out.

FAIN: What they've done at North Texas is that they've got these dosimeters in all the ensemble rooms. Every minute of every rehearsal is recorded and the decibel level is recorded. Scientific data means a lot. If you can document what's happening, then people listen…if they can still hear! [*laughter*]

NELSON: That's cute. I love it.

FAIN: Oh, Florence, with your energy and drive; you are a great organizer. You've got the experience doing it, but you've got the heart. Gee whiz, God bless ya.

NELSON: I don't know if I was able to help with anything here. Please feel free to call me back.

FAIN: I will, Florence. And what I may do; yes, you've answered every question. I mean I have my little list here but you've answered them without my even having to ask.

Interview with Dr. Adah Toland Jones

Dr. Adah Toland Jones is Professor of Flute at Texas State University, Principal Flute with the Austin Lyric Opera and the Victoria Bach Festival Orchestra. She plays extra with the Austin and San Antonio Symphonies and is a founding member of the flute quartet SONORA. Dr. Jones has been a featured soloist at National Flute Association conventions in St. Louis, Boston, and Orlando, where she also conducted the National High School Flute Choir, and is a member of the National Pedagogy Committee and Coordinator of the NFA Professional Flute Choir. She holds Bachelor and Master of Music degrees and a Performers Certificate from the Eastman School of Music and a Doctor of Arts degree from Ball State University. Her principal teachers include Patricia George, Joseph Mariano, Paul Boyer, and Jean-Pierre Rampal.

Flute and Hand Position

Dr. Jones plays on a silver Burkhart flute with an old gold Haynes headjoint. She plays with the classic alignment of joints but turns in the headjoint just a little bit. She feels that with thin lips, less of the hole gets covered, producing an airy sound. By turning it in ever so slightly, the tone is improved. At one point, Dr. Jones tried a true Rockstro position and could not manage it, returning instead to her original set-up.

Dr. Jones keeps her left hand under the flute and bends the IP joint of her left thumb to touch the B/B-flat thumb key. Her right hand thumb is under the flute as well, not pushing it forward but holding it up. She is able to keep her right hand little finger straight without any problems.

Body Position

Because of the rigors of her job and time spent playing in the opera orchestra, Dr. Jones reports that she spends about 90% of her practice time seated. She angles her chair and body to the right and keeps her shoulders level. Her elbows are slightly lifted out to the side.

Physical Challenges

Dr. Jones has been through significant problems related to her flute playing. During a time of personal stress and a trial period for different headjoints, she was unable to form an embouchure during an important moment in an orchestral performance. Dr. Jones took some time off work, during which she sought medical advice form a neurologist that worked with musicians. Guessing that she had focal dystonia of the embouchure, he then recommended a series of Botox injections. Not wanting to go through that, Dr. Jones instead sought out her own family doctor. He suggested biofeedback at a local clinic. After six months of treatment at this clinic, Dr. Jones was 95% cured. She credits this clinic with saving her playing and her career.

Besides the issue with her embouchure, Dr. Jones has also dealt with wrist pain and mild arthritis. Physical therapy involving stretches and strength building with weighted pulleys has helped. For the past fourteen years, Dr. Jones has faithfully participated in water aerobics. A great combination of moderate strengthening and stretching exercises, the time in the pool is also a good aerobic exercise.

Adah Jones Interview

FAIN: I know that you studied many years ago with Pat George.

JONES: I did, when I was in high school. We're talking 40 years ago.

FAIN: Could you summarize your training and education for me?

JONES: I studied with Pat my sophomore and junior year in high school when she was a masters student at Eastman. My father was the orchestra librarian at Eastman and I lived near Rochester, so I had the advantage of being in what they call the preparatory division which was for young students who could start piano or theory lessons or flute. I did piano, ballet, theory, and then I started flute. My sophomore and junior year I was with Patricia George. She finished her masters and moved away and I studied with John Thomas, who was the second flutist in the Rochester Philharmonic at the time. Then before Pat left, she insisted that Marianno listen to me at Eastman. So I played for him my junior year and was accepted into Eastman my junior year of high school. So I sort of planned out my whole senior year; I had already been accepted. So I studied with Joseph Marianno through all of my undergraduate years and also stayed on and did my masters at Eastman as well. I have an undergraduate degree, where I studied with Marianno, in music education and a masters in performance there as well. Then I went out and taught for awhile. You want all those jobs?

FAIN: [*mumbling*] well….

JONES: I had a college teaching position and stayed there a couple of years. My now ex-husband was in a service band so we were in DC for awhile but then I got a one-year position at State University at Fredonia. That was a one-year thing, the guy came back and rightly so. And I moved on and did a semester at a small school in Rhode Island called Roger Williams College. Nice little school but I wasn't doing anything with flute, just service courses, music history, theory, etc. I was the music department; it was just me. I wanted to do the flute, so I applied for the job at Ohio State. I got the job there and I was there four years. I knew that wasn't going to go anywhere so I got my doctorate at Ball State in Muncie, Indiana, because there was a doctoral fellowship. So, I studied with Paul Boyer, who in my opinion, if you want to put this in your report, is one of the unsung heroes of the flute world. He's one of those people that…well, I went there with quite a chip on my shoulder because I went to Eastman and what could I possibly learn anywhere else. My first couple of lessons I thought this is going to be a doddle because I'd had that kind of training. After about the first lesson and a-half, I thought wow, this guy really knows what he is talking about. I think I'm going to shut up and listen. He was just phenomenal. He was a really, really great teacher. Here he was stuck in Muncie, Indiana. He was a Kincaid student back in the 50s and then he toured with Columbia Artists with a harpist and a violist for many years. And then he just landed in Muncie and taught at Ball State and had wonderful students. I was his TA for two years; it was fantastic. Really, really great. Before that I actually went to Rampal's masterclass in Nice during the last 60s and early 70s for quite a stint there. Rampal was teaching at a summer academy in Nice, France, and I went there for the summer after my junior year and the summer after my senior year, then I went back in 1978 again, so I've studied with him for three summers, which was fantastic. When I was finishing up the coursework of my doctorate, I started applying for jobs and I got an interview here with what was then called Southwest Texas State University and about four to five years ago it changed its name to Texas State University. I've been here since 1982.

FAIN: I didn't realize that you'd been there that long. That's great.

JONES: Yeah. And since 1987, I've been playing principal flute in the Austin Lyric Opera. So I feel incredibly blessed and lucky to have a job and to get to play, to have students, to be in a good location. I feel sorry for the kids graduating now, like, oh my gosh, good luck. It's hard. So that's my background in a nutshell.

FAIN: Thank you. So could you tell me what kind of flute, headjoint, and footjoint that you use?

JONES: Yep. Right now I have kind of a hybrid. I'm using a Burkart flute and an old gold Haynes headjoint that I've had since 1979. Occasionally, footjoint-wise, my Burkart footjoint is not that great I hate to say. So at times, I have another silver Haynes flute – it's one of those bottom of the line models they made about ten years ago for a few years called a commercial model or something – and I bought one just to have a back-up flute. I use the footjoint from that flute on this flute, because it has a much better set-up for the footjoint than this one. I don't know, the response is better, it doesn't have a roller but I can maneuver my pinky much more easily. So I use that occasionally.

FAIN: How do you align your flute when you put it together?

JONES: Pretty much the basic one with the rod of the footjoint in the middle of the keys but my headjoint I turn in I wouldn't say considerably, but more than most people. I don't line up with the middle of the keys. It doesn't work for me because I have fairly thin lips. I just don't cover enough hole. And I think that started when I took one lesson with Wally Kujala once years and years ago. He convinced me to turn my headjoint *way*, *way* in and my hands way out. Well, the hands way out thing started *really* bothering my wrists. So, after six months or something I went back to the keys kind of being level to the floor and just turned my headjoint out a little bit. But I definitely still turn my headjoint in some.

FAIN: That's interesting that you feel like it's connected with your lips. So that affects…

JONES: …how much of the hole I cover.

FAIN: And the way you blow.

JONES: Yep. I think kids that have fairly thick lips, sometimes they can get away with being right in the middle of the line of the keys if fine because they cover about a third of the hole approximately. But if you put the flute up and make your normal embouchure and you're covering less than a third of the hole, you get a pretty airy sound. I've tipped it towards me for that reason.

FAIN: What wall thickness do you prefer?

JONES: I have a .016 right now. Point zero eighteen is way too much for me. I've got a student that has one plus she's got a C# trill and it's so unbelievably heavy. So no, I've an .016. I've no idea what my gold headjoint thickness is actually, but the body of my flute is .016.

FAIN: Is there anything on your flute that you would change mechanically? To better suit your hands? Or the weight?

JONES: One of your questions here is how long have you had this set-up? I've had the Burkhart about ten years now I would say. Before that, I've only had two other flutes. One was a Haynes that I had got in high school. That lasted me through college until 1979. That's when I got my gold Haynes, all gold not just the headjoint, 14K keys and all. About ten years ago I decided that was too much. It was hard to keep in shape. A gold flute to me, you have to be in shape all the time. You have to be practicing all the time. With my teaching schedule that's not always possible. So I switched to a silver flute and played the silver flute for a couple of months. And I played a recital and a whole bunch of friends of mine came to the recital and said, "Whoa, that does not sound like you," which is when I went back to the gold headjoint. I did try a Dana Sheridan for a few months and that's one of the things I wanted to talk about my physical problem that I got. Want me to do that now, while I'm talking about headjoints?

FAIN: Sure.

JONES: I got a Dana Sheridan headjoint just after I'd had the Burkhart flute for maybe six or eight months. I went to the convention and picked out a gold Dana Sheridan headjoint and I'd always thought they were really great headjoints. I thought this is going to be the answer, I'll stop cracking in the middle register and it's going to be the answer to all my prayers. I don't know if this exacerbated the problem, caused the problem, or it was going to happen anyway; I don't think I can really blame it on the headjoint. It was all kind of an interesting timing. This was when my now husband who is English (we met on a faculty exchange program) was going through early retirement from his job. He was basically quitting his job and getting a visa to come here for us to get married. And it was unbelievably stressful. I don't know if you've ever been in a visa situation but it is not the most fun and he was over there, I was over here and we weren't able to see each other because he wasn't allowed to travel to the States. When you're applying for a visa you can't come into the States. So it was very stressful. At all at the same time, I'm trying this new headjoint. I went to play a San Antonio Symphony gig and I was playing second flute on the Dvorak cello concerto. I will never forget it. I was playing a low A and all of a sudden I put my flute about one inch from my lip and my top lip started to shake uncontrollably. And I put the flute up and I could not make a sound.

FAIN: All of a sudden.

JONES: All of a sudden. And I totally freaked. I didn't tell anybody what was going on because I was terrified that I would lose my job, that I wouldn't get called to play. So I got out of the opera for that particular time. I told them I just wanted the time off because of my future husband's situation and I could not play. I could not make a sound for like three months. I would put the flute up and as soon as I would put any pressure on my lower lip, my upper lip in the left side would just go – I could not make a straight tone. It would be like (wobbling noise) I thought, oh, my gosh, this is crazy. After a few weeks of crying and freaking out, I went to a neurologist and he said, "Well, I think you might have to face the fact that your career is over." And I said, "Over my *very* dead body."

FAIN: And how old were you at that point?

JONES: Fifty. He recommended that I call this guy in Cleveland. I can't even remember the guy's name but some neurologist that works with musicians. I called him. I was actually in my office at the time and he said "Well, I think you should fly up and let's have an appointment," which I was ready to do. But he said, "Kind of explain to me what's going on, and how does it feel? I really think you'd be wasting your time and money cause it sounds to me like this is a done deal. I think what this is, is called focal dystonia." And I said, "OK, that's what the last guy said, so what is the solution?" He said, "Well, we've worked with a lot of musicians and you might get some function back but it will probably not be to the level you'd want." I said, "What is it that I need to do?" And he said, "Well, basically you can go through this series of Botox treatments." And I said, “Not on your life.” So I kind of gave up on that idea. I went back to my own doctor, you know, obviously hysterical and in tears and I said, “Now what do I do?” And he said, “Well,” and this is coming from my doctor who doesn’t even recommend taking vitamins, you know, he’s your typical old-fashioned doctor who gives you a pill for everything, “my recommendation for you is to… I went to this clinic about biofeedback. You might give this a try. Who knows, it might do something? It’s worth a try.” I said, “Look I’ll do *anything*.” So I made an appointment with this biofeedback center in Austin and I spent the next six months doing biofeedback. I don’t know if you’ve ever done that but…

FAIN: Well, I learned how to do that when I trained as a physical therapist, but not on the embouchure.

JONES: It was mostly training my brain. The way they described it to me and you can kind of tell by the way I’m sharing this with you that it obviously worked. I would say I’m 95% back which is pretty astounding from where I was. What happened was, there were three things that they did. It’s called neurolinguistic programming, which is they talk to you about stressful situations and they try to get you to visualize and minimize the stress of the situation. We did that and then we did…They hooked up my head to these electrodes and there was a computer screen in front of me and for an entire hour I would sit in front of the computer screen watching these bars. And they would say, “All we want you to do is to think about …” and what they were doing is reading out brain waves. There was like a delta, alpha, all the different brain wave things across the board and they said that a couple of my brain waves were out of sync. Of course, I’m going home thinking this is such garbage. I can’t believe I’m doing this. [*laughter*] And I thought, OK, I'm going to do anything. I'll try. And they seemed so convincing about it that I thought OK, I'm going to quit laughing about this and …

FAIN: …just be quiet and do it.

JONES: Yep. So I would just stare at this screen and just make this one bar stay above a certain line and when you did it made a sound. And as soon as it went silent, they said just concentrate on that bar and keep making it go up. So I did that. The third thing I did – I don't know what they call it – but they would hook up things to my lip, to my elbows, and to my shoulders, and they had a computer screen that read out neurological impulses, like how many volts it would take to fire up my embouchure. So I would try to play, which I could hardly do. I'd try to make a sound and they would say, "OK, put the flute down," cause it would read like 40 volts or whatever. And they would say now put your flute down and see if you can get that bar to come down to 1 or 2 volts really quickly. The first few times I did it, it took like 20-30 seconds for that thing to come down. And they said, "We want you to be able to do that in 1-2 seconds, so that you are releasing any tension in your embouchure really quickly." So we did that. This started in about September and by January I was back playing in the opera. In between times I literally could not make a sound. I didn't demonstrate for my students; I told them I was out of shape, I didn't really want to play for them, you know just kind of passed it off. I did not tell a soul. I was terrified that if this gets out blah, blah, blah. Well, come to find out you know, there are a lot of musicians experiencing this same thing. And I'm trying to get the word out about the biofeedback thing because it saved my playing. I didn't do any medicine. I didn't do any…well, I guess you could call it some kind of meditation maybe. It saved my life and my career anyway. I've been singing those people's praises ever since. How it has been described to me is the neurological track in your brain that has been used over a number of years just gets worn out and it sends something to you – well, I guess you must know since you're a more medical person – but they said that if you just change your embouchure just very slightly. Move the flute to the left, to the right, draw your corners down more or up more, or whatever you can do. This is coming from complete non-musician people. They learned a lot from me and I learned a lot from them. In fact, one of the girls is working on a graduate degree at UT in this whole thing with musicians. This has been several years now that I haven't talked to her or know if she's finished or whatever.

FAIN: Do you remember her name?

JONES: I can give you the number of the place where she was working and I'm sure they would be able to tell you.

FAIN: Even if you can just give me the name of the clinic.

JONES: It's the Austin Biofeedback Center. It's called ABC.

FAIN: I'll look that up.

JONES: Now, the lady that owns it and her first name is Lynda – they only ever went by first names – Lynda was kind of the head honcho. It's her daughter, whose name I believe was Jennifer, and she was the one who was going to do all this study and she was one smart cookie. Really, really brilliant girl. I'm sorry I haven't kept in touch with them. They really kind of handed my career back to me. That's probably what Pat was referring to. I mean, that was my big physical problem. I had wrist and hand problems, typical things like when I practice a lot, my wrists get tendonitis and I get elbow problems so I wear those arm band things they use for tennis elbow with the air bubble thing in them that you can push. If I wear those, it really helps my wrists so I have no idea why that works.

FAIN: Well, it just gives you another point that your muscle can pull against instead of at your elbow.

JONES: Ah hah.

FAIN: Does that make sense?

JONES: I put it up right near my elbow on top of that muscle that goes down the front to your wrist. That's helps a lot. The thing about the headjoint was, that they made a supposition, although it was not very conclusive and isn't a very scientific discovery but they were thinking that because this headjoint was different, it was putting pressure on my lower lip in a different way, that it kind of brought this about. They said our suggestion to you is to go back to what you've been playing all along if you can make that work and then just try to change your embouchure a little bit. So that's what I did. I just moved the flute slightly to the left. When I mean slightly, I mean 1/100th of an inch.

FAIN: You can feel it when it's just a little off. So, yeah, I can imagine what you're saying. In terms of the rest of the questions, if you could just explain to me how you position your hands on your flute and then your body in general when seated or standing. That's really the only other information I need.

JONES: I try to be good about this; I don't know why I get so sore. I'm always on my students about doing this properly. One of your questions is "do I sit or stand when I practice" and I tell my students to stand but at least half the time I don't. I practice probably 90% of the time sitting down mostly because the only time I get to practice is a 10 o'clock at night and I'm so tired. But if I'm at school, I'm teaching and I'm standing all day, pretty much. I would say at least 60% of the time I'm standing when I teach so I do practice sitting down. But if I'm getting ready for a recital and I have dress rehearsals in the hall and I rehearse with my accompanist, I'm standing. So how, then… I definitely turn my chair at a 45 degree angle to the right. And my body…I don't know if you've ever studied with Pat George but she…

FAIN: Oh, yeah. We've talked about this in great detail.

JONES: Now when she was teaching me, she was a pretty new teacher so all the ideas. So a lot of the things she is doing now are not the things she was doing with me at that age. Definitely the flute parallel to the music stand and my body at a 45 degree angle to the right. Definitely. I don't think either one of my shoulders is higher than the other; I saw your questionnaire about raising your right shoulder. I don't think so. Not at all. And I do try to lift, I tell my students to think that their arms are like a marionette. You're tied to the ceiling with little wires. And when you pick up your arms to play the flute, it's just like your forearms were connected to the ceiling and somebody just kind of lifted them onto the flute so that your elbows are at a very natural level, not sticking up.

FAIN: Are you saying that they're not straight down either?

JONES: No, I would say out from my body at about a 35 degree angle for the left arm; the right arm maybe more of a 45 degree angle to the floor.

FAIN: What about your hand placement on the flute?

JONES: You had asked about the left-hand index finger? I think I kind of put it in the normal place in between the base knuckle and the first knuckle in that nice little fleshy spot. So definitely not on the knuckle at all, but in between where there's more fleshiness.

FAIN: Is your left hand under the flute, or does it push it back to your chin?

JONES: It's absolutely kind of perpendicular. The bone that's down on your wrist below you're pinky? That bone is basically perpendicular to, it's not out in front of me more, it's definitely not under the flute. One thing I think I do too much is I hyperextend my wrist too far. The palm of my hand points towards the footjoint a little too much. I hyperextend that a little too much. You know how beginners and intermediate players flatten out their ring finger?

FAIN: Yes.

JONES: They pull their wrist too far the other way. I think I bend my wrist too far the other direction. If I had to make an analysis of my own hand position, that's what I would say. One thing I do do though, you didn't ask about and what I think might be an important question is what do you do with your left hand thumb? My left hand thumb… you see a lot of pictures in books and stuff that have their thumbs straight. I have mine curved, big time. I mean like in a C shape which if I had begun again I would probably not do but that's how I hold it. In your research, if you find out that that causes problems, let me know.

FAIN: It uses different muscles. If you keep your thumb straight, you end up using different muscle groups. If you bend either of the joints of your thumb, you're going to be using different muscles than if you kept it straight.

JONES: I definitely bend my thumb. My right hand thumb is under the flute. Some people pull it way back like towards them…and kind of push the flute forward. I don't do that. Mine is definitely under the flute. And then pointing straight forward. It's not curved or over to the side like beginners do or anything like that. Just straight. Definitely under the flute. And then I've not ever had trouble with my pinky. It is straight actually. My right hand pinky is straight. I don't curve it. My teacher at Ball State tried to get me to curve it and I couldn't maneuver the footjoint keys very well that way, so I've always had it straight. That trouble where a lot of my student have, it locks – I've never had that trouble.

FAIN: Some people can hold it straight without it locking.

JONES: I must be one of those people.

FAIN: I can't. Mine locks so I have to keep it bent.

JONES: Achiness as I get older. I can feel, I must have a little bit of arthritis in one of my index fingers. I can feel it getting a little bit achy. But most of my problems, besides the wrist stuff bothering me sometimes, are in my shoulders. What I do try to do, to answer your questions about what kind of exercises we do, I try to remember to do some stretching before I play. I do kind of wrist circles I got from a physical therapist. When I was having major wrists problems I was having physical therapy for about six months and he had me doing all kinds of stretching wrist exercises. He had this pulley system where he'd put my arm in a pulley and go up and down and up and down my right arm. He said there just wasn't enough oxygen getting to my tendons. You just need to be doing more aerobic exercises in your arms. So I started going to water aerobics and I've done that for about 14 years now. It's helps a lot. When I miss that for a week I feel a huge difference. We do a lot of punching in the water, moving your hands across the front of your body, pushing the water back and forth. When we do a cross country skiing motion, we do our hands forward and back cupping the water. We're doing sculling motions.

FAIN: A lot of that is going to be strengthening in your shoulders. Not in your wrists and hands as much, maybe a little but strengthening your shoulder. If you're strong there, it'll support your hand's activities better.

JONES: That's helped a lot. And the little wrist circles that I try to remember to do seem to help a lot. Opera is the worst thing for all this because they are so long sometimes. You do a Mozart opera and you're doing it for 3 ½ hours. Sometimes the first act is an hour and a-half. You asked about the seating thing and the pillow? I've tried those wedge pillows; I have one in my car actually. But I don't use it when I'm playing. I just have a regular pillow because I have a bony butt. I've tried the wedge thing when I'm playing and I don't like it. It just doesn't work for me. The oboist that sits next to me; she does. I don't. But I do in my car. And I have a lumbar support pillow behind me in my car.

FAIN: Yeah, I remember that. You took us to that nice restaurant in your car.

JONES: That helps a lot because again, I live an hour from where rehearsals are so I have an hour there and an hour back, so I have like two hours sitting in my car – not a good thing. I've been trying to make that seat as comfortable as I can. I try to use cruise control whenever possible to try to keep moving my legs and stuff.

FAIN: Well, Adah, this has been most helpful. I really love your attitude because one of the things I do hope is that we can be, as a community of musicians, more open about these physical problems and that people can learn not just what can be done, although that's fabulous, but also preventative measures and how to get the management of our orchestras and opera management to be more supportive of the struggles of these musicians. I think some of the things you've said are going to be really helpful along those lines.

JONES: I am more than happy to be public. As I say, when this was happening just a few years ago, I thought nobody was talking about it. They were talking about hand problems and things like that. But this focal dystonia just sort of hit the books right around that time. It was in the union magazine, articles about it. A friend of mine is a trombone player up in New York and she was subbing in the New York Philharmonic and she started to have this trouble. She had to quit playing for awhile. Somebody told her to call me; she used to play in San Antonio and I knew her there. She called me and I said, "You need to try this. I don't know if it would work for anybody else but me." People are spending thousands and thousands of dollars going to neurologists that aren't obviously telling them much. From what I can tell; at least the two I've talked to.

Interview with Dr. Amy Zuback

Dr. Amy Zuback teaches flute privately in Edmond, Oklahoma. Her students range widely in age and level, and include national and state competition winners and those who have graduated to the studios of prestigious teachers. She has presented solo performances at the National Flute Association (NFA) conventions in Dallas and Phoenix, and has participated in several NFA pedagogy sessions, as well as serving as chair of the Pedagogy committee and co-authoring the first edition of the NFA publication *Selected Flute Repertoire: A Graded Guide for Teachers and Students*. She previously served on the flute and music theory faculties of the University of Central Oklahoma and Oklahoma Christian University. Dr. Zuback earned her D.M.A. from the

University of Oklahoma, M.M. from the University of New Mexico, and B.M. from Oklahoma City University. Her major teachers include Dr. Valerie Watts, Christina Jennings, Frank Bowen, and Eleanor Duncan Armstrong.

Flute and Hand Position

Dr. Zuback uses the modified Rockstro position with the keys flat; the headjoint is turned in so that the far edge of embouchure hole lines up with the center of the keys. Her left hand is under the flute with the wrist bent quite a bit. Her right wrist is as straight as possible. A key extension for the C# key (left index finger) has been added.

Body Position

In the standing position, Dr. Zuback places her feet about shoulder-width apart with the left foot slightly forward and the right slightly turned out. Her head is turned to face forward while the trunk is angled to the right. When sitting, the chair is turned to replicate this angle.

Physical Challenges

Dr. Zuback changed from a 'smiley' tight embouchure to a looser set-up with the corners of the mouth turned down several years ago. A series of different headjoints were used during this process allowing her to perform consistently and successfully.

Dr. Zuback has suffered multiple problems related to flute playing, including shoulder and neck pain, and possible focal dystonia of the embouchure. Always concerned with posture, she trained in Alexander Technique and yoga, but did admit to a tendency toward being physically tense. Dr. Zuback's embouchure problems began during a particularly stressful time in terms of family and professional issues; it was not related to extended periods of practicing. At first noticed as a lack of control (attributed to lack of regular practice due to family obligations), it progressed to the point where, following an extended period away from the flute, the muscle memory for forming an embouchure seemed to be gone. Symptoms included shaking and inability to keep the aperture small. The lips seemed to repel each other. Only short notes could be played as it was impossible to sustain a tone due to the large aperture. Slurring from one note to another was impossible, even in quick succession. Additional problems occurred with exhalation. No other activities produced these problems; eating and speaking were normal.

During a four-year period, no real progress was made as practice continued to be interrupted by several family situations and a serious personal health condition. Small improvements would be achieved, but not retained.

After reading an article about embouchure dystonia, Dr. Zuback began experimenting with some techniques that helped improve her playing. She put a little piece of a plastic straw between the teeth and bit down on it while playing. The shaking of the lip decreased significantly. "Muscling out a sound" by pressing the lips together as hard as possible while playing resulted in better lip sensation and control but still nothing close to normal yet. Other techniques which helped included harmonics, whistle tones, and "buzzing" without the flute, a suggestion by Keith Underwood, a noted flute performer and educator. Dr. Zuback also tried blowing an airstream without the flute and then bringing the flute into position, fingering the flute while listening to recordings of prior performances, and blowing an airstream without the flute while listening to prior performances. She also paid close attention to body alignment and the opening of the chest area, and practiced various breathing exercises without the flute.

At the time of this writing, Dr. Zuback is still not performing. She continues to experience some shaking, but is able to sustain notes for a few counts. She is convinced that, with patience, she can recapture her ability to play the flute.

Amy Zuback Interview

FAIN: I know where you got your doctorate (University of Oklahoma) but where did you do your undergraduate and master's work?

ZUBACK: I did my undergrad at Oklahoma City University and masters at the University of New Mexico.

FAIN: So who did you study with at each of those two places?

ZUBACK: Eleanor Duncan Armstrong at OCU…

FAIN: Oh, is she the one that's at Penn State now?

ZUBACK: Yes. And Frank Bowen at UNM.

FAIN: Can you tell me the kind of flute and headjoint set-up that you have?

ZUBACK: I play a Brannen with a Sheridan headjoint. Both are .016, mid-weight. The flute is B-foot, has a C# trill, off-set G and I use a Brannen extension, the left first finger plastic do-dad. If you look on their website, they have all their extensions there and I'm pretty sure they have a picture of it. But it just snaps on the flute. I've been using that because my finger didn't want to curl up quite enough and it just lets you flatten that out a little bit.

FAIN: My flute has that built in, I think.

ZUBACK: Yes, I think it does. I think I remember seeing your new flute and it had that feature.

FAIN: When did you decide to add that on?

ZUBACK: That's been awhile.

FAIN: A couple years?

ZUBACK: No, I would say more like ten.

FAIN: Oh, OK. Then a long time then.

ZUBACK: Yes.

FAIN: And your finger just wasn't curling around?

ZUBACK: Yes, I started having arthritis problems and I realized that I was hitting the next key occasionally with the tip of my finger. It didn't happen all the time, but every once in awhile it was like, 'Wup, why did that key go down?' I realized that my finger at that very first joint wasn't quite curling up enough. I just happened to see a *Flute Talk* magazine with a picture of someone who had won a competition or something and she was holding her flute, and she has this little do-dad on it and I thought 'Oh, that would solve my problem.' And it did.

FAIN: So in your career how many different flutes have you owned?

ZUBACK: Career like going back to college or professional or…..

FAIN: I'm not so much concerned about step-up flutes, but after you got settled in your career.

ZUBACK: Really it's just this flute. Right after my masters or during my masters I played an Oston-Brannen flute, before that I had this beautiful old vintage Haynes which I got in high school and used through undergrad and I got a new Haynes that I didn't last with very long at all. I didn't like that very much.

FAIN: OK, when was that?

ZUBACK: That would have been in the early 80s. I sold that pretty quickly and I played a Powell for awhile during my masters then I got this Oston-Brannen flute – gosh I had forgotten about all theses flutes. But then I've had this flute for I would say the most of my professional career. I got finished with the masters – I think I was playing the Powell then – and then changed to the Oston-Brannen and then got the Brannen.

FAIN: Is it silver?

ZUBACK: Yes.

FAIN: So does it have anything on it that you would change so that it would make it easier for you to play it?

ZUBACK: No, not really. I don't think so. Other than adding that one extension key. When my arthritis started happening, I was having trouble with pain in my right thumb so I bought another Brannen flute that was as alike as it could be to the first one, but lighter in terms of it having a C foot and no C# trill. They were really good about making sure my headjoint would fit. You know all of that and that problem with my thumb went away and I was able to go back to the heavier flute which I always preferred. The wall thickness was the same, but for some reason it got a better sound to my ear with the B foot and even the addition of the C# trill. I was talking to someone about it and he said yeah, you have a little extra weight even though it’s just a key and it is going to change the sound of the flute.

FAIN: Do you still have that flute?

ZUBACK: Yes.

FAIN: Do you use it when your arthritis flairs up?

ZUBACK: I haven’t used it for a long time. But it’s always there for me if I have issues. And then I went through a number of headjoints as well. Once I got the Brannen flute, I played that headjoint awhile. And then I tried a Drelinger and then the Sheridan. I guess that’s all.

FAIN: So why were you trying different headjoints?

ZUBACK: I just wasn’t getting the sound I wanted, I was trying to make an embouchure change. I think the Drelinger really facilitated the embouchure change I wanted to make. But then it became limiting in terms of color and flexibility. But I think it was a really good training.

FAIN: How were you changing your embouchure?

ZUBACK: I was going to a looser more downward- type embouchure.

FAIN: So you had more of a smiley turn-up embouchure?

ZUBACK: Yes, and the Brannen headjoint was pretty resistant so it wasn’t helpful in making that change. If you were there already, you would have been fine with it but I found it really difficult to work with.

FAIN: So the one you ended up with was the Sheridan?

ZUBACK: Yes.

FAIN: All right. So we've already talked about the weight and the design of the flute, so we'll move on. When you were making these different changes with your flutes, did you ever have any problems with pain?

ZUBACK: Oh, yes. Once the arthritis in my hands settled down and that could have been tension, how I was holding the flute, I don't know. It's been such a long time now. The main issues I had were my right shoulder. I think I ended up with some bursitis in my right shoulder. And then finally that went away. I even did some physical therapy for that and then of course I was playing tennis at the time a lot. It actually could have been tennis-related and not flute-related at all.

FAIN: I quit tennis when I started playing seriously and I loved to play tennis. I wasn't that great at it but it was fun. But it's a hard sport…

ZUBACK: …on your body…

FAIN: … to combine with flute-playing.

ZUBACK: And so I think it may have had something to do with that because I was playing a lot and I used to practice with an ice bag balanced on my shoulder.

FAIN: Flute or tennis?

ZUBACK: Flute. [*laughter*] That was also during a time that I was also really intensely practicing a lot. I'm kind of tense anyway. I don't know that it was the flute set-up if anything. I think it was more a combination of all these things I was doing. But I do think the tennis probably aggravated it. And then it just made the flute-playing uncomfortable. So that was a big pain issue for awhile, but that's resolved now and I'm still playing tennis some but not as intensely as I was. Or maybe I'm stronger now. What they wanted to do at physical therapy was to strengthen my back muscles a little bit so that I wasn't using my shoulder – you know – so that I was using the proper muscles to move.

FAIN: Right. Did that help?

ZUBACK: Yeah, maybe a little. I think mostly it just resolved itself.

FAIN: Well, in looking at you to me you've always had really good posture.

ZUBACK: Thank you! I was exploring Alexander Technique, doing a lot of yoga, you know, things like that where I was just learning about how the body moves. I was always experimenting with various ways of holding and balancing and all of that….

FAIN: I forgot to ask you, how do you line up your flute?

ZUBACK: I use now and I have for several years what most people I think would call a modified Rockstro.

FAIN: Can you describe it so that I don't misunderstand you?

ZUBACK: The far edge of the embouchure hole is roughly in the center of the keys or just maybe a little more turned in and I think that has to do…well first of all, let me go back and say that I used to really have trouble hanging on to my flute. I just always felt like I was going to drop it. And this position just made a lot of sense to me because you got your left hand more under the flute. I do try to have the keys pointing up, or mostly up.

FAIN: What do you mean?

ZUBACK: When I'm holding the flute, the surface of the keys is pretty much toward the ceiling and not canted backwards.

FAIN: Do you mean like the keys are flat or parallel to the ceiling?

ZUBACK: Yes. But if they tip backwards, that's when I was losing the grip on my flute, you know, rolling off onto my hands.

FAIN: It sounds like the way you were balancing the flute you couldn't do that unless you rotated the headjoint.

ZUBACK: Yes, and there is also the issue of the natural angle of the airstream. At the time I wasn't aware of this so much… but I've come to think-that people have a tendency to blow more across or more down just because of their jaw structure…

FAIN: … maybe the way that their chins are.

ZUBACK: I've observed this with students by using the Blocki pneumo-pro. You can quickly see where people are blowing and a person who naturally blows more down can have a straighter set-up. I blow more across and I've worked with dropping my jaw and doing all those things to try to blow down but my structure just isn't going to do that and so I need to roll in to get the air into the flute at the right angle.

FAIN: That makes sense.

ZUBACK: I don't teach the same set-up to everybody – only if it looks like they need it. To me the important thing is to have those keys pointing upward so that your left hand is under the flute and then to adjust where you need the headjoint.

FAIN: But that sounds different from what a lot of people think of Rockstro as being, the keys are not flat but are angled forward with the rods up to the ceiling.

ZUBACK: Right. Then I'd call mine modified. I know I don't turn the keys as far forward as the regular Rockstro. I'm not turning at the wrist that much.

FAIN: So the rods of the flute are not coming towards the center.

ZUBACK: As far as my hands are concerned, I want my right wrist flat in a neutral position where there's no bend either way in the wrist. And then with the left wrist – and this is interesting to me with all the joint pains I've had – my left wrist is way turned back and I have never had any problems with it.

FAIN: Did you know that the neutral position for the wrist is in a little bit of extension?

ZUBACK: No, I didn't know that.

FAIN: Like if you were to make a fist and lay your forearm on a table and look at what your wrist is doing…

ZUBACK: Oh, yeah.

FAIN: It's actually extended backwards a little. So that your hand works really well – that's how we make a fist. If you make a really strong fist, look at how much extension there is in your wrist.

ZUBACK: That's about how my right hand is.

FAIN: Well, that's why you're not having any trouble.

ZUBACK: But in the left hand I cock the wrist way back so that I can get my hand under the flute and that has never been an issue pain-wise.

FAIN: That's interesting. I agree with you and it's never been a problem for me either.

ZUBACK: But I know some people, if you look at their hands, the left hand is flat and the thumb is coming in at an angle. I've seen some great players who play that way. Mimi Stillman and Christina Jennings both play that way. And I don't know how they hold on to their flutes.

FAIN: I don't either. Describe to me how you would set up your body to play standing.

ZUBACK: My feet are about shoulder-width apart with the left one a little forward and the right one turned out just a little bit so that my hip joints and shoulders are pointing to two o'clock. So it's open to the right. I've been studying Tai Chi for about a year now and I just discovered that the stance for flute-playing that I like is almost a Tai Chi stance. It's the 'bow' stance but smaller. I'm not stretched out so much. It's considered a very strong way of standing. I thought that was interesting. Then again if you were in a box or a clock, the flute itself is pointing directly at three o'clock to the right, directly to the right. I turn my head a little bit to twelve o'clock. And that is what I teach all my students. I'm pretty set about that.

FAIN: So your flute is at an angle in front of the plane of your body.

ZUBACK: Or my body is at an angle to the flute, however you want to look at it.

FAIN: So there's a wedge in between.

ZUBACK: There's a little modification in there because I play out of the left side of my mouth, so what I do is maybe slightly different than what I would teach a student that's playing right in the center but it's kind of a natural modification. I'm not exactly sure what I do but I just get it in the right place there. Sometimes the flute's a little more forward. Some days my embouchure seems to need more than others.

FAIN: And when you sit down how do you position the chair?

ZUBACK: It's the same; I turn the chair a little to the right to accommodate that.

FAIN: Good. Have you ever tried one of those wedges?

ZUBACK: No, I've seen pictures of them but I've never had an opportunity to try one.

FAIN: Just a little bit more about your hand position. Where does the flute touch your left hand in the left index finger area? You get your left hand under the flute…

ZUBACK: If you count from the tip of the finger, counting the joints one, two, three, it is between two and three and as close to two as I can get it.

FAIN: So you don't want it close to your knuckle, but rather the next one.

ZUBACK: I don't want there to be space between my finger and the flute so I keep it up as high in that area as I can. And my thumb is straight.

FAIN: When you teach students how do you talk with them about their position? Three points of balance? Four? Equal-handedness? How do you usually end up describing it to students?

ZUBACK: I talk about three points of balance being the chin, the left hand, and the thumb and not the pinky. It depends on the student on how much I go into this. If you look down the tube – it's kind of hard to describe on the phone – the thumb comes into the flute at an angle like a little foot, and then the left hand is doing the same thing. I usually don't teach a lot of pressure in the chin, but I'm starting to rethink that a little bit. About how much pressure could be applied there. The jury's kind of still out on that one. But I don't teach that the pinky is a balance point at all. And I have had some students experiment with the ThumbPort. I found that some students, once they've tried that, get a better idea. I don't have anybody playing with it full time. I just let them try it in a lesson and let them get an idea about getting the thumb more behind the flute instead of underneath it. I don't teach going straight into the flute which I think is a true Rockstro. I think you do teach that. I don't know, I just don't like the way that makes my thumb feel. It kind of jams my knuckle. Regarding pain, I do have left shoulder issues as well. We got kind of side-tracked. I want to go back to that; I don't know if you want to talk about that now.

FAIN: That's fine.

ZUBACK: And actually this is kind of interesting; I wanted to run this by you. The pain issues I have in my left shoulder are under the shoulder blade; that's the best way I can describe it. I'm having physical therapy right now because of post-surgical scar tissue and that shoulder was really bothering me. The physical therapist thought that being in the flute-playing position for so long can pull the rib cage forward. He said it was not as much a shoulder issue as it was a rib cage issue and then your scalenes get tight. But, if you try to stretch your scalenes by bending your head to the side, you just bring those ribs right along with you. He showed me how to put a strap around myself and pull down to hold the shoulder and the rib cage in place while stretching my scalene. He also had this little maneuver that he did on that area. I don't really know what he was doing. He had me put my right fist at my solar plexus and hold that really tight and then he put his hand on my right elbow and then somewhere in my shoulder area on the left side and kind of gave it a little chiropractic kind of…

FAIN: manipulation

ZUBACK: …manipulation. It felt a whole lot better after he did it. Since you're a PT, I just wanted to get your thoughts on that because it felt amazing. Then back to stretching the scalenes, I found that instead of using a strap, I could put a weight on my shoulder and lean my head the opposite way. I found this more comfortable than pulling the strap.

FAIN: The part of my document that I was working on last night is about support. It turns out that we play on this long exhale, and support is putting a brake on it so that all the air doesn't come out at once. The way we do that is with the muscles we use for inspiration. We just slowly release them and one of those is the scalenes. So we're always using that muscle when we play.

ZUBACK: And that has been my biggest pain issue – my neck muscles. And I just get as tight as can be.

FAIN: And I think I know why. It's because we always use the – especially the scalene, the sternocleidomastoid (the big muscle in front that is so easy to see when you turn your head) – those we use all the time.

ZUBACK: My husband has told me I look like a Cardassian when I play.

FAIN: What's that? [*laughter*]

ZUBACK: It's a creature from Star Trek that has this very pronounced sternocleidomastoid. One thing that helped that was Alexander Technique because I was reaching my head forward and those become more pronounced.

FAIN: Then you can get TMJ problems from that.

ZUBACK: So I would say of all the pain problems that I've had, the neck is the biggest issue because – tension just in general, in life. Of course! It's stressful to work on a doctorate or anything, you know. So it's really interesting that those muscles are being used all the time because I was trying to figure out how to relax these muscles but then I can't play!

FAIN: You can't. I thought erroneously before I did all this reading that to slow down our exhale, it was our abdominal muscles alone that were slowing it down. It's not.

Because I was thinking it was the expiratory muscles, which are really mostly passive. And we're, I think the best word is 'braking' the exhalation with the accessory inspiratory muscles.

ZUBACK: That will be really useful information because the idea of support and how we release the air has remained a huge mystery to me. My latest problem, which you know because you heard me play, is that I can't sustain a sound, and all of this has to do with holding on to that air stream. When this happened, I wasn't sure what muscles to even look at. How do I do this? I don't know. I used to be able to do it. Why can't I do it now? I realized I didn't even know what the mechanism was.

FAIN: All the muscles that we use to take a breath are the muscles we use in support. And we take such big ones, it's certainly not just normal silent breathing. It's all those accessory muscles – your pecs, the scalenes, the sternocleidomastoid, there's a couple others. You know what I'll do – I just finished writing the chapter on the thorax last night and I'll send you the chapter. There have only been seven studies done on the flute from a scientific viewpoint and two of them were on how we breathe. I reviewed those articles in detail because I thought they were really important. They were both basically saying that's what support is: putting brakes on expiration by using slowing releasing contractions of the accessory inspiratory muscles.

ZUBACK: You mentioned the pecs as well and the therapist has been having me do a pec stretch lying on a roller with my arms open like a 'T.' That has really helped. I think a big part of the problems I've had in my playing was my physical response to all the stressful things that happened in my life in recent years. I concaved my chest and pulled myself in to where I wasn't coming out of there. This was the realization I made last summer that this needs to open up. I couldn't do it. Now, just recently, working in yoga has helped. One of my yoga teachers is always trying to get me to raise my manubrium. That's the target she looks at.

FAIN: The top of your breastbone?

ZUBACK: I found that that was really helpful in opening me up. I don't know, my most recent personal challenge has been really interesting. You would think it would be overwhelmingly stressful but in some ways it hasn't. It's just been a real opportunity for discovery. I've been able to let go of a lot of the grief and a lot of the things that happened to me. So all of that physically made a huge improvement in my practice. I haven't played for a little while now but I felt like I was finally on the right track by making some of these discoveries about what was physically stopping me from playing. That's kind of an aside but it kind of fits in with what you're talking about.

FAIN: One last question about your embouchure problems. When did they start in the midst of all this?

ZUBACK: Well, my mother died in October of 2004. Leading up to her death, I was very busy and not practicing a whole lot. So that particular year was not great for me. I felt like my embouchure was – I wasn't having any of the shaking or anything – but it would be lack of control. I just assumed that it was all because of a lack of practice.

FAIN: So you certainly weren't over-practicing.

ZUBACK: Correct. So none of this ever occurred from over-practicing which is why my husband kept saying you can't have focal dystonia because that's from over-practicing. I kept playing throughout the year. I played a concert in April that year and so I was able to play. Some things weren't as in control as I wanted but again, I wasn't able to keep a really good practice schedule and I was pretty stressed out over everything. I was helping my father and also an aunt who lived out of state. That following spring, in May, my dad died. About a month after he died, I did a recording session and it was a disaster. I kept splitting notes. I think it was mostly support; that's when all that pulling in started. I wasn't supporting, I was getting two tones on my middle register notes. I wasn't really stressed out – it was an easy recording session, you know, jingles and stuff. I just didn't know what was happening. It was just crazy. I pulled it together enough so I could play this little concert I was supposed to play a couple weeks after that. I didn't have too much to play. Then I didn't play my flute for four months because we were cleaning out my parents' house. I just put it away and said I have to deal with this; i.e., the house. I don't feel like playing my flute.

FAIN: No, I understand totally.

ZUBACK: So, from June to October that year I didn't play at all. When I first took up my flute to play, it was like, how do you do this? It was like my mouth had absolutely no muscle memory of how to make an embouchure or how to do anything. That was when the big problems started happening. I got hired for a Christmas job and I thought, oh, I'll be OK by then. I'll be able to play in two months – no, that was a disaster. It just kept going like that. From that point on, it just started getting worse. I would think I was making some progress and then I would agree to play something, a gig, thinking it isn't for three months; I'll be fine by then. And then it would be a disaster. I should have just quit agreeing to play at that point but I kept thinking that it was going to be all right. I would agree to do something, and then I would have this horrible experience. It became not just this physical issue; it became a stage fright issue that was perpetuating itself as well. It pretty much became a downhill spiral. I kept trying. The last job I played was a Christmas job – I think it would have been 2006 at Christmas. I haven't played professionally since then. I haven't been able to solve these problems. I would practice for hours. I would just do headjoint; I would sit on the couch and be as relaxed as I could. It just kept getting worse. I just couldn't figure out what the mechanism was. So I think it was all these emotional things. I'm hoping that once my current challenge is over [*laughter*].

FAIN: Yes, get past this…

ZUBACK: I can start practicing and focus on that. I don't even know if you knew that after my parents died, I was taking care of my aunt in Ohio.

FAIN: Oh, that's right I forgot about her.

ZUBACK: I didn't even get to go to my graduation from OU. I was writing the dissertation, taking care of her. I had to spend the whole summer of 2007 taking care of her. She died that fall. There's just not been a good recovery period for me. And then last summer, thinking I was finally going to have this time to recoup for myself, a job came up that I wanted. I practiced and practiced thinking I can overcome this and I can play this audition. And that was a disaster, too. I could have pulled out, because I really knew it was going to be bad but I just really wanted to go through the audition process, the interview, and everything. But the audition was horrible. So that just added on top of all of those failed things.

FAIN: I remember thinking about you at the time and I'd just go, oh Amy.

ZUBACK: Things happen in people's lives and they go on playing their instrument, but not me.

FAIN: Well, some people can channel everything in to their playing in a productive way as a way of dealing with the stress in their lives. I think it's hard for us because we don't have anything we push against. We have to supply our own resistance and I think that makes it hard.

ZUBACK: Yeah, flute playing is not like piano or drums where you can bang out your frustrations. I'm hopeful based on what happened before I stopped playing this time again. It seems that every time I get going again some other disaster would happen. I'd put the flute aside…

FAIN: Hopefully, this time you will have covered everything. [*laughter*]

ZUBACK: I'm sorry; you're going to have to transcribe all that now…

FAIN: I'll leave out some of it probably but I do go down and see Pat George and if you want to see her when she comes to Dallas, the next time I go you're welcome to come along.

ZUBACK: To me it's an issue of not really needing a teacher but just having the time to discover and work through these things. Until I can play a little bit, I don't feel like a teacher is going to be able to do anything. When I worked with her at your house, when she was here, she basically took me back to the beginning, and that was fine and she had some good ideas. I experimented with some things, but that was pretty much what I had been doing. She did have some things I disagreed with because she's pretty adamant about how this is how you set your flute, this is how you do this, and this is how you do that. I did give them a little try but those were things I didn't think were going to work and they didn't. They were just some things that weren't useful for me.

FAIN: Let me encourage you to keep working at it. Whatever your embouchure issues are called, you need to keep a journal of what you do to fix it, because you're not the only one.

ZUBACK: Now, the shaking is actually gone. I did get rid of that and I'll tell you one way I did it. This was last summer. I read this article about embouchure dystonia and one of the things they talked about in shaking was to have some pressure and I actually put a little piece of a plastic straw between my teeth and bit down on them while I played. I almost inhaled one once. But that took care of the shaking.

FAIN: So you were playing just way too relaxed.

ZUBACK: Yes, too relaxed. And then the thing that I had success with just in recent months was putting a lot more tension in my embouchure. When you go back to playing everybody assumes you're going to be tight to try to have a good sound. All the advice I was getting was be relaxed, be relaxed. And I felt this is so flabby, nothing is going to come out! But I couldn't seem to locate the muscles that I was supposed to be using. It was like the neurological connection between my brain and my mouth had been lost. And once I started finding those muscles and figuring this out – this took a really, really long time. One thing I did this winter when I was practicing that actually gave me really good results was to play as tight as I could. I just packed down those muscles almost like a trumpet. And then they kind of reactivated and they found how to play. It's taken so long to find out these little nuggets.

FAIN: One of the ways I've described it to a student was it's as if you had a straw in your mouth, and you were taking it away but you were going to try to keep it.

ZUBACK: But I had to tighten down way more than that. Because I was working with a straw a little bit, kind of in the traditional way. I did have some luck with doing some of Keith Underwood's buzzing stuff, but the real break-through was in the recent months when I said 'I am just going to muscle out a sound here and I'm going to press my lips together as hard as I can the whole time I play.' I would do that for a few minutes and then I could play.

FAIN: And then when you were playing…

ZUBACK: When I was playing I wasn't doing that. It was like my muscles started remembering the way I used to play. It was like, oh, this is actually kind of familiar, which had not been my sensation for a really long time.

FAIN: That makes a lot of sense and it really does sound like you're on the right track.

ZUBACK: I may even go try practicing today.

FAIN: Yeah!

ZUBACK: Inspiring.

FAIN: I'll send you the chapter on support – what it actually really is.

ZUBACK: That would be really interesting. I keep reading all this conflicting information about breathing. Ok, the lungs fill from the top down. Why in yoga and tai chi and all these things do they teach you to do belly breathing?

FAIN: In the scientific literature I read they never talked about these two different ways to breath. They don't have you ever separate them out.

ZUBACK: My understanding is that you can think about it different ways but your body is going to do it the way it does it anyway. So if you think about it the wrong way, that can be working against you.

FAIN: When you take breaths as a flutist, your rib cage is going to expand; there will be changes in the abdominal area, too. Thank you so much Amy. I wish you the best of luck.

Summary

The interviews with these respected flutists show where we have come from and what we have learned. No teacher today would tie her students' wrists together or suggest that the elbows need to be as high as possible. As Katherine Borst Jones demonstrated, flute teachers today are much more observant and aware of what their students are doing physically when they play the flute. Having said that, other recent trends have made circumstances worse for the physical health of not only flutists, but all musicians. Professor Boyd's observation of the increase in playing-related injuries and the possible connection to computer-use is astute. Music students may take breaks in their practicing, but if those breaks are spent texting or writing emails, many of the same muscles and tendons are again being used and abused. On top of that, the high standards of competition and performance seem to be always increasing; they create enormous physical and emotional stresses upon musicians.

For some of the interviewees, the lack of medical knowledge in the flute profession early in their career resulted in serious consequences. Because of the damage performance-related injuries do not only to the body, but also to the psyche and security of employment, there is a growing need to deal with physical problems quickly and even better, prevent them in the first place.

The purpose of the following chapters is to investigate the functional anatomy of the flutist to clarify and minimize the physical demands of flute-playing. Our peculiar stance and the requirement that we provide our own resistance to the flow of the airstream are circumstances that complicate any simple explanation of what our bodies are doing. It is hoped that the new few chapters will provide at least some transparency in these muddy waters.

CHAPTER FIVE

INTRODUCTION TO SCIENTIFIC TERMINOLOGY

The scientific community has its own technical language which provides a detailed way of accurately referring to specific structures, conditions, and procedures. While providing a very important way for medical personnel to discuss and relay crucial information to each other, this same technical language tends to create a barrier between them and the patients they serve. Music educators should take advantage of the great accuracy and detail that scientific terminology provides, to improve their understanding of how their body organizes itself to play their musical instrument. Then, their own students will benefit by clearer explanations of anatomical features and processes. Both teacher and student will have a firmer grasp of medical science as it relates to music making. Throughout this document, both common and scientific terms will be used side by side, but the reader will benefit by understanding the general concepts and terms introduced below.

Spatial Terms

Terms that describe the orientation of the body in space and its various movements are crucial not only in understanding what the body can do, but also in communicating effectively with other professionals. Standard anatomical position for the human body begins in the standing position. The head and eyes are facing forward and the arms are next to the body with palms facing forward and the thumbs pointing out to the side. The feet are parallel with the toes pointing forward. When discussing any body part, relationship, or movement, this position is the assumed starting point.

Several different imaginary planes pass through the human body in anatomical position. The median or saggital plane divides the body into right and left halves and passes longitudinally through the body. The frontal plane is perpendicular to the median plane and can be imagined by standing with your back pressed against a wall; the frontal plane and the wall would be parallel to each other. It divides the body into a front side and back side. And finally, the transverse plane divides the body horizontally into an upper (superior) part and a lower (inferior) part (Illustration 1).

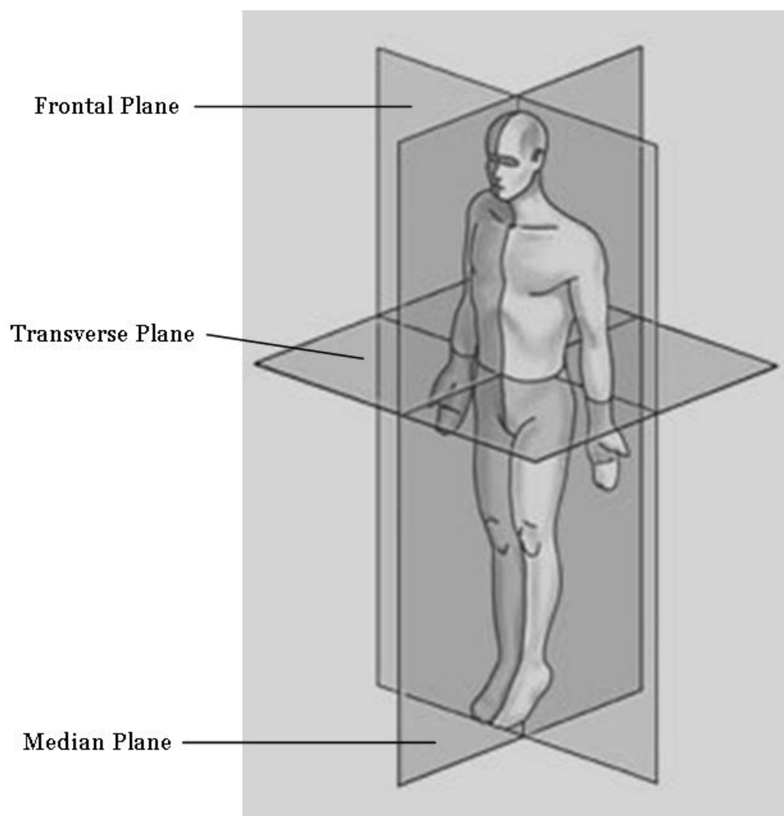

Illustration 1: Planes of the human body

Describing the relationships different body parts have to one another is also an important method of medical communication. The term medial refers to an object's relation to the median plane, or towards the center of the body when in anatomical position. Lateral references a body part that is farther away from the median plane or towards the outside of the body. For example, the lateral corner of the shoulder blade is at the tip of the shoulder. External and internal are terms used much as they are in regular English and mean essentially the same thing when applied to the human body with the reference point being the center of the body. Posterior refers to the back of the body and anterior the front. So, the face is on the anterior aspect of the skull; the shoulder blades are on the posterior aspect of the trunk. The terms proximal and distal are used when discussing the position of a body part along a limb. Proximal means nearer to the body; distal is further away. Fingers are distal to the elbow; shoulders are proximal to the hand. The term dorsum applies to the top or back aspect of any part of the body that protrudes from the front side of the body such as the tongue or feet. The back of the hand is referred to as the dorsum; the opposite side is the palm. As in common usage, the bottom of the foot is the sole.

Movement Terminology

The movements of the body are described by a large group of terms, some of which are shown in Illustration 2. Flexion refers to bending a joint; extension means straightening it. Hyperextension occurs when the joint continues further in extension beyond the normal limit. Abduction refers to a body part moving away from center; adduction brings it back. Lateral bending refers to the movement of the trunk curving to the right or left in the frontal plane. Rotation is turning along the long axis of body part; it can be described as medial/lateral or internal/external. Medial or internal rotation of the arm is shown when the forearm is pointing down; in lateral or external rotation of the arm, the forearm is pointing up (Illustration 3).

Circumduction is making a circular motion that combines flexion, extension, abduction, and adduction, such as making clockwise or counterclockwise circles with the wrist. It is a much larger and more complicated motion than simple rotation.

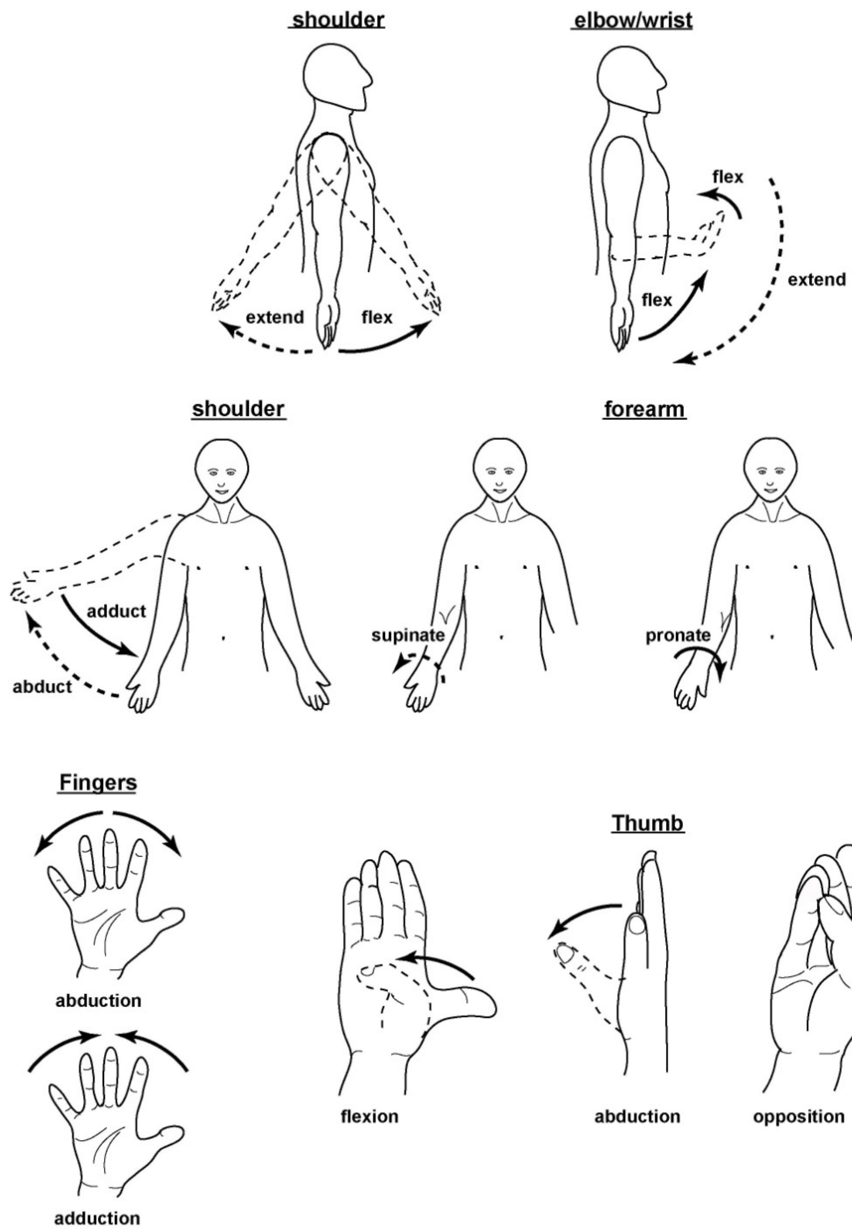

Illustration 2: Movements of the human body. From *The Biology of Musical Performance*, Alan H. D. Watson, 2009, p. 43, Scarecrow Press, Inc., Lanham, MD, 20706, with permission.

Another important concept of anatomy, range of motion, is shown by the overlaying of the compass on top of the picture of the woman in Illustration 3. Range of motion refers to the normal amount of motion through which any particular joint can move. So in this case, 0-90 degrees of lateral rotation in the shoulder is considered normal. Contrary to this illustration, only 0-70 degrees of medial rotation is normal.

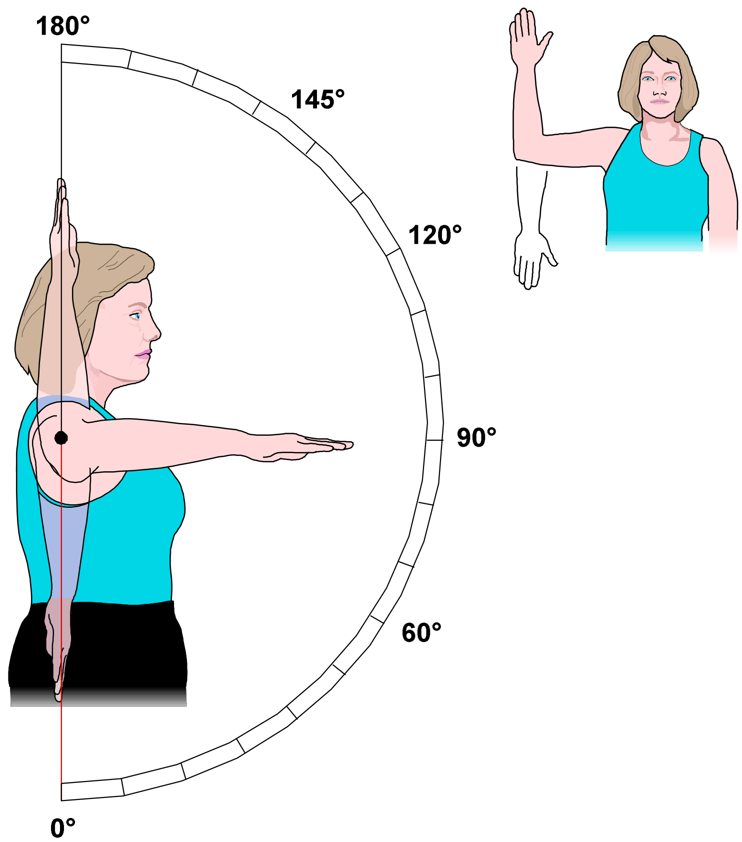

Illustration 3: Shoulder rotation

Elevation occurs when a body part is raised superiorly or upward, with the opposite returning motion being depression. Shoulders can be elevated and depressed.

A forward movement, such as the tongue can make, is called protrusion. Retrusion is a movement backwards or posteriorly; the jaws can protrude and then retrude. Similar motions occur with the shoulders, but, the terms protraction and retraction are more commonly used.

An important motion for flutist to understand is radial and ulnar deviation – motions that occur at the wrist (Illustration 4). With the forearm still, the wrist straight, and the hand palm-side down on a table top, radial deviation is moving the hand toward the thumb, or radial bone of the forearm. Ulnar deviation is moving the hand toward the little finger or ulnar bone of the forearm. The normal range of motion for radial and ulnar deviation is illustrated in the diagram below. As shown, the wrist is able to deviate in the ulnar direction much more than in the radial direction.

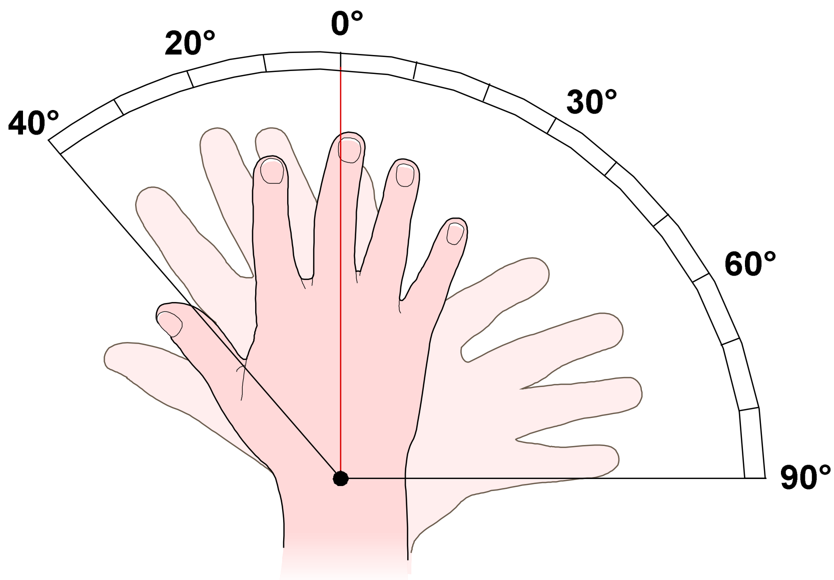

Illustration 4: Ulnar and radial deviation. In this illustration, radial deviation is to the left and ulnar deviation is to the right.

Opposition is a movement where the pad of the thumb moves toward the pad of the little finger, bringing the tips of those two digits closer together. Movements requiring opposition include holding a pen, using scissors, or touching the tip of the thumb to the tip of the little finger. The correct right hand placement for holding the flute requires opposition. Reposition is the action of returning the thumb pad to its anatomical position.

Throughout this study, references are made to surface anatomy, a technique used by health professionals to locate and name body parts that can be seen or felt through the skin. By feeling or palpating different boney prominences, muscles, tendons, and other anatomical features, musicians can learn more about how his/her own body functions.

CHAPTER SIX

POSTURE AND THE TRUNK

The relevance of posture and the trunk to the stance of the flutist is paramount. Strong core trunk musculature provides stability and endurance for long hours of practicing and playing the flute. Since our instrument is held up against gravity in an asymmetrical fashion, it is important for flutists to learn exactly what core musculature is required to maintain a healthy posture, both during and after playing. It is all too easy to play flute with the head tilted forward and to the side, slumped shoulders, and a slouching trunk.

According to a recent study in Sweden, music teachers whose instruments required an asymmetrical posture, which included flutists, had a significantly greater number of disorders than music teachers with symmetrical postures.[24] A large number of the flutists who responded to this document's survey reported a significant amount of neck and upper back pain, indicating the importance of spinal alignment.

Semantics

The term 'posture' has recently fallen upon hard times. The word suffers from misinterpretation, perhaps bringing to mind visions of soldiers standing at attention while

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[24] Cecilia Edling and Anncristine Fjellman-Wiklund. "Musculoskeletal Disorders and Asymmetric Playing Postures of the Upper Extremity and Back in Music Teachers," *Medical Problems of Performing Artists* 24:3 (2009), p. 115.

being berated by a raging drill sergeant, or a mother cajoling her child to 'sit up straight!' The word does imply a command to sit or stand up straight and frequently results in a snapping of the head and shoulders backwards, and a thrusting of the breastbone upwards and outwards. This position, which is certainly an awkward stance for the flutist, creates a strain on the neck because the chin is too high and the weight of the head falls behind the natural alignment of the body. The forward thrusting of the rib cage restricts the expansion and retraction of the ribs during breathing, resulting in more shallow breathing. In this military position of attention, the body is held erect in a single plane, a definite problem for the flutist. In order to hold the flute in the same plane as the body, the right arm and shoulder are forced back while the spinal column angles severely to the left. The left arm has further to reach, creating a strain on the left shoulder.

Yet, the term posture does not need to be abandoned because of faulty interpretation. Describing the position of one's body is paramount in many endeavors: sports, ballet, occupational health, and the description of medical conditions, to name but a few. In fact, the frequent use of the term 'posture' in the medical literature necessitates its inclusion in everyday vocabulary about the body.

The authors of *Clinically Oriented Anatomy* present a model for an ideal relaxed stance.[25] Their stated goal for a standing or sitting posture is "to attain a stable alignment of the body that can be maintained with the least expenditure of energy and the least stress on body structures." In the standing position, imagine a cross-section of the human body with a plumb line descending from head to foot (Illustration 5). It should intersect the following joints: the joint between the skull and the first vertebra (atlanto-occipital

[25]Keith Moore and Arthur Dalley, *Clinically Oriented Anatomy,* 5th edition (New York: Lippincott Williams & Williams, 2006), p. 588.

joint), the hip joint, and slightly forward of the knee and ankle joint. Notice that this textbook uses the word 'alignment' in their definition of posture.

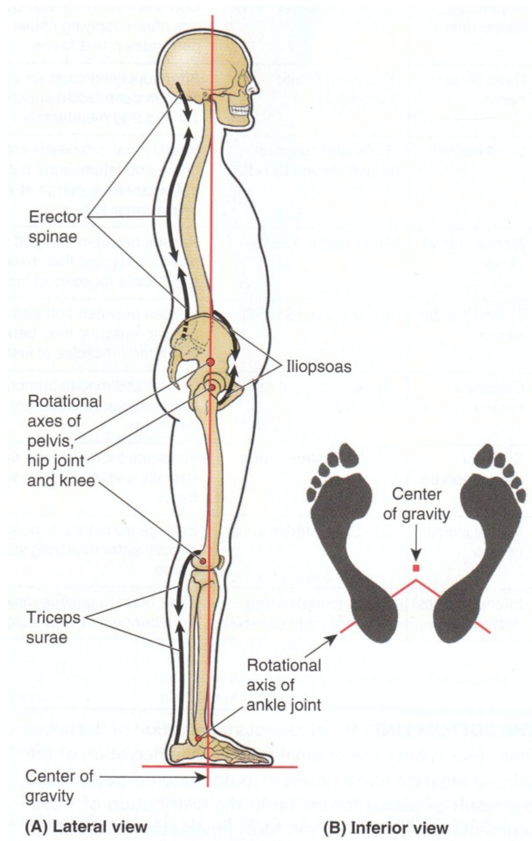

Illustration 5: The position of ease. From *Clinically Oriented Anatomy*, 5th Edition, Keith L. Moore and Arthur F. Dalley, 2006, p. 588, Lippincott, Williams & Wilkins, Philadelphia, PA, 19106, with permission.

Alignment is a more general term that emphasizes the arrangement of the bones and joints of the body on top of one another in the most balanced, natural way. Fitness and health practitioners in both traditional and alternative practices have encouraged their clients/patients to improve the alignment of their bodies by slowly 'stacking up' their vertebrae one at a time when rising from a bent-over position. This movement tends to begin at bottom, resulting in gentle rearranging of spine to a more neutral position whereas a command to sit or stand up straight is probably met with a stiff jerk as previously mentioned. The goal of finding the proper alignment is to find a healthy default for each individual in terms of balance. As both terms are accurate and descriptive in their usage, the terms posture and alignment will be used interchangeably in this document.

The Bones of the Vertebral Column

A better understanding of posture and alignment can be gained by a closer investigation into the anatomy of the trunk. As the flute is held up against gravity in an asymmetrical fashion by the shoulders and arms, the trunk must be flexible and yet stable in a rotated position. Understanding the anatomy will help the flutist see in their mind's eye the movement and stance of the spinal column required for playing the flute.

The backbone (spinal or vertebral column) is composed of thirty-three vertebrae and twenty-three intervertebral discs. As there are fewer discs than vertebrae, several vertebrae either have no disc between them or they are fused to one or both of their neighbors. The backbone protects the spinal cord and the spinal nerves that exit and branch out to the trunk and extremities. It supports the weight of the body above the hips and provides a structural support for the trunk that is both flexible yet maintains a certain amount of rigidity. The spinal column serves as an extended base for the head and has an important role in posture and locomotion. It is divided into five different sections according to shape and function and they are named in order from top to bottom as follows: cervical, thoracic, lumbar, sacral, and coccyx (Illustration 6A). Vertebrae in the sacrum and coccyx are fused.

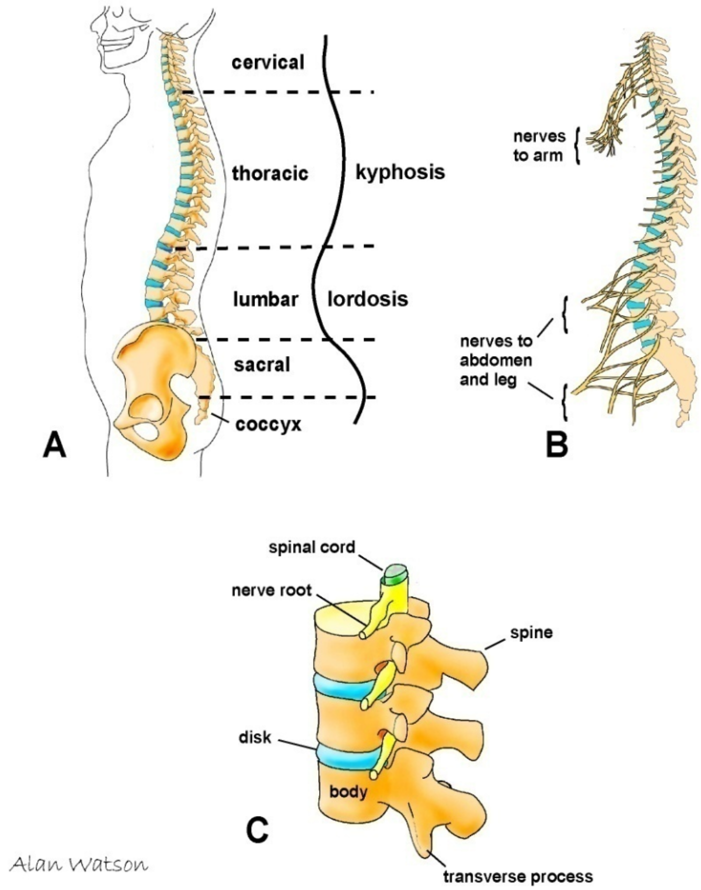

Illustration 6: The vertebral column and pelvis. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 18, Scarecrow Press, Lanham, MD, 20706, with permission.

The seven cervical vertebrae in the neck have the greatest range and variety of movement of the entire spine. The thin discs that separate them have a small body mass, and the areas where the bones meet (articular facets) project from the vertebrae in a way that allows this wide range of motion. Flexion, extension, lateral flexion (also called side-bending), and rotation of the cervical spine can be done independently or in combination with each other. The cervical vertebrae as a whole normally exhibit a concave curvature posteriorly, shaped like the letter ‘C’ (Illustration 6A). This same curvature is also found in the lumbar spine.

Spinal nerves exit the central spinal cord from between vertebrae (Illustration 6C). A unique feature of cervical vertebrae is the holes on each side (transverse foramena) through which vertebral arteries and veins enter and exit. A notch in the upper vertebrae is matched by a notch below it; the resultant opening allows the spinal nerve to exit with its accompanying vessels. The surrounding protuberances provide attachments for important neck muscles that will be discussed later. As blood vessels and nerves exit through these junctions and holes throughout the length of the spinal column, a slight misalignment of one vertebra atop another may result in a pinched nerve or blood vessel. By the maintenance of an asymmetrical posture over a long period of time, such as playing the flute, some of the structures attached to the neck may become either tight or stretched out. If not addressed, these imbalances can persist, leaving the afflicted individual with a decrease in normal range of motion, pain, and weakness.

The top two vertebrae comprise the craniovertebral region and have no intervertebral discs. The joint between C1, the first vertebra which is also called the atlas, and the skull is referred to as the atlantooccipital joint. It provides the largest opening for the spinal cord of any vertebra since the cord begins here as it descends from the brain. The atlantooccipital joint enables the flexion/extension or nodding movement of the head, as when saying 'yes.' The atlantooccipital joint also permits sideways tilting but only a small amount of rotation. Surrounding structures and membranes help prevent excessive movement of the joint. For any musician, this small nod can adjust eye level and head alignment over the body very simply with a discrete movement of only one vertebral joint. The remainder of the neck need not crane forward; in fact, it is imperative that the cervical spine stay in as good alignment as possible for reasons that will be made evident.

Between the atlas and the axis (C2), the atlantoaxial joint enables a large rotational movement of the head upon the neck, as when one indicates “no.” The cranium and atlas rotate as a unit around the dens, an upward protuberance of the axis, and have ligaments (alar ligaments) that limit rotation to a safe range. Fifty-eight percent of the total rotation of the neck occurs at the atlantoaxial joint (C1-C2) and 24% occurs lower in the neck at the levels of C3-C6.[26] This being true, over half of the head’s rotation is high, right underneath the skull with the rest spread out through the lower neck. The head can therefore turn right or left to a certain extent without involving the lower cervical vertebrae. The flutist can turn the head to the left while assuming a health playing stance and need not be concerned that this would overly strain the neck. The remaining five cervical vertebrae form the rest of the neck’s spinal column. Each vertebra also has a spinous process that can be easily palpated, or felt, at the center of the back of the neck. C7, the lowest cervical vertebra, has an extra long spinous process that can be easily palpated on the upper back at the base of the neck. The seven cervical vertebrae are connected to each other and the back of the skull via the nuchal ligament, a long slender elastic membrane that runs down the spinous processes.

The twelve thoracic vertebrae form the back or posterior aspect of the rib cage, articulating with the ribs at the back and with the breastbone (sternum) and costal cartilages at the front. Prolonging the length of the ribs in the front, the costal cartilages also contribute to the elasticity of the rib cage. The thoracic vertebrae are less flexible than those in the neck as they form a protective cage around the body’s most vital internal organs, the heart and the lungs. The long, overlapping spinous processes on either side of

[26] JL Dumas, et al. “Rotation of the cervical spinal column; a computed tomography in vivo study,” *Surgical and Radiologic Anatomy* 15 (1993): pp. 333-9.

each thoracic vertebra also limit flexion, extension and lateral flexion. Other structures that limit movement in this section of the spinal column are the joint capsules and ligaments. Yet even though the movements of the vertebrae and rib cage are limited, they are not altogether immobile. The upper portion of the thoracic vertebrae, T1-6, has more freedom of movement to bend sideways and to turn. This greater mobility makes sense because these vertebrae and their accompanying ribs are at the level of the shoulders, an area of great mobility. The flexion and extension of the vertebrae is once again freed up in T7 – 12, the lower thoracic vertebrae. The entire thoracic section of the vertebrae is arranged as an anterior concave curve. This backwards ‘C’ is also found in the sacral vertebrae (Illustration 6A).

In the flutist the arrangement and difference in the cervical and thoracic vertebrae allow quite a bit of freedom to rotate in the cervical and less so in the thoracic areas of the spinal column. An important goal for spinal column alignment is to achieve a playing stance that allows the shoulders to remain in a neutral position. A 45-degree left rotation of the cervical spine provides space for the flutist to bring the far end of the flute forward; the right arm then has room to hold the flute while keeping the right shoulder in a neutral position (Photo 1). Avoiding end-of-range motions for the shoulders will be covered in more detail in the chapter on the shoulder, arm, and hand; suffice it to say at this point, the less the shoulders and arms are required to move outside of their neutral position, the better. Another benefit of this left rotation of the neck and head is that the left arm does not have to be pulled across the chest as far in order to reach the flute. Instead of the flute being in the same frontal plane as the trunk, it can be 30 to 45 degrees forward, which decreases the distance the left arm has to reach to hold the flute (Photo 1).

Photo 1: Neck rotation. Image by Simon Hurst Photography.

The massive lumbar vertebrae extend below the thoracic vertebrae of the rib cage and end in the sacrum. They have no costal facets or transverse foramina. L5 is the largest of the five and carries the weight of the entire upper body. The lumbar area of the spinal column is in a lordotic curve (concave posteriorly) and flexion in this area is more limited than extension (Illustration 6A). The lumbar curve ends at the intervertebral joint between L5-S1, the lumbosacral angle. Below the lumbar area, the individual vertebrae are fused into one bone that is termed the sacrum. Below the sacrum, the coccyx ends the vertebral column. Fused from four segments, its tip may flex anteriorly during sitting. Displacement of the coccyx, as during childbirth, is common.

References to the different curves of the spine have been made in the preceding paragraphs. As the different types of vertebrae stack up one on top of the other, the spine reveals these normal curves that act like a shock absorber, giving the human body's upright stance flexibility within a structural framework. These curves are better than a straight alignment; the spine's ability to resist higher compressive loads increases ten-fold with normal curves as compared to what it would withstand if it were straight.[27] Kyphosis, an anteriorly directed concave curve (backwards 'C'), occurs in the thoracic and sacral regions of the spinal vertebrae. Lordosis, a posteriorly directed concave curve, occurs in the cervical and lumbar region (regular 'C').

The Muscles of the Back

A natural, stress-free alignment is accomplished not only by proper spinal alignment, but also by the use of the muscles supporting this alignment in an efficient way. These muscles cover the back in layers, connecting the spine, shoulder blade, and upper arm in a complex but highly effective way. Understanding how they are arranged and what they do is critical to an understanding of good body alignment. Trunk strength, support, and proper alignment are crucial for free and efficient movements of the arms.

Because the results of the survey in the first part of this document indicate that flutists suffer pain mostly in the neck, upper back, and shoulder, a thorough understanding of the muscles attached to the cervical spine is imperative. But a more general look at the actions of muscles as a whole will help explain the complicated interactions between different muscles in the back and shoulders. All motion occurs at a

[27] IA Kapandji, *The Physiology of the Joints,* 6th ed., Vol. 3 (New York: Churchill Livingston, 2008), p. 14.

joint or a series of joints. One end of a muscle is fixed (stabilized joint partner), causing the other end of the muscle (moveable joint partner) and the bone to which it is attached to move. For example, the shoulder muscles contract to lift the arms as they hold up the flute. If we were to hold onto a bar instead of the flute, the same muscles could contract and pull up the entire body. A lot of the same muscles are working in both instances; it just depends on which end is actually moving. In such a mobile area as the neck and shoulder region, the contracted muscle attached to the stable joint partner would be held in place by other muscles, tendons, and joints. When considering the fact that the neck involves several layers of muscles and these layers operate under this general principle, it is no wonder that this area of the body presents with so much tension and pain.[28]

In summary, a large group of muscles in the trunk is contracting in order to supply the support needed to hold the arms up against gravity while they hold and balance the flute. Medical professionals sometimes refer to the connected actions of muscles as a 'kinetic chain,' an appropriate term to use here. The muscles in the trunk contract to fix the shoulder blade so that the muscles that arise from it are free to move the arms.

Muscles of the Neck

Muscles in the neck can be divided into three groups: muscles that link the vertebrae of the spinal column together, muscles that link the vertebrae to the skull, and muscles that aren't attached to the vertebrae but act upon them indirectly.[29] Most of the muscles at the front of the neck flex or bend the head forward. Pairs of the longus coli

[28] Watson, *The Biology of Musical Performance*, p. 25.

[29] The way of organizing the muscles in this section was inspired by Dr. Alan Watson's text, *The Biology of Musical Performance.*

series, the longus capitus muscles, the small rectus muscles, and the scalenes accomplish this action. The longus coli, or long muscles of the neck, lie directly in front of the cervical vertebrae and attach the upper cervical vertebrae to the lower ones as well as to the upper thoracic vertebrae; their action of flexion involves the neck only. The longus capitus muscles attach from the cervical vertebrae to the skull and tilt the head forward (Illustration 7A). The rectus capitus muscles are two pairs of small, short muscles that connect the bottom of the skull to the first cervical vertebra. Together they stabilize the head; separately they either flex or extend the head as when nodding 'yes.'

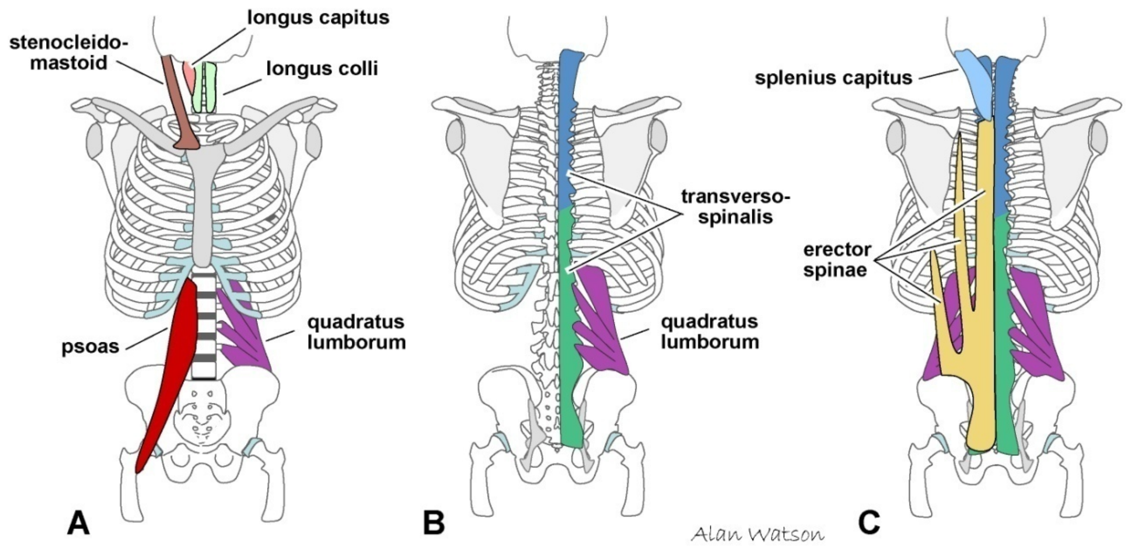

Illustration 7: Postural muscles of the back. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 23, Scarecrow Press, Lanham, MD, 20706, with permission.

Another set of muscles, the suprahyoid and infrahyoid muscles, assist in flexion of the cervical spine. These muscles are connected to the hyoid bone which lies atop the thyroid cartilage and wind pipe (trachea), behind the jaw bone (mandible) at the level of approximately C3. All of the muscles above the hyoid are the suprahyoid group[30] (llustration 8); the ones below are the infrahyoid muscles (not pictured). Flutists are taught to lower the voice box (larynx) to increase the space above it; this creates a larger oral/pharyngeal cavity, giving more room for the air column to vibrate and improve the resonance of the flute's tone. In order to lower the voice box without tension, the muscles above it, i.e. suprahyoid muscles, must be relaxed while the infrahyoid group pulls the hyoid bone down. If assisting in the flexing of the head, the suprahyoid muscles will be working and not relaxed. So a neutral position of the head (not overly flexed or bent forward) on the atlas would allow the infrahyoid mucslces to pull down the larynx without fighting the suprahyoid group. A nodding of the head causes the suprahyoid muscle group to contract and relax; during this motion, attention to the area above the hyoid bone can acquaint the flutist with the sensation of these small muscles working. The flutist can lift the face until the relaxation of the suprahyoid group is felt; it is here that the head is in alignment over the vertebral column. More details concerning the vocal tract are in Chapter Ten but at this point, the importance of balancing the head above the shoulders and not in front of them is made clear.

[30] Suprahyoid muscles include the mylohyoid, geniohyoid, stylohyoid, and digastric. Infrahyoid muscles are the sternohyoid, omohyoid, sternothyroid, and thyrohyoid.

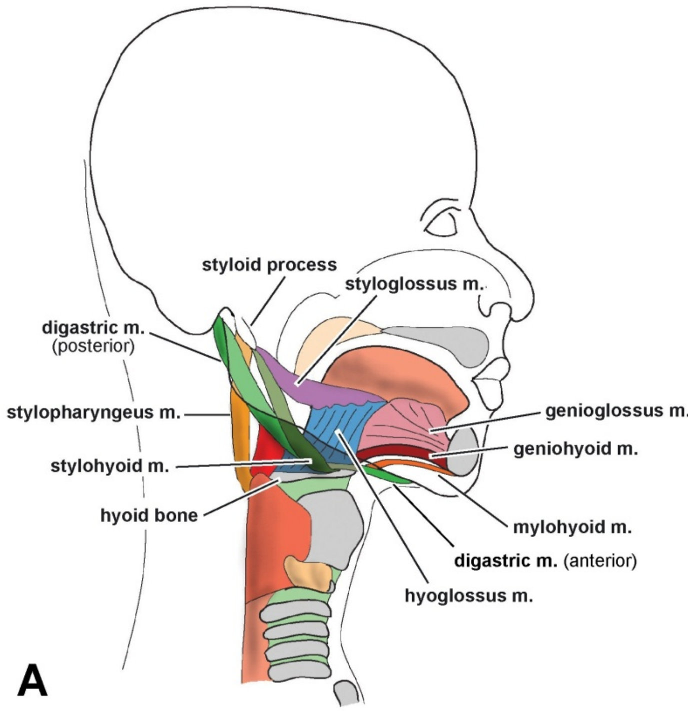

Illustration 8: Muscles supporting the larynx and pharynx, and hyoid bone. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 142, Scarecrow Press, Lanham, MD, 20706, with permission.

The scalene muscles, of which there are three parts on each side, all originate from the 4th – 6th cervical vertebrae and attach upon the first and second ribs (Illustration 9). These are of importance to flutists not only due to their action on the neck and collar bone, but also because they serve as accessory muscles of respiration during deep breathing. When the end of the scalene muscle that inserts onto the cervical vertebrae is fixed, its contraction will move the opposite end and the bone onto which it is connected, i.e., the ribs. The scalenes contract during forced inspiration (deep breathing) and lift the first two ribs, which is what flutists must do in order to take in sufficient air for playing a long phrase. These muscles can be felt by palpating directly above the collar bone and top rib on either side of the trachea; take a deep breath in and their contraction can be felt towards the end of the breath. The scalene muscles also flex and laterally bend the neck if the insertions onto the ribs are fixed (the ribs stay still and the neck moves).

If the flutist plays with the head forward, the scalene muscles will be in a shortened position, compromising their mechanical ability. Muscles work best if they are at their optimum length and in this shortened position, the scalene muscles will not be able to contract as effectively as they could in a more neutral position. If left in a shortened position by poor posture, they will weaken and shorten even more, further limiting their usefulness in raising the first two ribs during forced inspiration. Maintaining the widest possible excursion for the rib cage should be a goal of every flutist. Especially in the case of women as they age, a forward head position should be avoided at all costs.

Photos 2 and 3: Forward head posture followed by proper alignment. Images by Dr. Valerie Watts.

Flutists are known for the tilt of their head to the right; this requires the action of the right scalene to pull the head down and the left scalene, along with other muscles, to hold this position against gravity. Tilting the head to the right does avoid having to raise the right shoulder while balancing the flute, but as neck pain is such a problem among flutists,[31] priority must be given to placing the neck in a more neutral position. Since most of the motion of cervical rotation occurs at the level of C1-C2, the scalenes shouldn't be adversely affected by the flutist's need to have the head turned to the left. Any neck rotation is not against gravity and therefore requires less muscle action. So the best position for playing the flute should require a neck that is rotated left, but is still aligned vertically over the remainder of the spinal cord; i.e. no lateral bending or flexing (Photo 4).

Photo 4: Straight cervical spine. Image by Simon Hurst Photography.

Another issue involving the scalene muscles concerns the passage through them of the brachial plexus, a large nerve network that extends from the cervical spinal column, under the collar bone, and then continues on to the arm (Illustration 22).[32] If the scalene muscles become injured or spasm, the brachial plexus or parts of it may become compressed, resulting in numbness and tingling in the arm. The free and easy use of these muscles is critical to the balancing and playing of the flute so attention to proper

[31] See survey results in appendix.
[32] The brachial plexus is covered in more detail in Chapter Eight.

alignment is a must. Because the left scalene muscle is in a contracted shortened position and the right scalene is slightly stretched, the flutist must make sure to combat this asymmetry with stretching and possibly strengthening exercises to the neck.

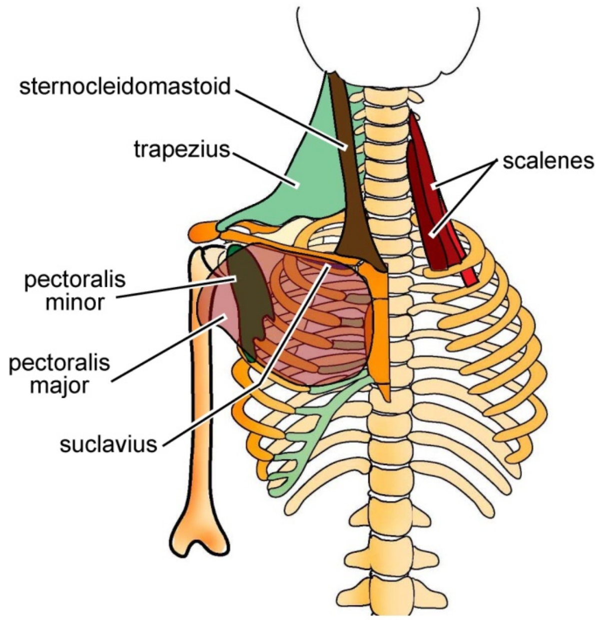

Illustration 9: Scalene and sternocleidomastoid muscles. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 110, Scarecrow Press, Lanham, MD, 20706, with permission.

The sternocleidomastoid (SCM), a set of clearly visible large muscles, extends from behind the ear to the collarbone (clavicle) and breastbone (sternum) (Illustration 9). In a contracted position, they form a large 'V' under the chin. When working together, they can extend the neck and lift the face upward or bend the neck forward and bring the face down. These muscles extend on both sides of the axis of motion of the neck; therefore, they can affect either motion when contracted. When working one at a time, the SCM turns the head to the opposite side. So in the position of holding the flute, the right SCM is contracting to turn the head to the left. The asymmetrical use of this muscle needs to be counteracted by strengthening and stretching exercises that would maintain the neck's ability to turn equally well in both directions. The SCM muscles also act as accessory muscles of inspiration. Thus, the comments concerning the scalene muscles in the previous paragraphs apply here as well. In the following illustration, the right SCM is standing in relief as a vertical column on the front edge of the flutist's neck.

Photo 5: The sternocleidomastoid muscle. Image by Simon Hurst Photography.

Other muscles, all of which are in pairs, that extend the neck include the splenius cervicis and splenius capitis (Illustration 7B). These muscles arise from the thoracic vertebrae. The splenius cervicis inserts on the sides of C1-C3 or C-4. The splenius capitis inserts instead upon the back of the lower edge of the skull. Thus, there is a kinetic chain all the way from the skull and cervical vertebrae down to the mid-thoracic vertebrae. The erector spinae series and the transversospinal group are intrinsic[33] back muscles which extend throughout the entire spine (Illustration 7B and 7C). The upper portions of these muscle groups act upon the neck to extend it. When only one side of these muscles contracts, the spine bends to that side. Again it is important to visualize the interconnectedness of the spine from the head down. If the head is held in a static forward position, the extensor muscles must contract to hold it in place against gravity. The resultant strain and fatigue leave less energy for the body to conduct its other missions during performance, including breathing, balancing the rest of the body, and providing oxygen for the brain to use while thinking.

In the body position required for playing the flute, the cervical spinal column is rotated left. Muscles used to accomplish rotation in the cervical area are the semispinalis, multifidus, splenius cervicis and rotatores. Rotatores are small intrinsic back muscles that connect adjacent vertebrae to each other. The splenius capitis, and SCM contract to rotate the head. Because of less mobility in the thoracic area and the need to avoid excess rotation in the lumbar area, virtually all of the rotation of the spine during flute playing should occur in the cervical region. Strengthening the neck extensors and rotaters in a bilateral fashion (both sides at once) and stretching the spine into right rotation would allay at least some of the problems associated with this asymmetrical stance. Frequent breaks during practice sessions in which the neck can be stretched would also be beneficial.

Also important to the function of the neck are muscles that connect the vertebral column to the back of the skull and the shoulder blade (scapula) (Illustration 10). The

[33] Intrinsic muscles are situated within the body part on which it acts; for example, the small muscles within the palm of the hand are intrinsic muscles. Extrinsic muscles extend outside the body part on which they act; most of the forearm muscles are extrinsic because they extend into and act upon the hand.

levator scapulae, the rhomboids, and the trapezius fall into this group. Scapulae are flat bones designed to glide over the back of the upper rib cage. They are triangular shaped with a horizontal ridge along the top edge. The bottom of the shoulder blade points downward. The levator scapulae and the rhomboids are similar muscles that arise from the cervical and thoracic vertebrae and insert upon the scapula. The levator scapulae are above the rhomboids and raise the shoulder blade and rotate it downward. The rhomboids pull the inner edge of the shoulder blade toward the spine; they also rotate it. As will be seen later, the shoulder blades are involved in elevation of the shoulders and arms. In order for them to perform those functions, the levator scapulae and rhomboids will be called upon to hold them in a fixed position. Since those two muscles are attached to the spine, a kinetic chain can be visualized between the spine and the upper extremities when they are in a lifted position. With respect to the playing position of the flutist, care must be taken to avoid excessive elevation of the shoulders and arms as the ramifications will extend all the way to the spinal column. Holding the flute in its playing position tends to push the right shoulder backwards and pull the left shoulder forward and around the front of the body. Because of the muscles connecting the scapula to the spinal column, the resultant forces also affect the spinal column, pushing the lower cervical and upper thoracic vertebrae to the left of normal.

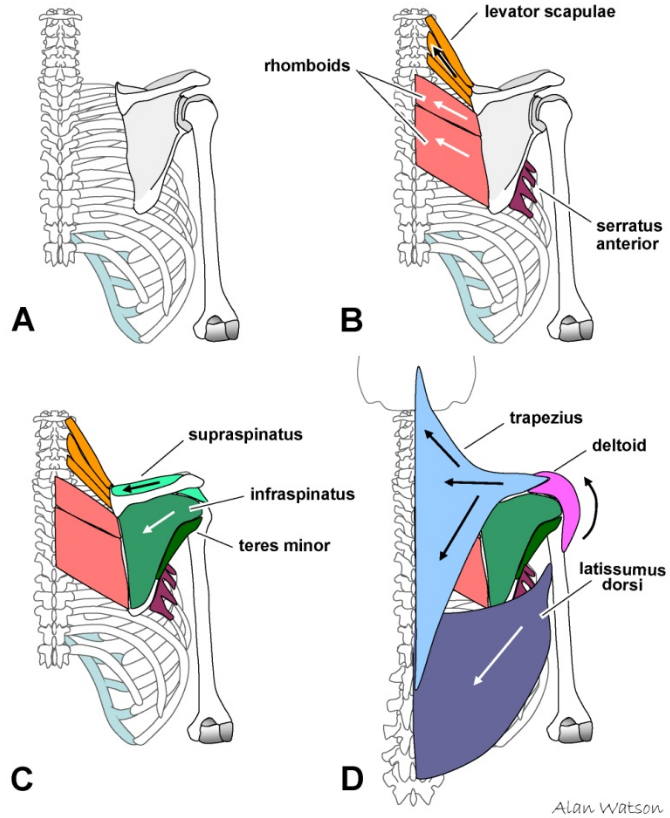

Illustration 10: Muscles attaching the shoulder blade to the back and to the arm. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 47, Scarecrow Press, Lanham, MD, 20706, with permission.

To summarize a balanced stance for flute-playing, the head faces forward with the trunk at a 45 degree angle to the right. In turning the head to the left, rotation of the neck is largely accomplished by the unilateral action of one of a pair of muscles. While it shortens and contracts, its partner lengthens and relaxes. In general terms, these are the small (and deep) rotators of the head and neck. Also included in the group are the right SCM, the left scalene, and muscles of the spinal column that extend upwards into the neck: the left side of the erector spinae group (intermediate layer of intrinsic back muscles), the transversospinal muscles (deep layer), and the interspinales (part of the minor deep layer) (Illustration 7).

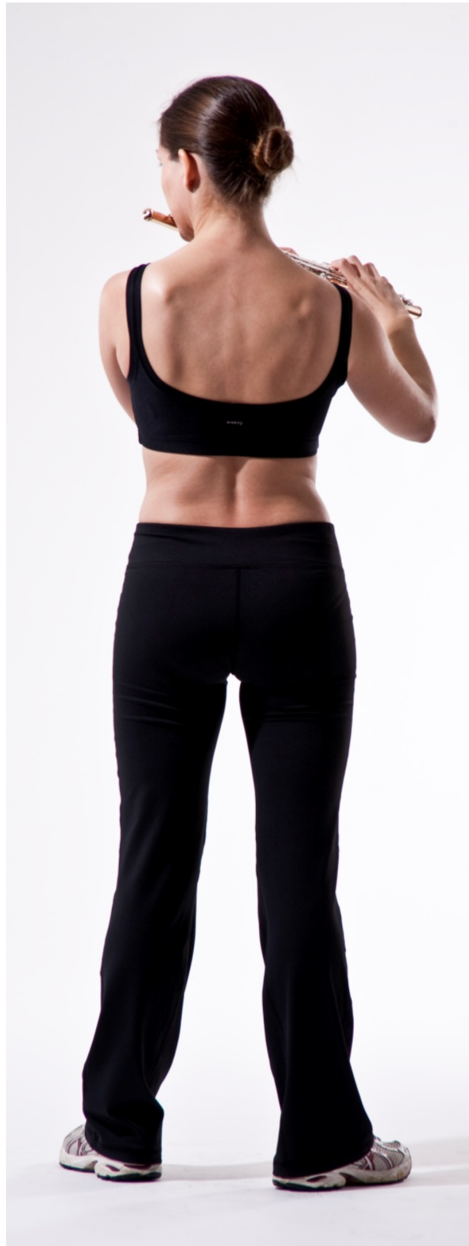

Photo 6: Balanced stance for flute-playing; posterior view. Image by Simon Hurst Photography.[34]

If the head is brought forward in addition to turning to the left, even more muscles would be involved and more work would be required to hold it up against gravity.

[34] The model in these photos reports that her right shoulder is lower than the left one due to the many years spent carrying a heavy backpack.

Gravity pulls the head down; a co-contraction of the neck flexors and extensors would have to be recruited to keep the head suspended in this forward position (Photo 2).

Muscles of the Trunk

Connections between the shoulder and spine serve to underscore the importance of proper arm use and body alignment in the flutist in order to avoid neck and back pain. Because of their close geography, the muscles in the thoracic and lumbar areas will be discussed as a unit. Bending forward, or flexion of the spine, is accomplished by the rectus abdominus, a sheath of muscles that extend from the lower ribs to the mid-region of the pelvis, often referred to as the 'six pack.' It is aided by the psoas muscle which runs from sides of lumbar vertebrae to the top of the thigh bone (femur). According to the principle of muscle movement discussed previously, the psoas bends (flexes) the trunk forward if the leg is fixed. If the trunk is fixed, as when lying on the ground, the psoas muscle, along with other muscles of the leg, lifts the leg upwards. It is the classic muscle that cheats during sit-ups. Three sheets of oblique and transverse muscle fibers form the rest of the abdominal wall on either side of rectus abdominus.

Extension of the thoracic and lumbar spine can be divided into two layers of muscle groups: deep and superficial. Muscles in the deep layer have fibers that go from the bony extension (process) of one vertebra to one several segments above it. They stabilize the spine when acting together and cause rotation when one side acts alone. The more superficial muscles of the posterior aspect of the trunk are the erector spinae group. These muscles extend between the spinous processes of the vertebrae or the bases of the ribs. When acting together, the erector spinae cause extension of the trunk, when acting on one side only, they cause sideways (lateral) bending (Illustration 7).[35]

Over all these muscles lays the latissimus dorsi and trapezius muscles (Illustration 10D). The latissimus dorsi extends from the spinous processes of mid- and lower center back vertebrae and inserts upon the upper arm bone (humerus). It acts upon the humerus when the trunk is stable (as in standing) and extends, adducts, and medially rotates it. Here again is another muscle that links the arm to the trunk.

The trapezius originates from the bottom of the skull and the cervical and thoracic vertebrae, and inserts onto the clavicle and the acromium and spine of the scapula.[36] The acromium is the top right angle of the scapula and can be felt at the top outer edge of the shoulder. Different parts of the trapezius have different actions. The upper part of the muscle elevates the shoulder and the lower part depresses it. The middle section of the trapezius retracts the scapula (as when the shoulder blades are squeezed together). The upper and lower trapezius work together to rotate the shoulder capsule in an upward direction. If the shoulders are elevated or the neck is tilted, the trapezius will be recruited. But with a neutral position of the neck and shoulders, the trapezius will not have to contract. It is yet another muscle with connections between the shoulder and spine and its involvement serves to underscore the importance of proper arm use in the flutist in order to avoid neck and back pain.

The trunk is divided into two sections: the abdominal cavity and the chest (thoracic) cavity. These two sections are separated by the diaphragm, a thin dome-shaped

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[35] Watson, *The Biology of Musical Performance,* pp. 25-26.
[36] The trapezius is also covered in Chapter Eight.

sheath of involuntary muscle[37] that extends from the lower edges of the ribs and the superior lumbar vertebrae to a central tendon; during its resting state it is shaped like an upside-down bowl. It is the chief muscle of respiration; its central area descends during inspiration and ascends passively during expiration. Further discussion of the breathing process, critical to flutists and other wind instrumentalists, is found in Chapter Ten.

In the thoracic and lumbar spine, rotation is accomplished by the transversospinalis group (rotatores and multifidus), the erector spinae group (iliocostalis, longissimus, and spinalis), and an external oblique acting at the same time with the opposite internal oblique (both abdominal muscles). In the upright position, studies have shown that the majority of the twisting work is done by the obliques (internal and external) and the latissimus dorsi muscles.[38] Thoracic rotation is limited by the rib cage and rotation in the lumbar area is associated with increased risks of injury. Hence, the majority of spinal rotation for the flutist occurs in the neck where flexibility of the spine is at its greatest. Further studies into this aspect of the flutist's set-up need to be undertaken.

Abnormalities of the Spine

One of the most common and serious abnormalities of the spinal column, scoliosis, has a direct bearing upon the breathing apparatus and therefore, the playing of the flute. This deformity involves a lateral curvature of the spine and occurs more

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[37] An involuntary muscle is not under conscious control.

[38] WS Marras, KG Davis, and KP Granata. "Trunk muscle activities during asymmetric twisting motions." *Journal of Electromyography and Kinesiology* 8 (1998), pp. 247-56.

commonly in young girls – the flute world's very population.[39] Overall lung capacity can be restricted, but the asymmetry of the disorder affects one side more than the other, compromising one lung. When checking for scoliosis, health care professionals look for a rib hump on one side of the back when the patient bends over and touches her toes. Outward signs of scoliosis may include unequal shoulder angles, unequal arm distance from body, a prominent hip, and unequal waist angles. Upon visual inspection, the hem of a dress would appear uneven, the shoulders of a shirt might bunch up or have folds in the fabric, one hip might appear to be always sticking out, or the individual may look like he/she is listing to one side. This deformity can progress with time unless checked and can interfere with breathing and the function of other internal organs. Intervention by bracing and even surgery involving the implantation of Harrington rods may be required.

Awareness of the problem is critical and the flute teacher must communicate openly about how the flute stance impacts the alignment of the spine. The asymmetrical nature of our playing position may actually exacerbate scoliosis and flute teachers should be observant for the signs of this abnormality since the majority of those affected are adolescent girls ages 12-15. Particularly in these students, stretching and strengthening to counter the flute stance should be actively encouraged. While the breathing mechanism might be compromised because of scoliosis, the repeated use of the respiratory muscles called for by flute playing may actually help maintain respiratory fitness in these patients.[40] If the asymmetry of our playing position is in opposition to the abnormal curves, flute-playing for these individuals may be a help rather than a hindrance. The

[39] 87.5 – 91% of elementary and secondary flutists are female according to studies by Dr. Scott Harrison; see "Women in Brass: re-examining gendered involvement in music, a preliminary report in to Musical Preference Stereotypes," *Proceedings of the 27th Australian Association for Research in Music Education,* Australian Association for Research in Music Education, (2005).

[40] Another area for further research.

prevalence of flute players afflicted with scoliosis would be another excellent topic for research.

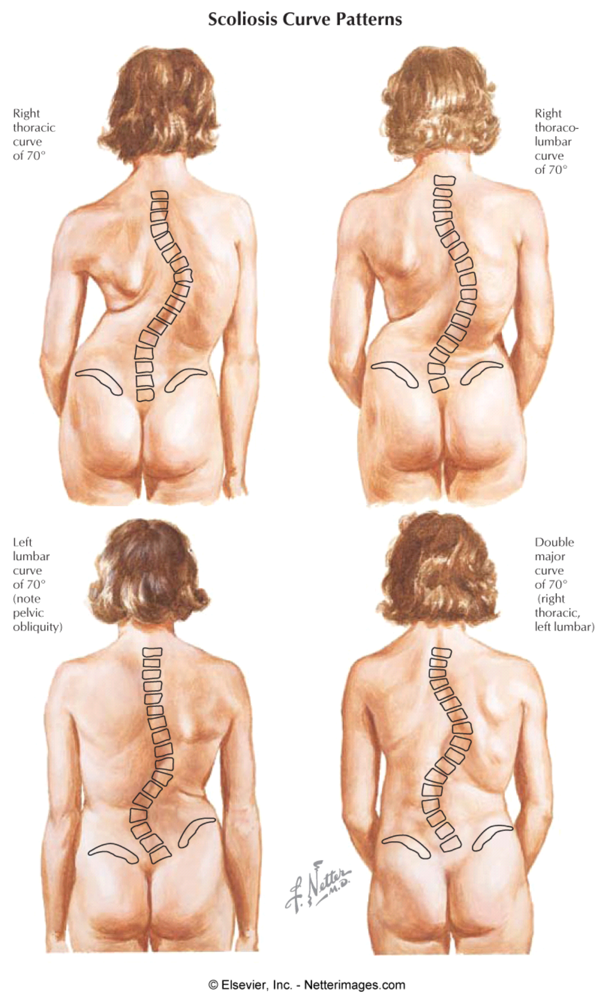

Illustration 11: Scoliosis curve patterns.

Another more prevalent problem in our general population is a forward head posture (Photo 2). The negative affects resulting from this increased lordosis in the neck are legion. Muscle ischemia (diminished blood supply to a part of the body), pain, and fatigue, and a protrusion of one or more cervical discs are all possibilities. The symptoms may extend to the jaw and tempomandibular joint where pain and inflammation can limit its range of motion. The increase in the cervical lordosis itself has its own set of problems. Damage to the spinal cord and/or the nerve roots exiting from it can lead to paralysis. Damaged cartilage increases wear and tear on the joint, decreases movement and causes pain. The body typically reacts to pain by avoiding movement. As the ligaments, tendons, and muscles move less, they become weak and shorten. The entire joint capsule as well as muscles can shorten leading to joint adhesions. These can also cause pain resulting in a further loss of motion. In the forward head posture, the scapulae are prone to rotate inward as the cervical curve exaggerates. This in turn causes the thoracic kyphotic curve to increase in order to keep the body balanced. A loss of height is only one result. The upper back muscles stretch out and the anterior shoulder muscles shorten, resulting in a decrease in vital capacity, the maximum volume of air that a person can exhale after maximum inhalation. The range of motion in the shoulder and arm decrease as well, resulting in rounded shoulders.[41]

As a review, when postural defects remain for a longer period of time, the muscles on the shorter side of the curve shorten, and the muscles on the longer side get stretched out. Over time, these muscles lose their ability to return to a neutral normal position. The result is reduced range of motion (ROM) and with the ribs this means less expansion of the rib cage for breathing.

The ramifications of a forward head posture are manifold. It should serve as a stern warning to flutists to avoid this ‘hunched over’ position. An extreme forward position decreases the distance between the rib cage and the pelvis, creating less space for the abdominal contents. By sitting or standing properly aligned, this distance would be larger, leaving more space for the abdominal contents to be displaced when diaphragm

[41] Pamela Levangie and Cynthia Norkin, *Joint Structure & Function,* 4th ed. (Philadelphia: F. A. Davis Company, 2005), p. 497.

descends during inspiration. But, as previously stated, standing up straight in an exaggerated fashion should be avoided as well. In the hyper-extended posture, an over extension of neck muscles creases stress and pulls the body out of neutral alignment. By rocking the head in a gentle up and down motion, a nod, one can find a point of balance where over-extension and a too forward position can be avoided.[42] The music stand should be adjusted in such a way as to maximize this position.

The posture for playing the flute is asymmetrical, as has been noted. The flute is held out beyond the right side of the body, out of eyesight. In order to position the flute with the maximum efficiency, a rotation of the head to the left must occur. The bulk of this rotation takes places in the cervical area of the spinal column. The stance of the flutist should begin with feet at roughly right angles, the left foot straight forward and the right foot turned out to a three o'clock position. This turn-out is the result of the entire leg rotating outwardly from the hip.[43] No stress or tension should be felt in the knees or ankles; if either of these joints feels strained, the right foot can be brought back to the two o'clock position. With the feet thus placed, the body of the flutist should then be facing a virtual corner to the right at approximately a forty-five degree angle. In this set-up, the thoracic and lumbar spine are in a neutral position, allowing comfort and the full use of the thoracic and abdominal cavities for activities that support the playing of the flute – core stabilization and expansive respiration.

The cervical spine functions in a way that allows breathing, talking, eating, etc. with the head turned. The trachea, the tube that transports air to and from the lungs, is made of fibrous cartilaginous tissue and is supported in on open position by rings also

[42] George, *Flute Spa.*
[43] Ballet training teaches dancers to turn from the hip in order to avoid sheer at the knee joint.

made of cartilage. The diameter of the trachea is about 2.5 centimeters, larger than the diameter of a quarter. Its flexible structure makes a turn of the head to the left possible while maintaining an open airway.

Jacques-Martin Hotteterre, a celebrated flutist of the Baroque Era, espoused this position in his method book *Principles of the Flute, Recorder and Oboe* approximately two hundred years ago!

> Whether one plays standing or seated, the body must be kept straight, the head high rather than low, turned slightly toward the left shoulder, the hands high without lifting either the elbows or the shoulders, the left wrist bent in and the left arm near the body. When in a standing position, one must be firmly fixed on one's legs, the left foot advanced, the body rest on the right hip, all without strain. One must, above all, refrain from making any body or head motions, as so do in beating time. When this posture is achieved, it is quite graceful and will gratify the eye no less than the sound of the instrument will delight the ear.[44]

[44] Jacques-Martin Hotteterre, *Principles of the Flute, Recorder and Oboe,* trans. Paul Douglas (Toronto: Dover Publications, 1968), p. 9.

Photo 7: Balanced flute stance; frontal view. Image by Simon Hurst Photography.

The rotation of the flutist's spine should be restricted to the cervical area, notwithstanding the problems flutists have with their necks. This rotation to the left is best avoided in the thoracic area in order to keep the rib cage neutral. Rotation should also be avoided in the lumbar area, especially when seated, as injuries are more prone to occur in that position or when the spine is rotated.[45]

When seated, many flutists follow the direction of their chairs and align their bodies with the shoulders parallel to the music stand. Because of the asymmetrical nature of playing the flute, they are then required to look at the music from the right side of their

[45] Ana Torén, "Muscle activity and range of motion during active trunk rotation in a sitting posture," *Swedish Institute of Agricultural and Environmental Engineering*, May 17, 2001.

eyes and probably tilt their head to the right. Over time, this crooking of the neck can lead to bigger problems. With the body set up as described in the previous paragraph, this is not necessary. Although the upper extremities will be discussed in detail later, at this point it is important to point out that the shoulders, specifically the right, can and should be held in a relaxed and neutral position. The head, even though it is turned to the left, can be held straight with the flute angling down at whatever angle is needed to avoid raising the right shoulder.

Photo 8: Seated position. Image by Simon Hurst Photography.

For all flutists, the importance of strength and endurance of trunk musculature as a base of support for breathing and for upper extremity work is paramount. The curves in the spine create a dynamic environment for alignment, so care must be taken that the flutist's stance is as close to neutral as possible without adding any extra tension. Exercises to strengthen the trunk and combat the flutist's asymmetrical stance can guard against the development of muscular imbalances and their resultant side effects.

CHAPTER SEVEN

STANCE AND THE LEGS

While the set-up of the back, shoulders, and arms are certainly integral to the playing of the flute, the lower body provides a stable undergirding for the actions of the upper body. Because so much of the mind is wrapped up in the actual playing of the instrument and managing the arms and breathing, less attention is given to what the hips, legs, and feet are doing. Great flute-playing can be quickly under-minded by a sloppy, off-balance approach to deportment. At a live performance, the audience may in fact arrive at preconceived notions of how well they think a flutist is going to play before one note is heard – all because of how the performer walks onto the stage and how they stand while they are waiting to begin. The feet and ankles, knees, and hips will provide our anchors for this discussion of the stance and the legs.

Feet and Ankles

The purpose of our feet is to bear weight of the body and enable the body to move, balance, and/or remain in a stable position. Because we have two feet, the weight of the body can be distributed to a wide platform, which increases stability. Since playing the flute primarily involves standing and weight shifting, the foot’s function of enabling mobility will be omitted, with our focus shifted to the balance and stability that the feet provide.

The foot is divided into three sections: the hindfoot, the midfoot, and the forefoot. Within the hindfoot, an irregular-shaped bone called the talus provides the only articulation with the tibia and fibula, the bones of the lower leg. Below it, the calcaneus, more commonly known as the heel bone, is easily palpated through the skin. Several small bones lined up in rows comprise the midfoot. These bones are called the navicular, cuboid and three cuneiform bones. The ball of the foot and the toes make up the forefoot. Bones in this area include five metatarsals and fourteen phalanges. The metatarsals are shaped like small shafts and can be easily felt on the top of the foot. The big toe is composed of two phalanges and the remainding four toes each have three phalanges.

The arch of the foot is the area between its weight-bearing areas, the heel and the ball of the foot (metatarsal heads). It provides shock absorption and is a springboard for the rest of the body. The arch is flattened by the weight of the body when standing; it returns to its normal curvature when the weight is removed, as during sitting, lying down or lifting the foot off the ground. The arch itself has lateral and longitudinal arches within it so that it supports the body not only front-to-back but also side-to-side. The main supports of the foot’s arches are ligamentous, not muscular. Ligaments are the strong connective bands that attach one bone to another. Weakened muscles can be strengthened by exercise, whereas weakened ligaments cannot. Trauma, congenital deformities, musculoskeletal disorders, or excessive weight can cause damage to these ligaments and in turn the arch, resulting in serious and permanent consequences.

The ankle is the joint between the foot and the lower leg; it is held together on the sides by two major ligaments, the medial ligament and the lateral ligament. The medial ligament is on the medial, or inside aspect of the ankle. The lateral ligament is on the outside or lateral aspect; it is the most often injured ligament in the body. While flute playing is not a dangerous activity, without a firm stance it is easy to ‘pop’ this joint because of a temporary loss of balance.

Twenty muscles support the actions of the foot. Fourteen are on the plantar aspect, the bottom of the foot, while only two are on the dorsal aspect, the top. Four muscles comprise an intermediate layer. With so many layers of muscles below the bones and not much padding above them, it is easy to see why it hurts so badly when you drop something on your foot. In considering the actions of the foot, fine control is not really important. The muscles work as a group to protect the arch, fix the foot, and increase pressure against the ground to give the body stability.

The axis of motion in the ankle is generally above the arch, not at the back of the heel. Proper alignment is not directly over the heel but over the arch; 50% of load goes to the heel, 50% to the forefoot. The exact line of proper total body alignment goes slightly in front of the axis of the ankle, which allows for dynamic balance using the large posterior lower leg muscles to maintain an upright position while pumping blood back up to the heart through their contractions.[46]

While setting the body to play the flute, the position of the feet is a good place to start. But maintaining a totally static position during performance and practice is not a healthy option for several reasons. Without movement, muscles can tense or co-contract leading to stiffness, fatigue, and eventually pain and muscle imbalances. Co-contractions occur when opposing pairs of muscles contract at the same time; i.e., such as the muscles that bend the knee (flexors) and those that straighten it (extensors). The simple action of

[46] See Illustration 5.

shifting weight[47] between the feet can at least partially prevent these problems as well as enhance the expression of the music being played. Occasionally the player might even pick up one foot completely,[48] but care should be taken to do so only slightly as to avoid excessive counter-movements.

The area between and under the feet is the body's base of support and balance. If the feet are close together or are parallel (Illustration 12A), the area over which the body's center of gravity must balance is very small. The further apart the feet are, the larger this area becomes and the easier it is to balance the body over it. By placing one foot in front of the other, the front-to-back distance is increased as well (Illustration 12B). By angling the feet outwards, the area can be increased even further (Illustration 12C). The amount of flexibility differs greatly between individuals, so the degree of outward rotation is variable. Finally, the difficulty of keeping the body's center of gravity with high heel shoes is shown in Illustration 12D.

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[47] George, *Flute Spa.*
[48] An idea first proposed by Michel Debost, flute professor at the Oberlin Conservatory.

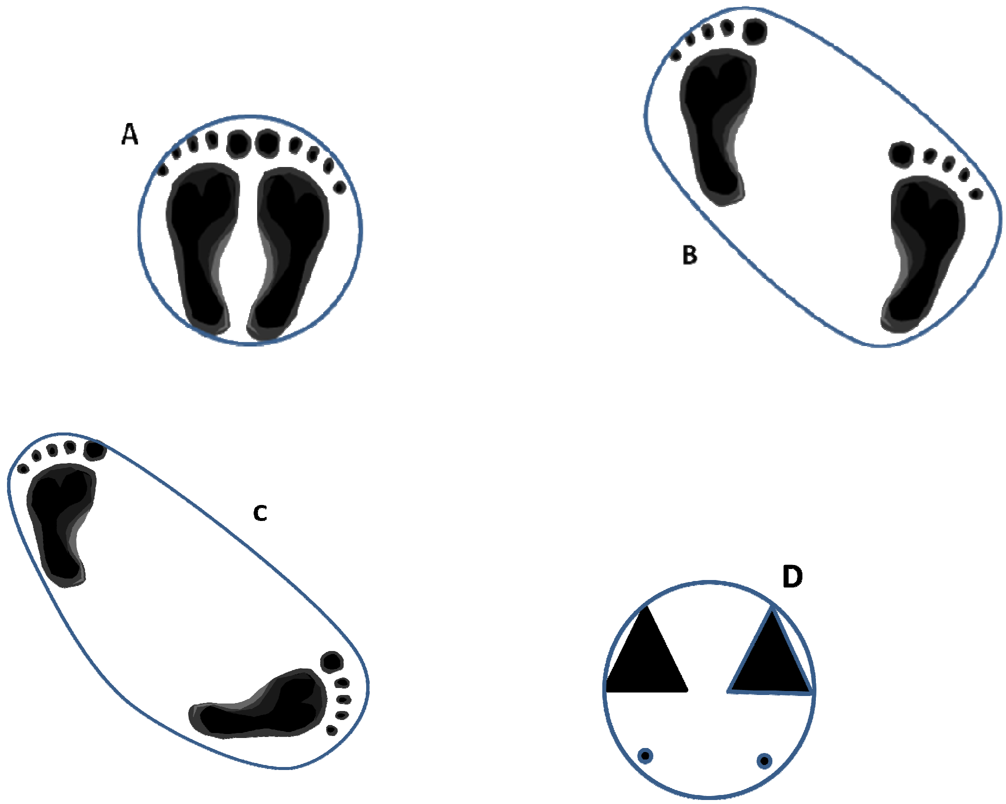

Illustration 12: Base of support over which the body's center of gravity balances. Drawings by author.

Shoes also have an effect upon the surface area which provides the base of support for the body. With heels, especially those that are high and thin, the support area is lessened quite a bit; flat shoes would provide the most area possible. The heel height causes a shift in center of gravity forward, which results in several counter-balancing actions of the body. The lower back (lumbar region) hyperextends, the neck (cervical area) then leans forwards in order to counterbalance. The quadriceps, the muscles on top of the thighs, contract to keep the body in check; the toes may even flex. The domino effect of muscular responses plus the decrease in the support base makes the option of heels less appealing.

Despite the current trend toward 'pointy-toed shoes,' shoes with an adequate toe box are essential for circulation and free movement of toes. Tight shoes can lead to a disruption of nerve conduction which can eventually cause permanent numbness. The presence of nerves provides the brain with clues to maintain balance; if you can't feel your feet, this becomes more difficult. The brain is busy enough with the task of playing the flute; pain signals from the feet are an unnecessary interruption.

Ergonomically designed shoes are available from several different businesses although they tend to be expensive. Some brands include Taryn Rose Shoes, Aravon, Munro, Gentle Soles, and New Balance. Quality rightfully demands a fair price and supportive, comfortable and classy shoes can be a silent but powerful partner in expressive musical performances.

Thigh, Knee, and Calf

The knee's dual roles of mobility and stability carry the human body throughout the day through a variety of routine and difficult activities. This multi-layered joint, surrounded by a joint capsule, is where the large bone of the thigh (femur) meets the bones of the calf (tibia and fibula). The joint surfaces are padded by menisci, wedges of cartilage that serve to increase stability, provide shock absorption, and facilitate motion. Ligaments attach the ends of the bones of the calf to the end of the thigh bones. On the front of the knee joint, the knee cap, or patella, provides additional leverage for the quadriceps, the large front muscle of the thigh. The patella also serves as a bony surface that can withstand the forces that occur during kneeling and the excessive friction that occurs during running.

One end of the quadriceps muscle inserts onto the knee, but it begins with four separate parts at the upper end of the thigh bone and lower trunk. The rectus femoris, the central and most superficial of these heads, straightens the knee and steadies the hip joint. It is the only head of the quadriceps that attaches to the pelvis; the other three heads, called vastus lateralis, medialis, and intermedius, all have their beginnings on the upper end of the femur. One of the advantages of positioning the feet at twelve and two-three o'clock is that the front-and-back movement allowed by this stance keeps the quadriceps muscles from contracting at the same time as the muscles on the back of the thigh (Photo 9). This co-contraction sometimes happens when an individual is nervous and tense; the quadriceps tighten up almost involuntarily. But the motion of shifting weight between the front and back foot keep the quads in a cycle of contracting and relaxing, allowing for a less tense and more fluid stance.

Photo 9: Side view of balanced stance. Image by Simon Hurst Photography.

The sartorius, a smaller muscle of this same forward thigh compartment, is similar to the rectus in that it crosses the hip and knee joints, but it does so diagonally and is superficial to the rectus. Other muscles of the anterior thigh which connect the femur to the pelvis include the pectineus and the iliopsoas. The pectineus is small and short, while the iliopsoas is a group of three large muscles that insert together on the inside top portion of the femur. The psoas major comes from the sides of T12-L5 and lies diagonally in front of the pelvis on its way to the femur (Illustration 7A). The psoas minor is a smaller muscle running from T12-L1 to the femur. The iliacus is a shorter but broad muscle that begins on the top horizontal edge of the pelvis, ending at the same approximate spot on the femur as the psoas. These three muscles together are the main flexors of the thigh; they also assist in lateral rotation of the thigh. In addition to these actions, the iliopsoas is a postural muscle in that is active during standing. It maintains the normal lumbar lordosis and resists hyperextension of the hip joint.[49] Although a connection between the actions of the iliopsoas and the diaphragm has been a frequent topic among musicians, nontraditional health practitioners and others, I could find no evidence in the medical literature of any such connection. Both of these muscles do have tendons that insert upon the lumbar vertebrae, but beyond that, any type of relational action has not been reported in medical literature and must be held in suspect.

The thigh muscles on the back of the leg, collectively known as the 'hamstrings' are the semitendinosus, semimembranosus, and the biceps femoris. These muscles straighten the thigh but they can also extend the trunk when the leg is fixed as in standing. The lower leg muscles of the calf include the gastrocnemius, soleus, and plantaris. As the most superficial muscle in the lower leg, the gastrocnemius arises from

[49] Moore and Dalley, *Clinically Oriented Anatomy,* p. 592.

two heads on the back of the lower end of the femur. A more common name for the calcaneal tendon that attaches the gastrocnemius to the calcaneus is the Achilles' tendon. The muscles of the front of the lower leg compartment include those that bend the ankle and extend the toes.

The capsule of the knee joint is filled with synovial fluid, which lubricates the joint. The knee is actually two joints: between the tibia and the femur, and between the kneecap and the femur. The tibiofemoral joint is a double condyle joint, with a rounded, knuckle-like articular area that usually occurs in pairs. This joint allows three motions – its primary motion of flexion/extension, and also rotation and abduction/adduction. In the patellofemoral joint, the patella acts as a pulley for the quadriceps. The inside of the patella is divided in half by a ridge.

Mobility is not as applicable to flutists as stability, so we will focus on the supportive function of the knees. Several problems related to the knee joint are relevant to our discussion. The strength of the quadriceps muscles is paramount to the health of the knee. The quadriceps keeps the patella sliding properly in its groove. A weakened muscle will result in an imbalance and may lead to chondromalacia, a softening of the interior side of the patella. A method of determining the force placed on the patella involves measuring the Q angle (Illustration 13),[50] the angle between a line connecting the anterior superior iliac spine (on the pelvis) to the midpoint of the patella and the extension of a line connecting the tibial tubercle, the large bump at the top of the shin, and the midpoint of the patella. This angle is larger in women because they have a wider pelvis; the discrepancy results in a larger sheering force placed upon the knee and patella. If one of the heads of the quadriceps becomes weak, the patella may be pulled in a new

[50] Levangie and Norkin, *Joint Structure & Function*, p. 427.

direction, pulling it out of its proper alignment and causing extra wear-and-tear on its posterior aspect.

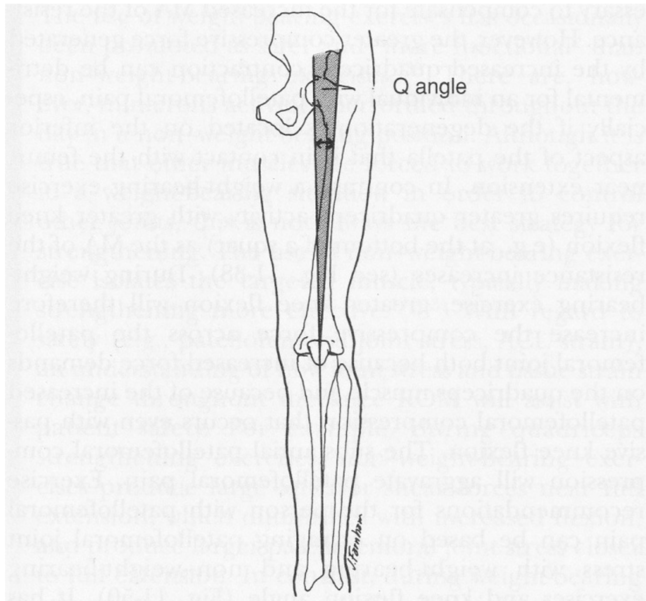

Illustration 13: The Q angle. From *Joint Structure & Function*, 4th Edition, Pamela K. Levangie and Cynthia C. Norkin, 2005, p. 427, F. A. David Company, Philadelphia, PA, 19103, with permission.

Other complicating factors in maintaining healthy knees include the postural adjustments caused by high heeled shoes and the loosening of ligaments brought on by the hormonal shifts of pregnancy. These factors add stress to the knee joint, which speeds the degenerative processes. These issues are of prime importance to flutists since the majority of them are women. Since we spend so much time standing during our practicing and performing, we need to consider the effect this has upon the health of our knees. Developing and maintaining strong quadriceps not only provides a great base for our stance during flute-playing, it can also enhance the rest of our activities of daily living.

A common abnormality in many people is a postural hyperextension in the knees, known in scientific circles as genu recurvatum. The knees are slightly behind an imaginary line between the balance points of the hips and ankles. Individuals with this posture tend to 'hang on their hips' with their lower trunk in front of its proper alignment. In assuming a good stance for playing the flute, the previously mentioned arrangement of having the left foot facing forward and the right foot rotated out to the side provides a good basis for shifting the weight of the body back and forth. This stance allows both knees to remain slightly flexed and moving within a small range of motion. The problem of genurecurvatum is negated by a fluid posture with the knees bending and straightening in an alternating manner.

Locking the knees can occur to almost everyone but it can be avoided by the same turned-out stance and weight shifting described previously. A locked-knee posture may provide a temporary stance of ease, but it is not a stance of flexibility. It can be considered another way of 'hanging on the hips,' with the thigh and gluteal muscles contracting and the kneecap (patella) being pulled upward. In this position, the abdominals are relaxed and a swayback posture is adopted with a counterbalancing increase in thoracic kyphosis (a forward curve). The lack of periodic muscular contractions in the legs causes blood to pool there, so less blood gets pumped back up to the head and lungs, which can predispose an individual to fainting or experiencing shortness of breath. Less air is available for playing, focusing, and thinking. Military and marching band organizations warn their participants to keep their knees and/or quadriceps 'soft' or relaxed in order to avoid 'hitting the pavement' during a long period of standing at attention.[51] With the feet at twelve and three o'clock and the knees held softly in a slightly bent position, the body is free to move in support of the music.

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[51] An incident I observed with horror at drum major camp.

Hips

The hip joints support the weight of the head, arms, and trunk when the body is still and when it is doing activities that require movement such as walking, running, and stair climbing. These joints, along with the knees and ankles, are built to bear the weight of the entire upper body. The head of the femur moves within the acetabulum, or socket, of the pelvis. This ball-and-socket joint has three degrees of movement: flexion/extension, abduction/adduction and medial/lateral rotation.

As mentioned in the previous section on knees, the quadriceps femoris has one head, the rectus femoris, which crosses over the hips and connects to the pelvis. This muscle flexes the hip and extends the knee. When not used, such as during an injury or bed rest from an illness, it rapidly atrophies, or weakens. Other muscles that function in hip movement are the inner thigh adductors. The back hip compartment is composed of the gluteus muscles and other smaller muscles. All these muscles either straighten the thigh and/or assist in turning the leg inward or outward (medial or lateral rotation).

Nerves exiting the lumbar and sacral areas of the spine supply the lower trunk and lower extremities. The nerves exiting L1 – L5 are referred to as the lumbar plexus; nerves exiting S1 – S4 are the sacral plexus. Major nerves from L4 – S4 pass behind the pelvis and then run forward through the sciatic foramen, a large opening under the lower rim of the juncture between the sacrum and the ilium. Two large nerves from this group, the common fibular nerve and the tibial nerve, together are referred to as the sciatic nerve; it exits the pelvic area, descending in the posterior thigh until it divides behind the knee.

During the position of ease as stated in Chapter Six, only a few of the back and lower limb muscles are active; the mechanical arrangement of joints and muscles are such that a minimum of muscular activity is required to keep from falling.[52] The hip and knee joints are extended and are in their most stable position. Note that the knee is not hyperextended; that is, the kneecap is relaxed and not pulled upward. Since the ankle is less stable, the line of gravity falls between the two limbs just in front of the axis of motion of the ankle joints. The vertical line that represents the center of gravity falls through the skull/C1 vertebra, the axes of the pelvis and hip, and then in front of the knee and ankle. An occasional contraction of both calf muscles (plantar flexion) is all that is required to maintain this position. Other texts align the body directly over the axis of the ankle, which would require corrections of balance both forward and backward. Since correcting from a backward motion is less coordinated and more difficult, I agree with the authors of *Clinically Oriented Anatomy* and recommend a slightly forward-leaning stance. An adequate spread of the feet increases stability by providing a large base of support as previously described.

[52] Illustration Five is repeated again following this paragraph.

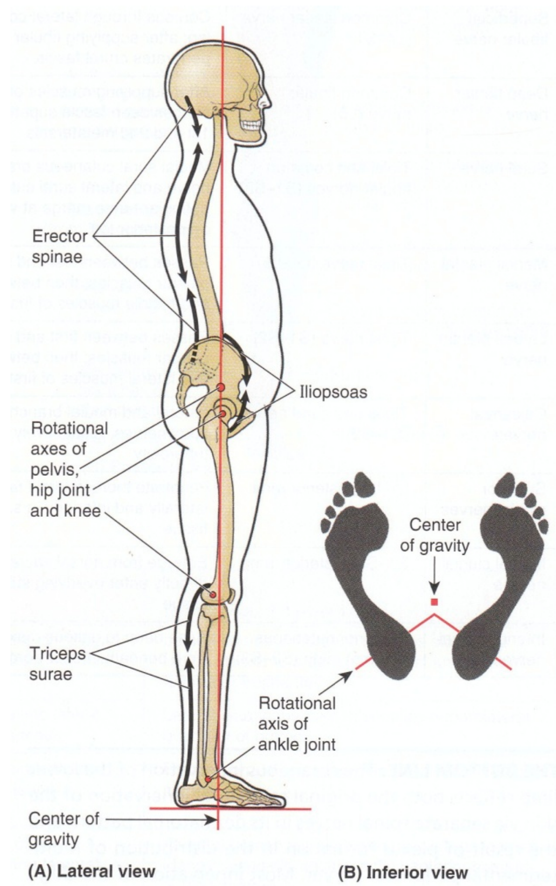

Illustration 5: The position of ease. From *Clinically Oriented Anatomy*, 5th Edition, Keith L. Moore and Arthur F. Dalley, 2006, p. 588, Lippincott, Williams & Wilkins, Philadelphia, PA, 19106, with permission.

If there is excessive lateral sway, such as might be the case when someone loses their balance, a collective contraction of several groups of muscles has to occur for the body to regain its position. A lot of work is required to return to an upright position after a temporary loss of balance. The work of playing the flute is best supported by obtaining and keeping a solid stance that allows a reasonable amount of flexibility and movement. But a natural stance is not the same as a military attention position with the head and upper back held in a rigid posture with the chin somewhat high. The chest is also thrust outward in this attitude, causing the shoulder blades to retract and the upper spine to extend. Flutists require a more dynamic posture and the stiffness inherent in the military position is counterproductive not only to the fluid use of the body during playing, but also to the expressiveness of the music.

Creating and maintaining a balanced stance is a more challenging proposition for women than it is with men. As previously stated, the angle of the hips with respect to the knees is greater in women than in men. Although this measurement and its importance is debated within the scientific community, the fact that women have wider hips than men is obvious. In observing professional male flutists during solo performances, it is easy to note their solid stance not only because they are wearing pants and flat shoes, but also because their legs tend to stay straight under or slightly spread below their hips. There is no social or cultural precedent for them to adopt a 'legs together' pose as would be the case with women. But clearly, the typical stance men use provides them with a firm base of support from which to work while performing. In the case of women, it is truly ironic that with our wider hips, we nonetheless tend to keep our feet even closer together than would a man. With the cultural pressure of high heel shoes and the 'beauty queen' stance of legs together with one foot slightly crossed in front of the other (in order to look thinner), the base of support may end up being very small. Women flutists should position their feet apart with the hips rotated out (this leads to the feet being turned out; the motion that causes this outward rotation should originate in the hips, not in the knees); the feet are under the hips or perhaps even further apart. The area of support will be greater, the body will have a firmer base from which to make slight movements that ease the burden of long-term standing, and the performer herself will enjoy the confidence this stance brings.

Another issue related to standing posture of both sexes is assessing the best location for bending the trunk. The ball-in-socket joint of the hip allows a great variety of motions. These motions in turn provide the mechanism for leg movement, but also create ways for the body to shoulder the burden of long-term stability during the many hours of standing we do each day. During these hours of upright stance, the body tends to slump forward, substituting flexion of the spine for a bending forward of the hips. The spine has less freedom of movement than the hip joint at least as far as forward bending is concerned, and the substitution of spinal flexion for hip flexion can expose the back to unnecessary wear and tear. The waist is not an anatomical part;[53] bending from the waist compresses the abdominal contents and therefore decreases the space into which the lungs descend during inhalation. Restricting the breath is not a good idea for any wind instrumentalist or singer.

In a sitting position, the goal is essentially the same as in standing: to attain a stable alignment of the body that can be maintained with the least expenditure of energy and the least stress on body structures. A turning of the chair forty-five degrees to the right with the flute and upper extremity set-up roughly parallel to the music stand allows the right shoulder to be relaxed and in a neutral position (Photo 10). The right end of the flute can be brought even more forward. Details concerning this position of the upper extremities are in the Chapter Eight.

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[53] An idea first taught by Leah Pearson, author of *Body Mapping for Flutists* (Chicago: GIA Publications, Inc., 2006).

Photo 10: Angles of seated position. Image by Simon Hurst Photography with permission.

Another adaption that improves the position of the body during sitting is a foam wedge (Photo 11). Cellists have no other choice but to sit, and they have been using foam wedges or special chairs with sloping seats for some time. Either of these modifications increases the angle between the trunk and the legs, which effectively causes the hips to bend less than they would otherwise. OSHA (Occupational Safety & Health Administration) lists three ergonomically safe seating positions; two of these have hip angles greater than 90 degrees.[54] The idea of a foam wedge, with its angle of 15-20 degrees, is to keep the pelvis as close as possible to the same alignment that occurs when standing, which promotes a normal lordotic curve in lumbar spine. More space is provided for the femur to angle down, thus avoiding forces that would force the pelvis

[54] <www.osha.gov/SLTC/etools/computerworkstations/positions.html>; accessed April 1, 2009.

backward.[55] This curve, the backward sway of the lumbar vertebrae, is decreased and flattened out in the sitting position; the foam wedge enhances that curve, promoting a more healthy position for the lower back. This position in turn provides a better base for a balanced spine on top.

Photo 11: Foam wedge. Image by Simon Hurst Photography with permission.

The sitting position of flutists in large ensemble arrangements, especially concert bands, is problematic. Frequently placed on the front row, flutists are spaced too close together, making a difficult situation even worse. A simple solution is to place the flute section on the second row, allowing much more space in which to angle chairs and assure

[55] Richard Norris, *Musician's Survival* Manual (St. Louis, MO: International Conference of Symphony and Opera Musicians, 1993), pp. 39-44.

adequate distance from neighbors. Allowing each player to have their own stand also avoids crowding and awkward positions. Clarinets can be placed on the front row.

Amy Porter, flute professor at the University of Michigan, has been quoted as saying that “the floor is the bottom of your sound.” A scientific translation of this important concept is that the flutist needs to feel firmly set in his/her stance so that no extraneous unplanned movement distracts or interrupts their concentration when playing. The throat should be relaxed and the jaw dropped. Knees are kept soft, i.e. not hyperextended or locked. The muscles of the lower body are used for balance and stability, beginning with the feet positioned in a wide stance. As the muscles of the legs and trunk are balanced and stable, the muscles in the upper half of the body are free to be used for playing the flute.

CHAPTER EIGHT

THE SHOULDER, ARM, AND HAND

The physical mechanisms of the shoulders, arms and hands are central to the playing of the flute. Even though great variety exists among human beings with no two of us being exactly alike, certain fundamental principles apply when looking at how the musculoskeletal system functions. While we all share the same basic anatomical structures, there are yet small variations in internal anatomy. Tendons join one another at different levels, joints have different degrees of flexibility, and some muscles may not be present in certain individuals at all. With this in mind, a flutist's ability to skillfully hold, balance, and play the flute will depend to an extent upon the knowledge they have of their own unique body. In addition, certain facts about the make-up of the human body have particular bearing upon the activity of flute playing. Because of the way the flute must be supported by the arms during the excursions of the rib cage and the slow exhalations and quick inspirations of the lungs, placing the bones and muscles of the shoulders and arms in the best possible position is a worthwhile goal for any flutist. While making observations and drawing conclusions specific to flute-playing, a brief review of basic anatomy will provide the necessary scientific vocabulary to understand this important subject.

The Shoulder

The three bones that meet at the shoulder may at first seem rather simple, but upon closer inspection, it is one of the body's most complicated joints. The shoulder blade (scapula), the collar bone (clavicle) and the long bone of the upper arm (humerus) together meet at the shoulder (Illustration 14). The term "shoulder (pectoral) girdle" refers to the two clavicles and the two scapulae; these four bones encircle, albeit incompletely, the upper torso and provide attachments for the proximal muscles of the arms. The shoulder girdle also attaches the arms to the axial skeleton, or more simply, the body.

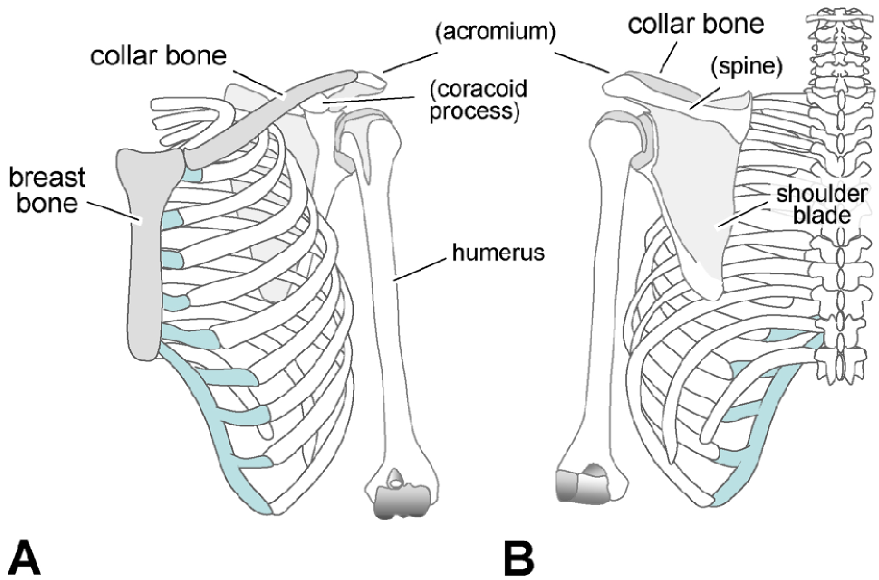
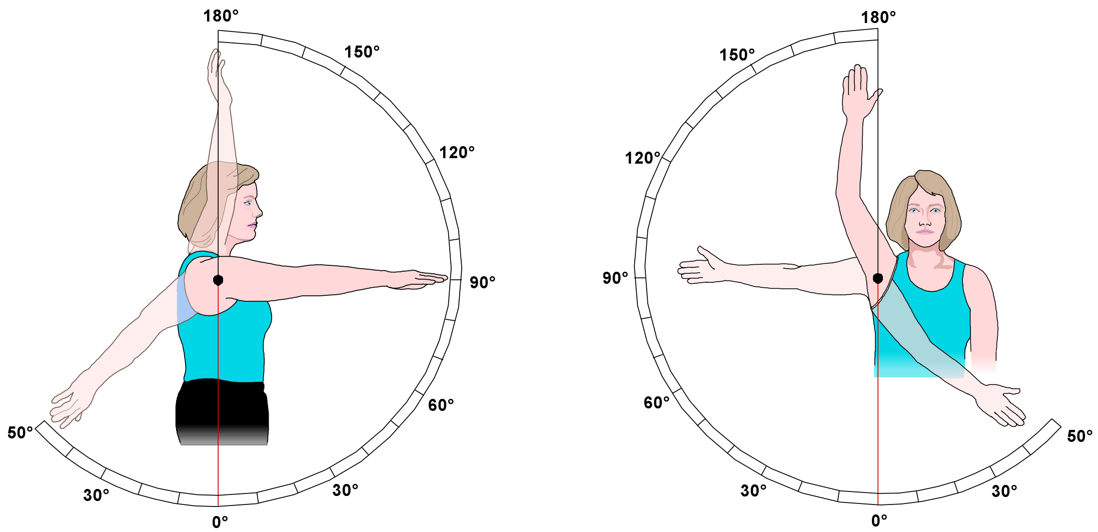


Illustration 14: The skeleton of the shoulder. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 45, Scarecrow Press, Lanham, MD, 20706, with permission.

Fluidity in the shoulder joint is achieved by a limited bony connection (articulation) between the arm and the trunk at the sternoclavicular (SC) joint. This small joint can be felt at either side of the top notch of the breastbone (sternum), to which it is connected by ligaments. The outer (lateral) end of the clavicle attaches to the shoulder blade (scapula) at the acromioclavicular (AC) joint, which is at the upper edge of the shoulder. By bringing the shoulder forward, the clavicle can be easily felt (palpated) as an elongated S-shaped bone. This shape gives the clavicle its strength yet it is the most frequently fractured bone of the human body. A fall on the outstretched hand is the typical accident that causes the clavicle to break, an even Lance Armstrong, the famous American cyclist, recently experienced during a professional road race. The small articulations of the clavicle to the scapula and the sternum provide the shoulder complex with great freedom of movement. When balancing the flute, the clavicle need not elevate since the shoulders themselves do not need to be raised. But because of the rotating of the arm in our playing position, the muscles attached to the clavicle will be engaged and the clavicle will rotate on its long axis in response. During stretching activities, which are a crucial part of a complete training program for a flutist, the clavicle provides that added mobility that allows the anterior chest muscles to be stretched out fully.

Since the shoulder blade is so close to the skin's surface, its bony prominences are visible and easy to feel. The acromium process of the shoulder blade is the hard corner felt on the top outer edge of the shoulder. Proceeding downward and toward the center of the back from this point, the horizontal spine of the shoulder blade can be easily felt. Another bony prominence not so easily palpated is the coracoid process. This thumb-shaped protrusion is on the underside of the scapula and sticks through to the front of the body under the front edge of the clavicle. Attached to this small knob are several muscles and ligaments, one of which is the pectoralis minor, an important muscle used in slowing the exhalation so important to flutists. The shoulder blade as a whole is a flat triangular bone with its apex pointing downward. The smooth surface on the inner side of this flat bone allows it to glide easily over the back side of the chest wall, forming a functional joint even though there is no true bony connection. While the shoulder blades lie on top of the rib cage, their relative position has little if any bearing upon respiration. As the lungs fill up and the ribs expand, the shoulder blades slide as needed without helping or hindering the amount of breath taken in. The borders of the shoulder blade are referred to as superior, medial and lateral while the angles are named inferior, superior and acromial.

During elevation of the arm, the movement of the shoulder blades over the chest wall increases and supports the range of motion of the arm (Illustration 15). The relation of the motion of the shoulder blade to that of the arm is called scapulohumeral rhythm. The proportion of motion is generally 2:1 (arm elevation to shoulder blade motion) but doesn’t begin until about 30 degrees of arm (humeral) elevation. The shoulder blade rotates counterclockwise and the inferior angle moves outwardly to the side (laterally) as the arm elevates. Movement of the shoulder blade can be easily felt on oneself or a partner. When holding the flute, keeping the angle of arm elevation as small as possible reduces the need for engagement of the shoulder blade muscles. This position involves keeping the shoulders and elbows down and will be described in more detail later.



Shoulder Flex/Ext:
Lateral view of woman exhibiting normal range of movement in the flexion and extension of the arm at the shoulder joint.

Shoulder Abd/Add:
Anterior view of woman exhibiting normal range of movement in the abduction and adduction of the arm at the shoulder joint.

Illustration 15: Movements of the shoulder.

The glenohumeral joint, which is the articulation of the upper arm bone (humerus) and the shoulder blade, has the greatest mobility of any joint in the body. It is a ball-and-socket joint; the head of the humerus is the ball and the socket is formed by the upper outer corner of the shoulder blade and surrounding supportive tissues. The head of the humerus is held in place not by bones and ligaments, but by a synovial joint capsule and the tendons of many different muscles that pass through it. Synovial joints are one of three basic joint types; these classifications include synovial, fibrous, and cartilaginous joints.[56] Bones of synovial joints are united by a joint capsule or a sac that encapsulates the joint and is filled with a lubricating fluid. Within the context of this joint, the actions of the shoulder (glenohumeral) joint are flexion, extension, abduction, adduction, medial rotation, and lateral rotation (Illustration 15 and 16). The strong but mobile

[56] Fibrous joints occur in the skull. Cartilaginous joints are found in epiphysial plates and intervertebral discs.

sternoclavicular joint allows this large freedom of motion. When the arm is raised, the clavicle elevates as much as 60 degrees; when the arm is flexed forward during elevation, the clavicle also rotates.

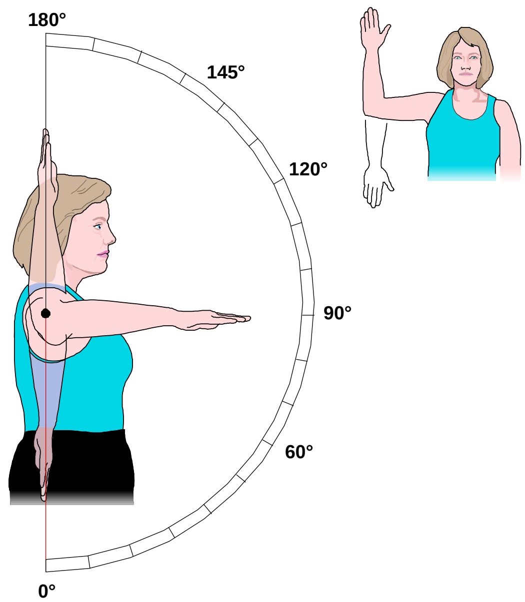


Illustration 16: Medial and lateral rotation of the shoulder.

Several important muscles attach the clavicle and shoulder blade to the vertebral column (Illustration 17). One of the largest is the trapezius a superficial muscle that holds the shoulder blade in place. It covers the back of the neck and the top half of the back of the trunk, connecting the spine to the skull, clavicle, and scapula. Because of its large size and convergence upon the shoulder, the fibers of the trapezius run in different directions; the fibers slope downward, horizontal, and upward. Its actions therefore depend upon which part of the trapezius is contracting. Actions of the trapezius include raising the shoulder upwards (shrugging), pulling the shoulders downward, or pulling the shoulders toward the spine. The upper edge of the trapezius can be felt during shrugging of the shoulders. Young flutists, when trying to figure out how to hold the instrument, will sometimes rest the end of the headjoint on their left shoulder and use their trapezius (and other neck muscles) to lift the flute to within reach of their lips. While this is easy to correct, a more insidious problem is the lifting of the right shoulder by many flutists in their everyday playing posture as they try to keep the flute horizontal. Because this involves other muscles surrounding the shoulder as well, we will discuss them first and then tackle the issues of flute posture.

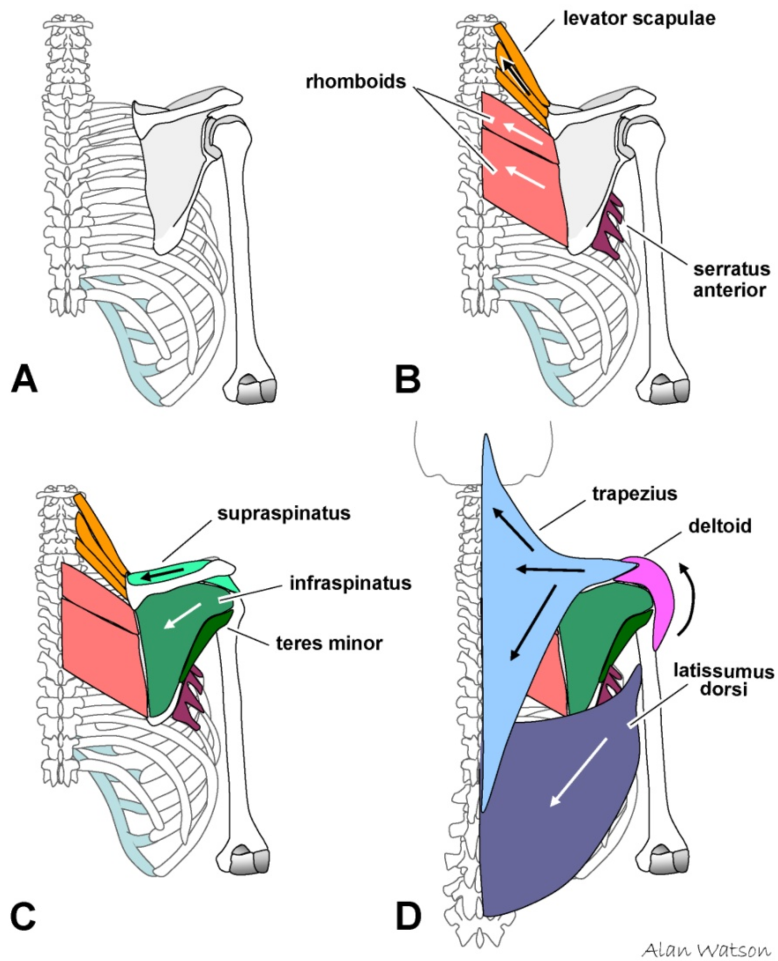


Illustration 17: Muscles attaching the shoulder blade to the back and to the arm. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 47, Scarecrow Press, Lanham, MD, 20706, with permission.

The rhomboids are two rather short muscles under the trapezius that run obliquely from the inner (medial) border of the scapula to the spine. Designated major and minor, they are two separate muscles with the rhomboid minor above the rhomboid major. These muscles pull the shoulder blade inward and upward. Above the rhomboids, the thick strap-like levator scapulae muscle connects the shoulder blade to the transverse processes of the upper cervical vertebrae. The levator scapulae are more steeply sloped than the rhomboids but assist them in pulling the shoulder blade inward and upward.

As Dr. Watson notes in his *Biology of Musical Performance*, the above muscles are frequent sites of tension in all musicians and attention to their health is of paramount importance. The rhomboids and levator scapulae are part of a group of muscles that contract to stabilize the shoulder blade so that it can serve as a base for muscles that control the arms. Careful attention to a healthy playing posture, strengthening exercises, stretching of opposing muscle groups, and massage are all important components of a plan to combat problems in this area.[57]

The serratus anterior and pectoralis minor are two muscles that attach the scapula to the ribs (Illustration 18). The serratus anterior is a group of slip-like muscles which extend from the frontal surfaces of the first through eighth ribs on to the inner border of the underside of the shoulder blade. Along with the rhomboids, the serratus anterior holds the shoulder blade against the chest wall and fixes it during movements of the arm. The actions of the rhomboids and the serratus anterior in stabilizing the shoulder blade are crucial to the holding of the flute. As the serratus anterior is also an accessory muscle of breathing, the rhomboids must work even harder to stabilize the scapula while the serratus anterior muscles are busy providing a braking action for the long exhalation

[57] See the Appendix F for recommended books on exercise.

required by flute-playing.[58] These muscles must be strong and in the best position of mechanical advantage in order to do their work. In a slumping posture, with the head and shoulders brought forward, the rhomboids are put on a stretch and must work harder to pull the shoulder blades back into place. The ribs have less room to expand, limiting the action of the serratus anterior. If the right shoulder is pulled backward when holding the flute, the right rhomboid and levator scapula have to work even harder to pull the right scapula backward. Conversely, in a more upright properly aligned posture, the rhomboids can work from a more neutral position and the serratus anterior has more room to assist in the expansion of the rib cage.

[58] Breathing strategies and mechanisms are covered in more detail in Chapter Ten.

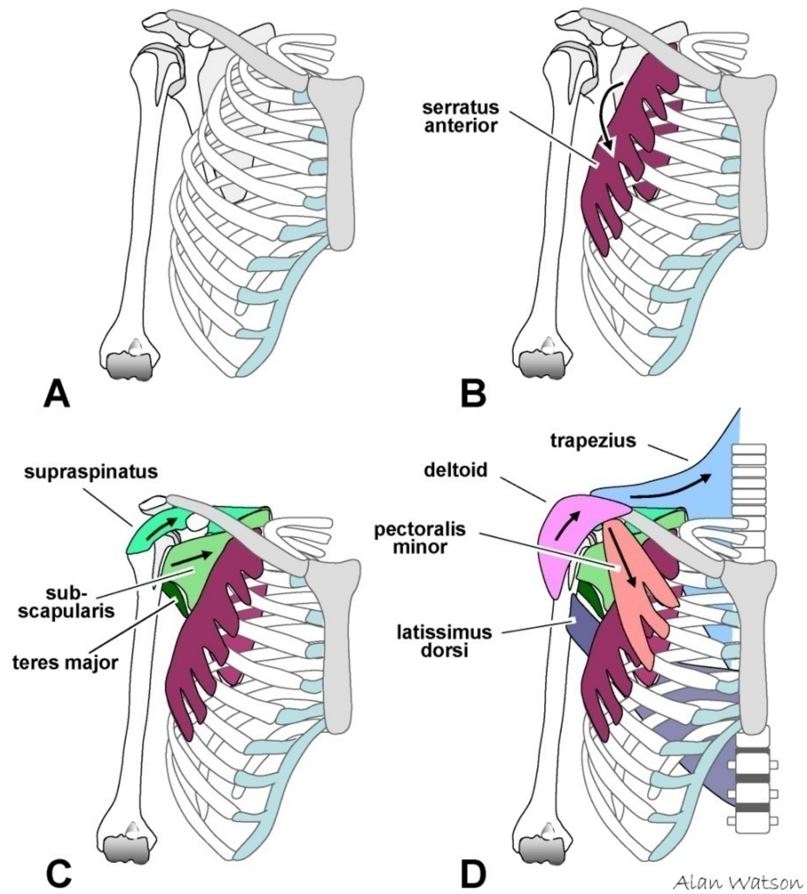


Illustration 18: Shoulder muscles as seen from the front. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 48, Scarecrow Press, Lanham, MD, 20706, with permission.

The pectoralis minor is a small muscle of the chest that lies underneath the much larger pectoralis major. Extending from the front of the rib cage to the coracoid process of the shoulder blade, it assists the actions of the serratus anterior which include stabilizing the shoulder blade and assisting with movements of respiration. So, like the serratus anterior, this pectoralis muscle has two functions during flute-playing – assisting with the braking of exhalation and stabilizing the shoulder blade while the arm holds up the flute.

An important concept in muscle action is worth clarifying at this point.[59] Virtually all muscles are connected by tendons to bones. When a muscle contracts, its individual fibers shorten and the overall length of the muscle is decreased. As the muscle shortens, the bones that it is attached to move closer together. During a muscle contraction, one bone is usually stationary, so the shortening muscle causes the other bone to move closer. There are other types of muscle contractions when the bones remain stationery, or when a bone is moving away slowly, but here we are only considering shortening or concentric contractions in which the involved bones are moved closer together. When considering this type of muscular action, it is important to understand which bone is stationary and which bone is moving. For example, when considering the rhomboids, the spine remains stationary while the rhomboids act upon the shoulder blade, moving it closer to the spine.

Four of the muscles that connect the shoulder blade to the arm (humerus) are collectively called the rotator cuff. The tendons of these muscles merge with the fibers of the shoulder joint capsule, strengthen it, and help keep the head of the humerus down in the shoulder socket. These four muscles, the supraspinatus, infraspinatus, teres minor, and subscapularis, are together referred to as the SITS muscles. The supraspinatus lies in the area above the spine of the shoulder blade while the infraspinatus and teres minor lie below the spine. The fourth muscle, the subscapularis, lies on the inner side of the shoulder blade.

In addition to holding the head of the humerus in its place, the SITS muscles act upon the humerus to move it (Illustration 19). The supraspinatus works with the deltoid to raise the arm out to the side. It initiates and assists with the first 15 degrees of this

[59] Watson, *Biology of Musical Performance,* p. 25.

motion, making its work crucial to the holding of the flute. However little we raise our right arm while playing the flute, the supraspinatus is doing the work. If the flutist has been taught to keep the flute horizontal, the supraspinatus will be taxed even more. Eventually this muscle will tire, and the right shoulder and neck will begin to substitute motions to keep the flute high. Fatigue and pain often result from the overuse of these muscles and the stress placed upon their tendons. The tendon of the supraspinatus passes through a small gap underneath the acromium on its way to the humerus. If the surrounding tissues get swollen, the tendon can become pinched (impingement), resulting in pain and loss of range-of-motion. A cycle of pain and lack of motion is dangerous in the shoulder area as it can lead to a "frozen shoulder," a condition with a very difficult path to recovery.

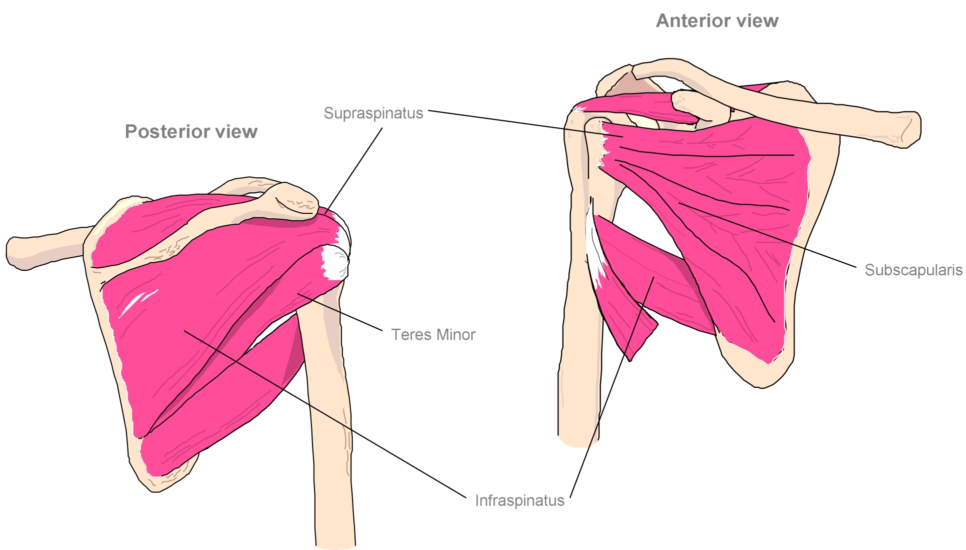


Illustration 19: The rotator cuff.

The deltoid muscle lies over the rotator cuff like an upside-down cape with the hem arising from the spine and acromium process of the shoulder blade (Illustration 20). The converging fibers of the deltoid attach to the outside aspect of the head of the humerus. This muscle is divided into three general areas: anterior, mid-, and posterior aspects. All three sections work together to abduct the arm, bringing it up and out to the side. The anterior deltoid assists the pectoralis major in flexion of the arm, bringing it forward while the posterior deltoid assists the latissimus dorsi in bringing the arm away from the back of the body. As mentioned previously, the supraspinatus assists the deltoid in the first 15 degrees of humeral abduction. The supraspinatus must initiate abduction; from 15 degrees onward, the deltoids take over. An important bursa separates the deltoids from the supraspinatus and the acromium process of the shoulder blade. This thin-walled sac contains a small amount of fluid to facilitate smooth motion of the supraspinatus tendon as it moves within its channel. The sides of the bursa slide across each other as the biceps and supraspinatus contract and relax.[60]

[60] Watson, *The Biology of Musical Performance,* pp. 48-9.

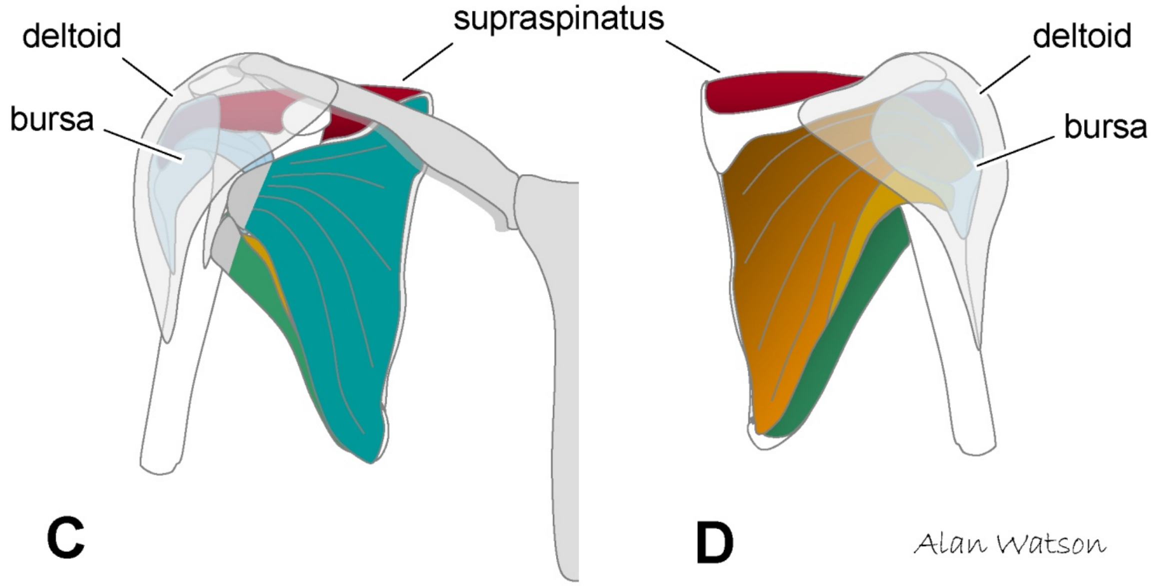


Illustration 20: The rotator cuff and bursae. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 45, Scarecrow Press, Lanham, MD, 20706, with permission.

At the outset, when holding the flute, both upper arms should hang down in relaxed position. Any elevation of the elbow necessitates scapular movement, which is then stabilized by the rhomboids and other muscles that are attached to the vertebral column. The prolonged position of raised arms fatigues these muscles and can lead to upper back and lower neck problems.

The position of the elbows while balancing the flute comes into play here even though we have not yet discussed that joint. In placing the hands on the flute, the hands become fixed. In order to bring the elbows up and out to the sides, both arms internally rotate, with the axis of motion centering on the head of the humerus in the shoulder socket. While the action is that of internal rotation, it is an isometric or holding contraction of the external shoulder rotators that holds the arms in this position. These muscles include the deltoid, infraspinatus, and the teres minor. Even though the supraspinatous and subscapularis are internal rotators and are called to rotate here (gravity does the work), they still assist in this action as stabilizers of the head of the humerus, keeping it down in its socket and also as an opposing contraction to balance the work of the external rotators. The muscles contracting to keep the arms in this abducted position are the deltoid, serratus anterior, supraspinatus, and trapezius. Keeping the elbows up and out in a prolonged contraction against gravity such as this leads to muscle fatigue, a buildup of metabolic waster products, and potential strain to the structures involved. Some abduction of the right shoulder and adduction of the left shoulder are unavoidable; a lifted position of the elbows, which requires internal rotation of the shoulders, can be avoided.

Another issue involves an intentional discrepancy in muscle balance between the shoulder flexors and internal rotators and its extensors and external rotators. Because our bodies are designed to do work in front of us, our shoulder flexors and internal rotators are stronger than our extensors and external rotators. Imagine a baseball pitcher trying to throw a fast ball over his back. It would never happen. So if the elbows are raised in the position the flutist takes to balance her instrument, her weaker shoulder muscles, the abductions and external rotators, are forced to contract in order to hold the arms and flute up against gravity. Solutions include strengthening these muscles of course, but limiting the demands placed upon them is also a wise course of action.

Even though the biceps muscle is more often considered a muscle of the arm and not the shoulder, it is discussed here because one of its proximal tendons, both of which attach to the scapula, runs through the synovial joint of the shoulder (Illustration 21). The biceps tendon emerges from the long head of the biceps and hugs the outer edge of the top of the humerus, sliding under the transverse humeral ligament, which keeps it in its groove. It then inserts onto the top edge of the scapula's shoulder joint surface. The short head of the biceps attaches to the coracoid process on the underside of the scapula. Both parts of the muscle combine at about the mid-arm level to form one muscle, whose main tendon inserts onto the radius, the forearm bone on the thumb-side. Therefore the biceps muscle spans two joints, the shoulder and the elbow. A triangular membrane emerges from the biceps tendon as it connects to the radius; it then blends into the deep fascia that covers and protects the forearm flexors on the medial side of the forearm. Fascia is the name given to materials within the body that serve as wrapping, packaging, and insulation.[61] The biceps' main action is to bend (flex) the elbow. Because of its attachment to the fascia of the forearm, the biceps assists in supinating the forearm, or turning it from palms down to palms up. In balancing the flute, the left forearm is in a supinated position. Since the biceps extends all the way from the shoulder blade while it is assisting supination of the forearm (in a flexed position), a neutral position of the scapula would provide a better base of support for this action. By turning the trunk to the right and bringing the flute forward from the frontal plane of the body, the left shoulder is placed in a more neutral position, making it easier for the biceps to exert a force upon the forearm as it turns it outward.

Also important to note is that the insertion of the biceps' two tendons in the shoulder area. The tendon of the medial head of the biceps (nearer the center of the body) attaches to the tip of the coracoid process of the shoulder blade. This protrusion is on the underside of the shoulder blade; the pectoralis minor and coracobrachialis also have tendons that insert there. In the raised position of both arms in balancing the flute, the shoulder blades are slightly rotated out of their neutral position. Muscles that are attached

[61] Moore and Dalley, *Clinically Oriented Anatomy*, p. 16.

to them contract to stabilize the shoulder blades so that the arms can be held up against gravity. The pectoralis minor, as will be later seen in the chapter on breathing, is used to help slow down our exhalation. Therefore, we might infer that the coracobrachialis and the medial head of the biceps work a little harder to stabilize the shoulder blade while the pectoralis minor is slowly releasing its contraction during exhalation. The tendon of the lateral, or outside, head of the biceps, travels over the outside top of the humerus through a groove and then through the bursa of the shoulder joint. It too attaches to the shoulder blade, only this time at the upper edge.

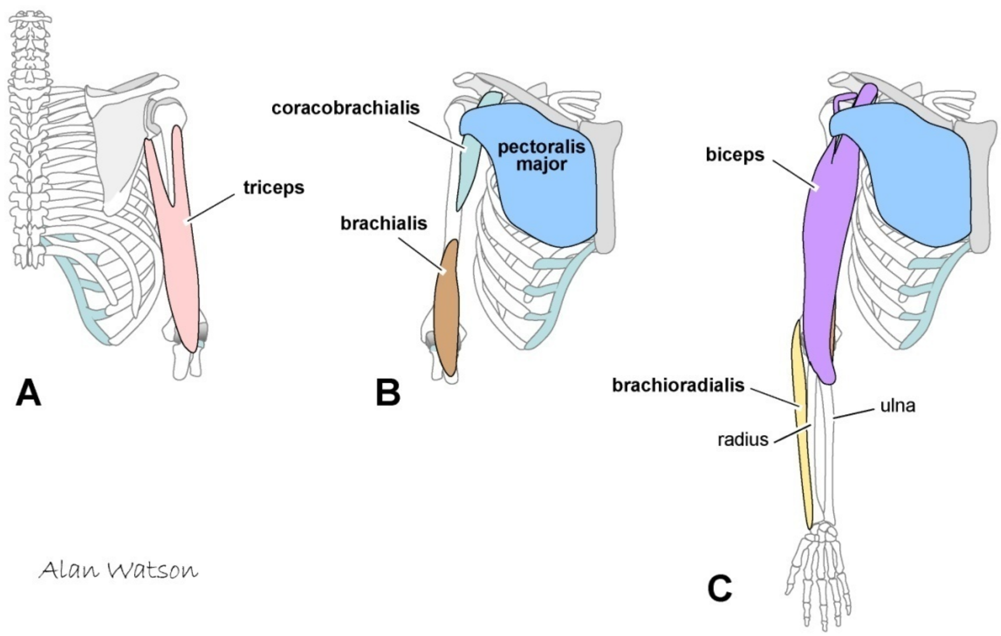


Illustration 21: Muscles of the upper arm. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 50, Scarecrow Press, Lanham, MD, 20706, with permission.

The upper extremity is innervated by the brachial plexus, a group of nerves exiting the spinal cord at the levels of C5-T1 (Illustration 22). The peripheral nerves (nerves outside of the spinal cord) in the upper limb that spring from this plexus are the axillary, musculocuntaneous, ulnar, median, and radial nerves. These nerves and accompanying blood vessels exit above the top of the rib cage and run under the pectoralis major muscle and clavicle on their way out to the arm. The axillary nerve serves the teres minor and deltoid while the musculocuntaneous nerves supplies neural connections for the muscles of the upper arm. Branches of the medial, radial, and ulnar nerves trail all the way down into our fingertips, supplying of the muscles of the forearm and hand. A compression of the brachial plexus and/or the arteries that also pass through this opening can lead to a disorder known as thoracic outlet syndrome. Nerve and blood supply to the arm is compromised, contributing to symptoms of pain and tingling. Of particular concern is the extreme adduction of the left arm, which could conceivably cause thoracis outlet syndrome symptoms. Treatment includes physical therapy to correct the muscle imbalances, pain medication, and in some cases, surgery. A stance that keeps the shoulders as close to neutral as possible and exercises to combat muscular imbalances will help avoid this condition.

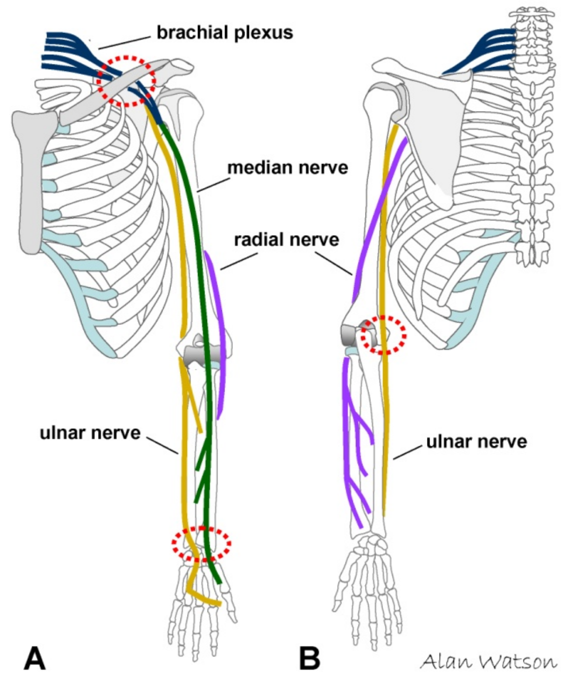


Illustration 22: Nerves of the arm and shoulder. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 63, Scarecrow Press, Lanham, MD, 20706, with permission.

As mentioned before, the position of ease includes relaxed shoulders and arms hanging down by the sides of the body with the palms facing inward. Any action that lifts the arms up and/or away from the body requires muscular contractions as the limb is moved against gravity. The shoulder acts as a stabilizer for the movements of the arm. If when holding up the flute the shoulder is raised, a chain of muscular contraction all the way to the spine takes place. The flute can be held with the arms in such a way that the shoulders remain down in a neutral position with a minimum of arm rotation. Many flutists find that when they keep their shoulders neutral, they are forced to tilt their head to the right in order to hold the flute. This position can be avoided by angling the embouchure plate of the flute on the lips. The angle of flute depends on the direction of the air stream as it hits the inner wall of embouchure hole. Although headjoint designers are reluctant to speak openly about the cut of their headjoints, behind-the-scenes, makers have confirmed that their cuts are asymmetrical. Visual inspection can detect the slight asymmetry of the opening. So there is no need to place the full bottom lip against the lip plate and blow straight across the embouchure hole. The asymmetrical embouchure hole is better served by an angled position of the lips. Much like the sweet spot of a tennis racket, each embouchure hole has its own sweet spot. An angled position of the lips is more likely to create a stream of air that hits the sweet spot. This spot can be found by blowing through a thin straw placed on the edge of the embouchure hole closest to the lips (Photo 12).[62]

Photo 12: Finding the sweet spot. Image by Dr. Valerie Watts.

As previously discussed, the left shoulder by necessity must come slightly forward so that the left arm can cross in front of the body as it holds the flute. To create more room and decrease the tight adduction (crossing over) of the left arm, the trunk and shoulder girdle should rotate to the right as a unit about 45 degrees. With this extra room

[62] George, *Flute Spa*.

for the left shoulder stabilized, the next problem is to create the same space for the other shoulder. In order to keep the right shoulder from elevating or from moving backwards in its accommodation of the flute, the instrument can be angled forward from the frontal plane to a fairly large degree (Photo 13).

Photo 13: Minimizing adduction of left arm. Image by Simon Hurst Photography.

The flute creates a 'pie wedge' [63] angle to the frontal plane of the body. This position remains the same whether sitting or standing and allows the right shoulder to remain in a relaxed, neutral position. It is not crunched back (retracted) in an effort to keep the flute in the frontal plane as it would be in the marching band posture. The right shoulder should not be drawn backwards for a flutist's healthy playing stance, nor should it be elevated in order to keep the lip plate parallel to the lip line.

[63] George, *Flute Spa.*

Every fall, flutists in marching bands are required to twist their upper backs, bringing their entire right arm and shoulder back behind the frontal plane of their bodies. The body of the flute must be straight across the flutist and in line with their fellow bandsmen. The left shoulder is in a position of extreme adduction. Flutist must be taught that this position is not the correct position for playing the flute; it is an adjustment to suit a particular activity.

The two photos on the following page dramatically demonstrate the effect of the standard marching band position upon the alignment of the spine. Photo 14 shows an highly exaggerated curve of the thoracic spine and a marked protrusion, or forward displacement, of the left shoulder blade. The spine moves in this fashion because segments of the trunk must rotate to the right as the right arm and shoulder are pulling the flute back into alignment with the frontal plane of the body. The left shoulder blade moves forward as the entire left arm is severely adducted, reaching for the flute all the way across the body. The cervical spine is more extended as evidenced by the lower placement of the flutist's bun. The right shoulder blade is more clearly seen because it is retracted (pulled toward the spine) and the muscles used to pull it into this position (rhomboids) are markedly contracted and bulging. Even though the preferred posture (Photo 15) of the flutist used here has a lower right shoulder than normal,[64] she is still in a much better alignment than Photo 14. The spine is straight and the neck is more relaxed. The shoulder blades are in a more neutral position with the flute forward and the end slanted downward.

[64] The model credits years of holding a school backpack as the cause of her slightly lower right shoulder.

Photo 14: Marching band position. Image by Simon Hurst Photography. Illustration by Jason McAlexander, Quail Springs Studio.

Photo 15: Balanced playing stance. Image by Simon Hurst Photography. Illustration by Jason McAlexander, Quail Springs Studio.

Michel Debost, flute professor at the Oberlin Conservatory, and Patricia George, a nationally-known flute pedagogue and author, devised a training position to teach and re-enforce this asymmetrical stance of the upper extremity while holding the flute. This "cross-hand technique" forces the flute into a position forward of the frontal plane with the appropriate amount of downward slope. The right hand grasps the flute at the barrel (the area of the middlejoint of the instrument where manufacturers typically put engraving) with the palm forward. The left hand is placed on the appropriate keys as usual and the flutist puts the lip plate under his/her chin. This position reduces the load on the left hand so that it can assume better finger positions on the keys. As stated before, the flute is forced forward and slightly downward because the right hand is on the barrel. Stress on the shoulders is eliminated. Additionally, the cross-hand position allows firm placement of the lip plate under the chin so that flutist can have good contact. Making use of harmonics, George has created a group of short songs that flutists can play in this left-handed position.[65]

[65] "Left-Handed Melodies," by Patricia George, are found in Appendix E.

Photo 16: Cross-hand technique. Image by Simon Hurst Photography.

The reason for reducing or eliminating any shoulder movement that deviates from neutral lies in part in the affect this movement has upon the spinal column. Turning the head involves vertebral rotation down to T4 and elevation of the arm involves vertebral rotation down to T6. Arm movements involve the musculature surrounding the scapula, which in turn is connected by muscles to the spine. While the shoulder girdle is designed to support the arm so that it can do detailed work at various heights, the prolonged efforts of flute performance and practice necessitate a restriction in the amount of work that the shoulder is called upon to do. Here, less is definitely better and results in minimized fatigue and better avoidance of injury.

Arms

The elbows and forearms serve the hand with mobility and stability. Elbows allow the hands to approach or extend away from the body, with the forearm fine-tuning the approach of the hand to an object. Fifteen muscles cross the elbow as it connects the shoulder to the wrist. The humerus is the bone of the upper arm while the forearm has two bones: the radius and the ulna. With the palms facing up, the radius is the long bone on the thumb-side or lateral aspect of the forearm. In this same position, the ulna is the long bone on the side of the little finger. The tip of the ulna nearest the shoulder is called the olecrannon, which forms the point of the elbow.

Muscles of the upper arm can be divided into flexors and extensors. The flexors, muscles that bend the elbow, include the biceps, brachialis, and the smaller coracobrachialis. The action of the biceps depends to a large extent upon whether the elbow is straight or bent. When the elbow is extended, the biceps flexes the shoulder and forearm as a unit. If the elbow is bent, the biceps works more as a supinator of the forearm. So in the left arm of the flutist, with the elbow bent slightly more than 90 degrees and the left hand in a position of supination, the biceps is the muscle doing the work. The brachialis is attached on either side of the elbow and contracts to bend it. The coracobrachialis is higher up on the arm, with one end attached to the middle of the humerus and the other connected to the coracoid process of the underside of the shoulder blade. Its actions include flexing and adducting the arm.

Extension of the forearm is handled by the triceps, so named because of the three separate heads or starting points of the muscle. Two of the heads of the triceps arise from the humerus, with the third coming from the lateral angle of the scapula. Thus both the biceps and triceps have origins in the shoulder blade. The opposite distal end of the triceps inserts upon the head of the ulna. The triceps is the only major muscle that extends the elbow, whereas three muscles assist the biceps in flexing the elbow.

The major nerves and blood vessels of the arms are located in the anterior compartment of the forearm where they are more padded and protected. The median nerve is the principle nerve of anterior compartment of the arm where the flexors are located. The radial nerve supplies all the nerves that go to the posterior or back side of the arm and forearm. These muscles are extensors and include the triceps. The ulnar nerve goes through the triceps on the back of arm and then passes posterior or behind the medial epicondyle of the humerus but medial to the olecrannon where it enters the forearm. When bumped, this is the "the funny bone" because of the shock wave of tingling felt when the ulnar nerve is hit.

The elbow is a loose hinge joint that enables flexion and extension; the ulna also slightly rotates on its own axis (Illustration 23). The radius has a large degree of rotation possible that provides for a variety of hand positions. When the hand goes from a supine or palm-forward position to a pronated or palm-backwards position, the radius and ulna cross over each other with the radius on top. When the motion ends in a palms-down position, it is called pronation. When it ends in a palms-up position, it is supination. The radius and ulna are roughly parallel to each other when the forearm is supinated. The proximal end of the radius, or the end nearest the elbow, is shaped like a thick ring. A ring-shaped ligament surrounds it and allows it to rotate during supination/pronation motions. The movement of these two bones can be seen more easily by marking the skin above the radius when in neutral position with three 'x's'; the more distal 'x' will move much more than the proximal one during pronation and supination.[66]

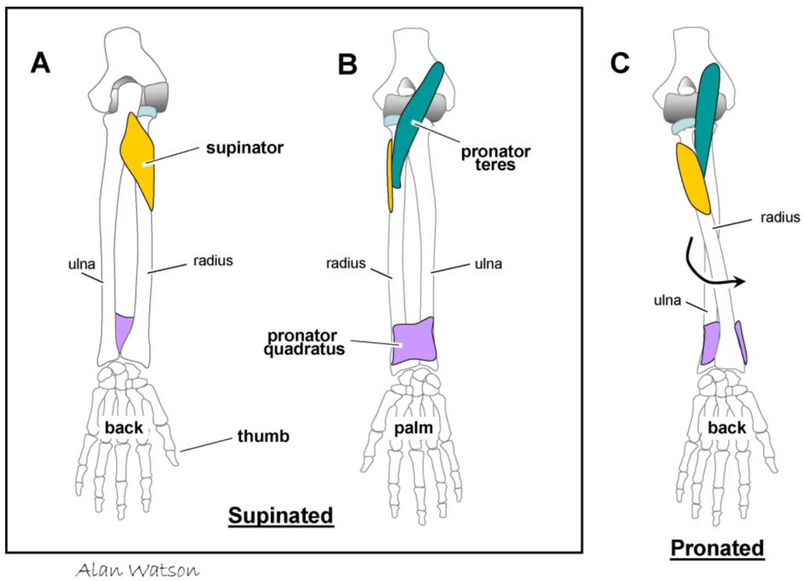


Illustration 23: Pronation and supination of the forearm. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 51, Scarecrow Press, Lanham, MD, 20706, with permission.

In piano pedagogy, the half-way point between these two extremes of pronation and supination is called the 'position of function.' The arch of the hand is evident; the joints of the fingers are all slightly bent and the thumb is slightly opposed. Scientific experiments show that a wrist position with a small degree of pronation (palms downward) has the least amount of pressure in the carpel tunnel area.[67] Movement in the flexion/extension planes causes the most increase in the pressure within the carpal tunnel.

[66] A method devised by Barbara Conable of Andover Educators.

[67] R. Werner, J. Armstrong, C. Bir, and M. Aylard. "Intracarpal canal pressures: the role of finger, hand, wrist and forearm position." *Clinical Biomechanics* 12:1 (1997), pp. 44-51.

In the medical community the functional position of the wrist is similar, but the wrist is held in slight extension and ulnar deviation. The wrist is halfway between supination and pronation, the fingers are all slightly bent and the thumb slightly opposed. As the hand and forearm pronate or supinate, the pressure in the carpel tunnel increases. Therefore, pronation of the forearm should be minimized in order to keep the muscles and vessels supplying them in the most neutral and relaxed position. In placing the right hand on the flute, begin with a fist, in order to obtain a natural amount of wrist extension; the explanation for this will follow shortly. Place the right little finger on the E-flat/D-sharp key, then the ring finger, middle finger, and index fingers.[68] By doing so in this order, the forearm will be pronated the least amount possible, allowing as much space between the distal ends of the radius and ulna as possible. This method is also helpful for beginner flutists; it is easy to see where you place your fingers if you start from the keys at the bottom of the flute. If the fingers of the right hand are slanted toward the right or left, this may indicate that the wrist has been pronated or supinated too much. As comfort allows, the angle of the fingers of the right hand to the flute should be as perpendicular as possible.

The left hand of the flutist supinates during the balancing of the instrument. In order to limit the degree of supination, the left hand should be placed under the flute, not alongside it. In this position, the palm of the left hand faces the end of the flute and is less supinated than it would be if the palm was more parallel to the flute. In this position, the fulcrum of the flute rests atop the 2nd metacarpal, much like the middle of a see-saw. This small bone is easily felt on the backside of the hand directly in line with the index finger. In this posture, it is functioning as a natural anatomical crutch for the flute; the use of the

[68] Michel Debost and Patricia George.

term referencing the crutch Theobald Boehm designed for some of his flutes in the first half of the 19th century (Photo 17).

Photo 17: Placement of fulcrum on top of 2nd metacarpal. Image by Dr. Valerie Watts.

In playing the flute, the prolonged flexion of the elbows is usually not much of a problem, but while playing the piccolo the degree of flexion is much greater. The elbow flexors can experience fatigue and the various blood vessels and nerves that traverse the arm can be compressed at the elbow where the arm bends. The right arm is more flexed than the left and frequent stretches during practice and/or performing are a simple way to avoid any physical problems. Simply let the arm hang down straight for a minute or so.

Photo 18: Increased elbow flexion in piccolo stance. Image by Simon Hurst Photography.

Wrist Complex

The wrist is one of the most complicated joint complexes in the body and exhibits a high degree of variance between people. Subtle variations between individuals can produce differences in how a given function occurs; a fact that has important consequences for flutists.

At the wrist, the radius and ulna, bones of the forearm, meet the carpals, eight cube-shaped bones. The motions of the wrist are up and down (flexion and extension) and a sideways motion termed deviation. During ulnar deviation, the hand angles toward the ulnar side or little finger. In radial deviation, the hand moves toward the radial, or thumb side (Illustration 24). The same muscles that flex and extend the wrist, pair up differently to deviate it to the right or left. The average amount of flexion normal for the wrist is 65-85 degrees; the amount of extension is 60-85 degrees. Ulnar deviation is normal 20-45 degrees and radial deviation 15-21 degrees.[69]

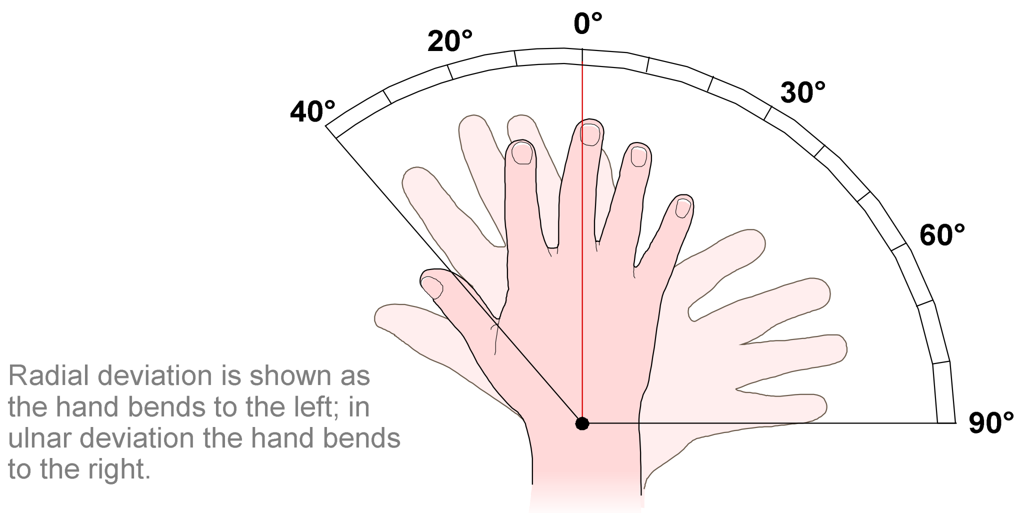


Illustration 24: Ulnar and radial deviation of the wrist.

The wrist itself is not thought of as a place for muscles, yet the tendons of many muscles that control the hand travel through it. The forearm muscles serve the hand by providing a stable base that is flexible enough to allow the muscles of the long fingers to create small controlled movements. Blood vessels, nerves, and tendons enter into the hand after they cross the wrist. The carpel tunnel is the space in the wrist that houses these tendons and vessels. It is surrounded by bone on three sides and by the transverse carpal ligament on the remaining side (palmar). Nine structures pass through this small area: the median nerve, tendons of the flexor policis longus and the flexor carpi radialis, and the multiple tendons of the flexor digitorum profundus and the flexor digitorum superficialis. Except for the median nerve, all the structures that pass through the carpal

[69] Levangie and Norkin, *Joint Structure & Function*, p. 306.

tunnel are tendons to hand and finger muscles. These are enclosed in sheaths that are designed to reduce friction. If overused, the sheaths and their tendons can become inflamed. Repeated injury can cause the tendons and sheaths to thicken, causing crowding and impingement of the median nerve – carpal tunnel syndrome.

As previously stated, the wrist is in neutral position when it is neither flexed nor extended. But the more ergonomic functional position with 30 degrees of extension and 10 degrees of ulnar deviation provides a better mechanical advantage for hand and finger action.[70] The correct amount of wrist extension can be approximated by making a gentle fist and laying the forearm and hand down on a table top (Photo 19). When the hand is raised from this position without moving the wrist, the thumb continues the line of the forearm and the back of the hand (giving it a little ulnar deviation), and the wrist is at a small angle to the forearm (wrist extension).

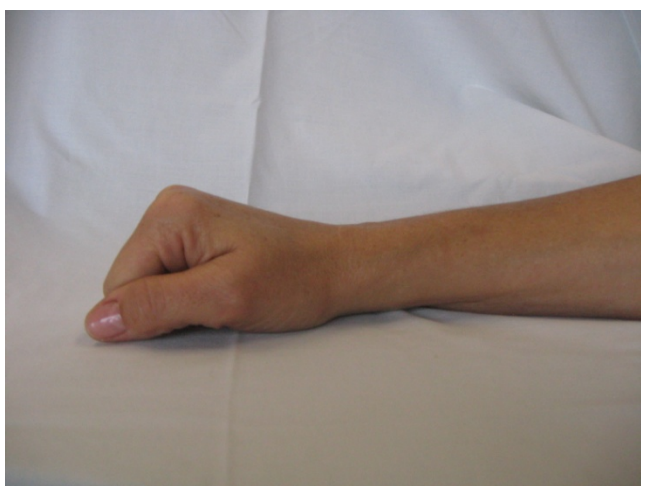


Photo 19: Finding functional amount of wrist extension. Image by Dr. Valerie Watts.

[70] Levangie and Norkin, *Joint Structure & Function*, p. 314.

For the right hand of the flutist, the flutist must try to assume a position as close to the functional wrist position as possible. The problem with the Rockstro position, modified or not, is that it requires the right wrist to be either in a neutral or zero degree position, or flexed to some degree. Neither the neutral nor the flexed position of the wrist place the hand in an ideal set-up to accomplish the finely-controlled repetitive actions required of flutists. The medial nerve and the flexors tendons of the forearm are pulled against the flexor retinaculum and movements result in more friction of the tendons within their sheaths. In the true Rockstro position, additional anatomical accommodations in the shoulder and arm are required to bring the right hand over the flute so that the fingers can reach the keys. A kinetic chain of muscular contractions all the way back to the shoulder girdle and the vertebral column are required to support the Rockstro hand position. Added to a tilted cervical spine, the results are problematic at best; disastrous at worst.

Photo 20: Rockstro position. Image by Dr. Valerie Watts.

When considering the position of the left wrist in flutists, the variability of the length of the flutist's arm is important. The left wrist must either be in the functional position (up to 35 degrees of extension) or extended even more to help support the flute. In young flutists who have not yet finished growing, extension in the left wrist might be less, but the amount of extension may increase with growth. A curved headjoint solves many of the problems flutists of small stature experience.

A concern for more physically mature (adult) flutists would be the possibilities of injury with excessive extension of the left wrist. One explanation may be that many flutists who keep their left wrists straight lift their left arm out away from the body more than flutists who extend their left wrist. Since approximately 30 degrees of extension is the functional position for the wrist, assuming a position of slightly more than that shouldn't be a problem. With the left wrist extending more, the left arm need not be elevated, lessening the load on the left shoulder and arm. Another positive result of an extended left wrist is the improved position of the forearm extensor tendons. With a straight wrist, the extensor tendons on the ulnar side of the wrist are stretched in order to adequately reach the keys of the flute. But with an extended wrist, the extensor tendons aren't stretched; they are in a more mechanically advantage position to do their work.

Opinions on this issue are diverse. Michel Debost, in his work, *The Simple Flute*, recommends a small angle found by pointing the nose to the crease in left elbow and gently touching the right earlobe with the left hand.[71] He espouses a straight left wrist as well as keeping the left elbow close to the chest. Debost explains that this set-up helps direct the airstream properly. But in this position, the left hand cannot come under the flute; it must come along side it as the left index finger is used to push the embouchure plate into the chin. Pressure can occur on the lateral (thumb) side of the left first index finger, frequently causing impingement of the palmar digital branch of the median nerve. Because of this disorder's association with flutists, it is referred to as the flutist's neuropathy in scientific literature. Excess pressure here can lead to loss of sensation, muscle weakness, and other problems associated with nerve entrapment. Surgical intervention may be required.

With the wrist extended, the left hand can come under the flute and act as a fulcrum.[72] The approximate middle of the flute sits upon the base of the second metacarpal and is balanced much like a see-saw. The right thumb and chin serve as balance points that also provide opposing horizontal adjustments as the flute sits cradled

[71] Michel Debost, *The Simple Flute* (Oxford University Press, 2002), pp. 103-4.
[72] Pat George, *Flute Spa*.

on the left hand. Excessive pressure is never required. This ‘cuddling’ of the left hand around the flute allows ample room for the fingers to reach their designated keys (Photo 17).

Hands

A good set-up of the flutist gets the hands in their optimum placement for good playing technique. With the shoulder and the arm optimally positioned, the hand can quickly act upon the signals sent to it by the brain. Any loss of function in the shoulder or the arm will result in a decrease of function in the hand. For example, weak and stretched-out muscles around the shoulder area will hamper quality movement of the fingers. Assuming a healthy shoulder and arm set-up, let us now investigate the bones of and the muscles leading to the hand.

Most of the bones of the hand are relatively easy to palpate or feel (Illustration 25). The only exceptions are the carpal bones of the wrist. These irregular cube-shaped bones are organized into two rows with four carpals in each row. They give the wrist and hand flexibility as the two rows glide upon each other and the individual carpal bones glide each upon their neighbor. Whereas the carpals are difficult to feel, the metacarpals, which form the palm of the hand, are easily palpated on the back side of the hand. An intricate semi-rigid framework of ligaments connects the carpals and metacarpals. The only separation in this framework is between the thumb, formed by one metacarpal, and the palm, which is formed by the other four. Each digit has two or three bones called phalanges which extend from each metacarpal. The thumb has two phalanges while the other four fingers each have a proximal, middle, and distal phalanx.

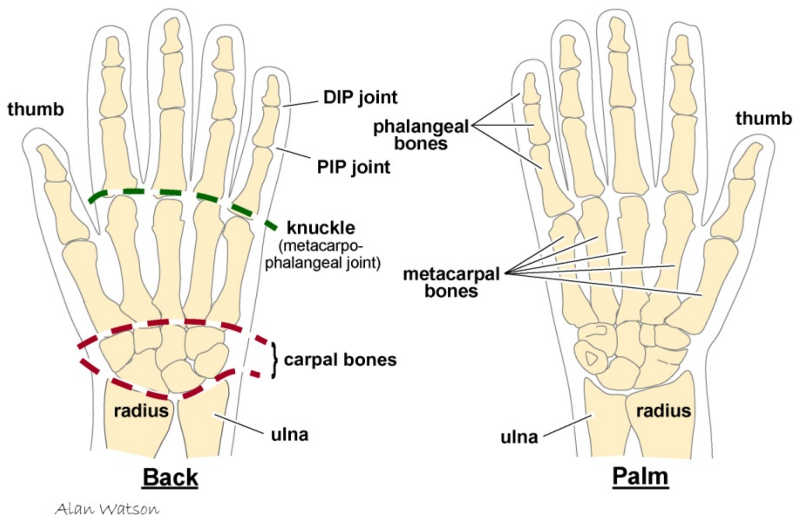


Illustration 25: Bones of the hand. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 52, Scarecrow Press, Lanham, MD, 20706, with permission.

Because of the importance of the fingers in playing a musical instrument, the abbreviations for the names of the finger joints are worth learning. The knuckles of the fingers are metacarpophalangeal joints (MP). At this joint, the fingers can flex/extend, abduct/adduct, and circumduct, or move in a large circle. The next joints on the finger are the proximal interphalangeal joint (PIP) followed by the distal interphalangeal joint (DIP). The thumb only has one interphalangeal joint (IP) since it has only two phalanges.

Most of the muscles in the forearm extend into and control the hand through long tendons that pass through the wrist. Muscles on the inside of the forearm bend or flex the wrist and fingers while the muscles on the back of the forearm extend the wrist. As a group, they have twice the bulk and strength of the muscles on the opposite or backside of the forearm. These two muscle groups are mechanically off-balanced for functional reasons, as more strength is required for grasping actions in front of the body than any action in extension.

The two forearm muscles that flex the fingers are the flexor digitorum superficialis (FDS) and the flexor digitorum profundus (FDP) (Illustration 26). These muscles each begin as a single unit; they then divide into separate muscles leading to the tendons that attach to each of the four fingers, allowing for varying degrees of independent control. Neither the FDS nor the FDP has connections to the thumb. The FDS is more superficial and arises from the ulnar side of the humerus, as well as from the radius and the ulna. The bulk of the muscle lies in the forearm; then the tendons travel through the wrist, palm, and fingers to flex the PIP joints. The ends of the tendons of the FDS split into two at the PIP joint and then insert onto the sides of the middle bone of each finger. In addition to bending the PIP joint, the FDS also helps with bending the knuckles (flexing the MPs). If the FDS tendon is absent in a finger, which is fairly common in normal hands, PIP *extension* rather than flexion can occur along with DIP flexion, an action commonly referred to as hyperextension. The FDP is the deeper and more active of the two muscles and can flex all three joints of each finger, reaching all the way to the end of the fingertips. It arises from the ulna near the elbow and lies under the FDS. Like the FDS, the FDP splits slightly above the wrist into four tendons that each go down to a finger, this time inserting on the last bone of the fingertip. The portion of the FDP that goes to the index finger is more clearly separated giving that finger more independent control. The tendon of the FDP emerges from where the FDS's tendon splits to attach to the last bone of the finger. It works with delicate movements while the FDS is recruited when more force is needed. An easy way to remember the difference between these two muscles is that the deeper the muscle, the more distal the action. Therefore the muscles that control the finger tips are deep flexors of the fingers (Illustration 26A).

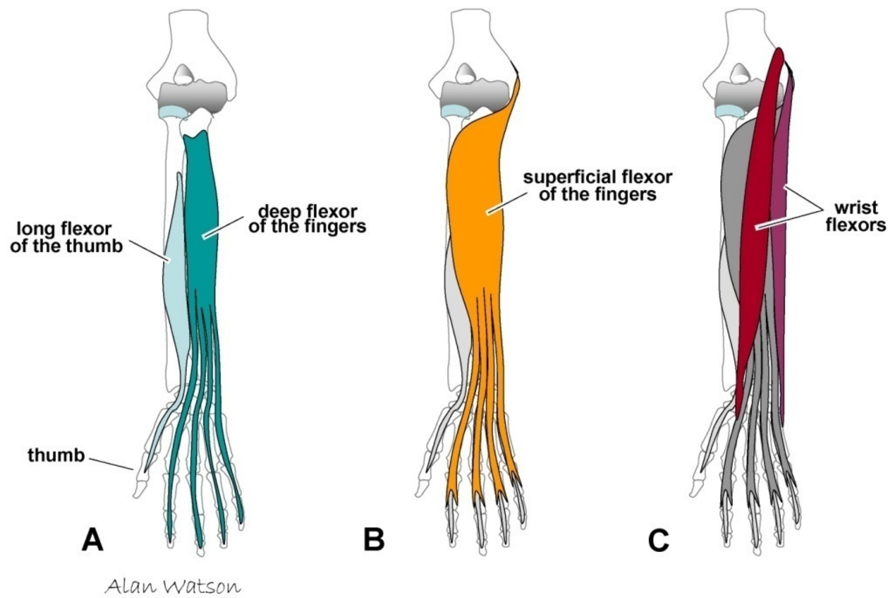


Illustration 26: Muscles that flex the fingers. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 53, Scarecrow Press, Lanham, MD, 20706, with permission.

In addition to these muscles, this anterior compartment of the forearm also contains muscles that pronate the hand. To recap, this action occurs when the hand is brought to a palms-down position as the radius crosses over the ulna. Muscles which accomplish this action are the pronator quadratus which lies toward the end of the forearm, and the pronator teres which lies near the elbow. The opposing action of supination, moving the hand to a palms-up position, is accomplished by the supinator with assistance by the biceps (Illustration 20).

For the flutist, power in finger movement is not needed, so contraction of the FDS is unnecessary and should be avoided. The difference can be felt by gently and then forcefully tapping the fingertips on a table top; use the opposite hand to feel the underside of the forearm. Pressing down on keys with excess force not only makes muscles work harder; it also calls unnecessary muscles to action. A second issue comes into play as both of these muscles gently assist in wrist flexion because they cross the wrist on their way to the fingers. To avoid flexion of the wrist, muscles opposing the FDS and FDP, called antagonistic muscles, must contract to counteract the force of the flexors. The resulting tension may eventually lead to problems such as tendinitis.

Extension or straightening of the fingers is accomplished by a single layer of muscles and includes the extensor digitorum (ED), the extensor indicis, (EI) and the extensor digiti minimi (EDM) (Illustration 27). The shape of the ED is similar to the FDS and FDP; it begins as one muscle that is connected to the thumb side of the humerus just above the elbow and then separates into four tendons that extend down into the hand. After the tendons from the ED cross the wrist, they fan out as they near the individual fingers. Before they reach the MP joints, interconnections exist between these tendons that limit independent extension of the fingers. For example, if any one finger is fully flexed, the other fingers cannot fully extend. Fibrous bands link the adjacent tendons together in a variety of patterns and at different levels. In addition, some tendons divide into two parts at the knuckle, sending one each into adjacent fingers. In order for one finger to extend, the adjacent fingers that are ‘enslaved’ require some force to keep them from extending as well. Opposing flexor muscles, such as the FDS and FDP, are then activated to keep those fingers down.

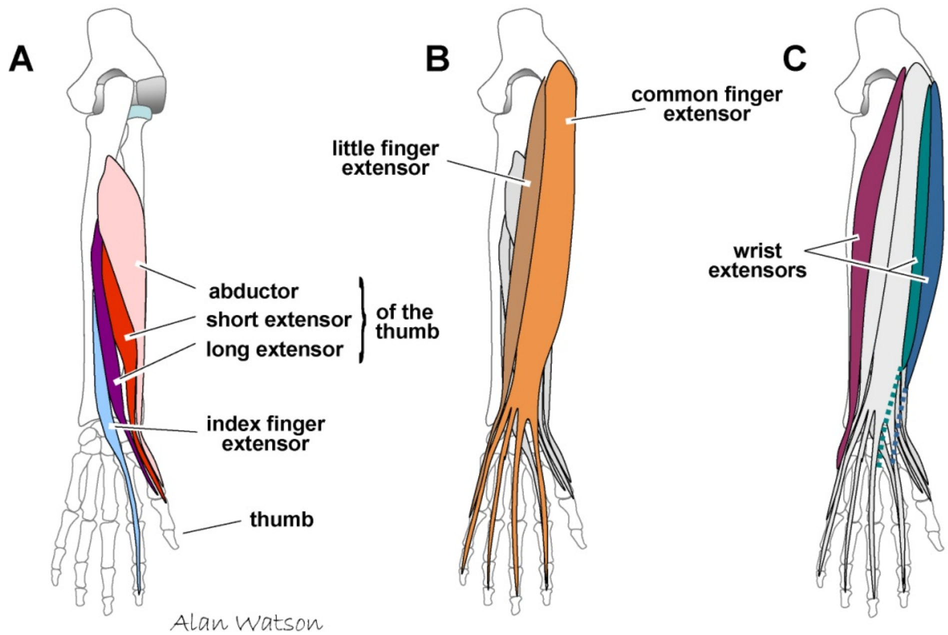


Illustration 27: Muscles that extend the fingers. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 55, Scarecrow Press, Lanham, MD, 20706, with permission.

Once the tendons from the ED reach the fingers, they flatten just beyond the MP joints into an extensor expansion (Illustration 28). This visor-like hood is a triangular-shaped flat sheet that wraps around the back and sides of each knuckle and its finger. It holds the ED tendon in the center over the MP joint and is anchored by ligaments on its sides. The ED acts to extend the fingers at the MP joint and assists with extension at the PIP joint.

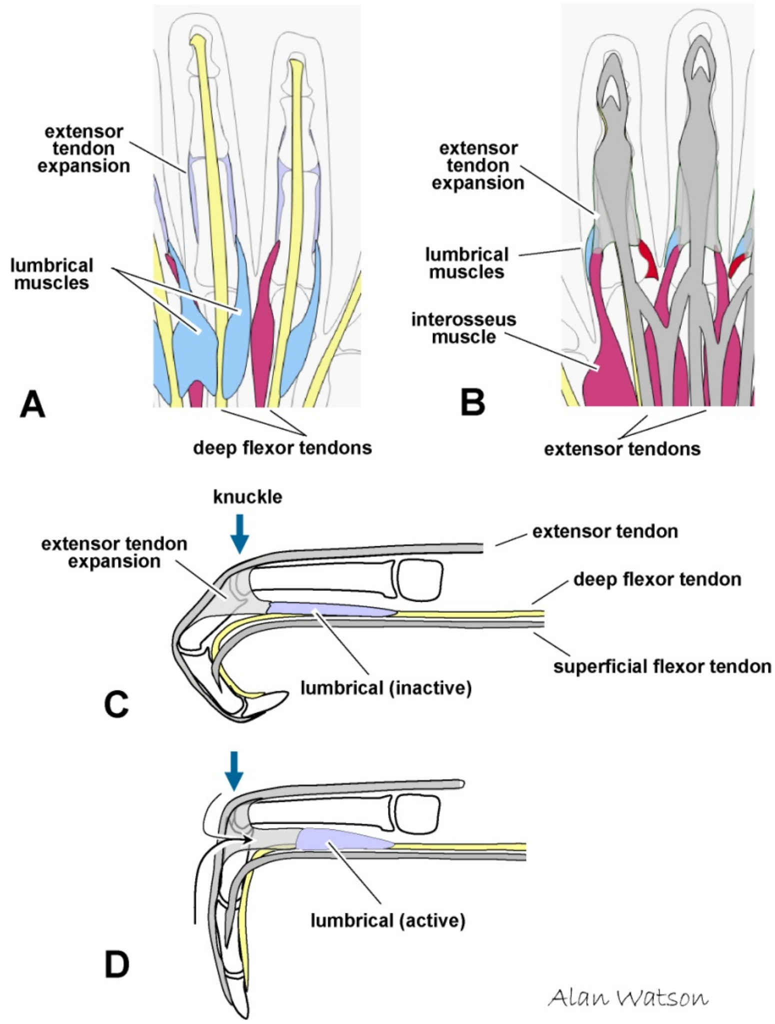


Illustration 28: The extensor mechanism and hand muscles. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 58, Scarecrow Press, Lanham, MD, 20706, with permission.

The EI straightens the index finger while the EDM straightens the little finger. Both of these muscles begin at this same location on the humerus as the ED. But because these two muscles are separate from the ED, they provide more independent control to the index and little finger, off-setting the enslavement caused by the intertendinous connections in the ED.

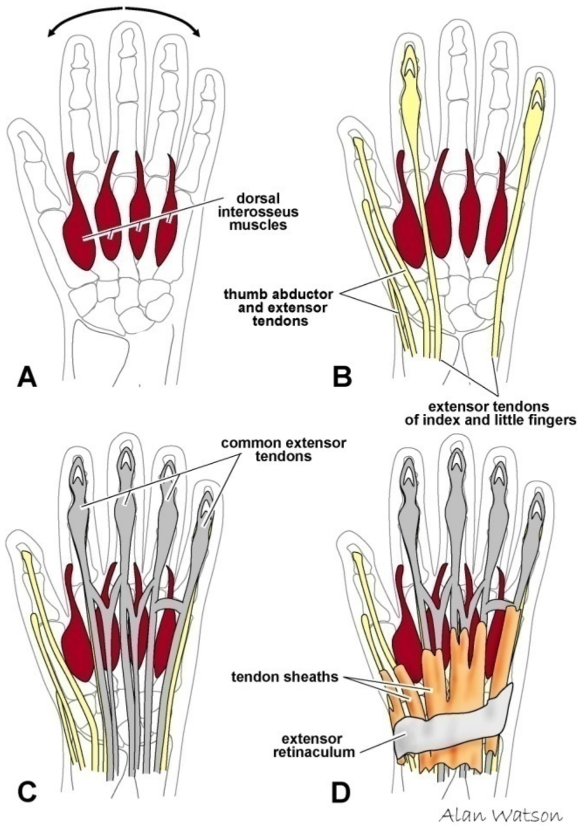


Illustration 29: Muscles and tendons on back side of the hand. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 56, Scarecrow Press, Lanham, MD, 20706, with permission.

Another group of muscles whose tendons insert onto the extensor expansion are the lumbricals (Illustration 29). These worm-shaped muscles are the only muscles in the body that insert onto another tendon instead of a bone. Unlike the FDS, FDP or ED, the four lumbricals of each hand are independent muscles with no connection to each other. When contracting, they bend the knuckles and straighten the fingers. Another group of muscles that are located within the hand are the interossei (Illustrations 29 and 30). Similar in shape to the lumbricals, the interossei are grouped in two layers. The layer of interossei nearer the back of the hand spreads the fingers apart; the layer on the palmar side brings the fingers back together. Along with the lumbricals, the tendons of the interossei insert into the sides of the extensor expansion of the fingers.

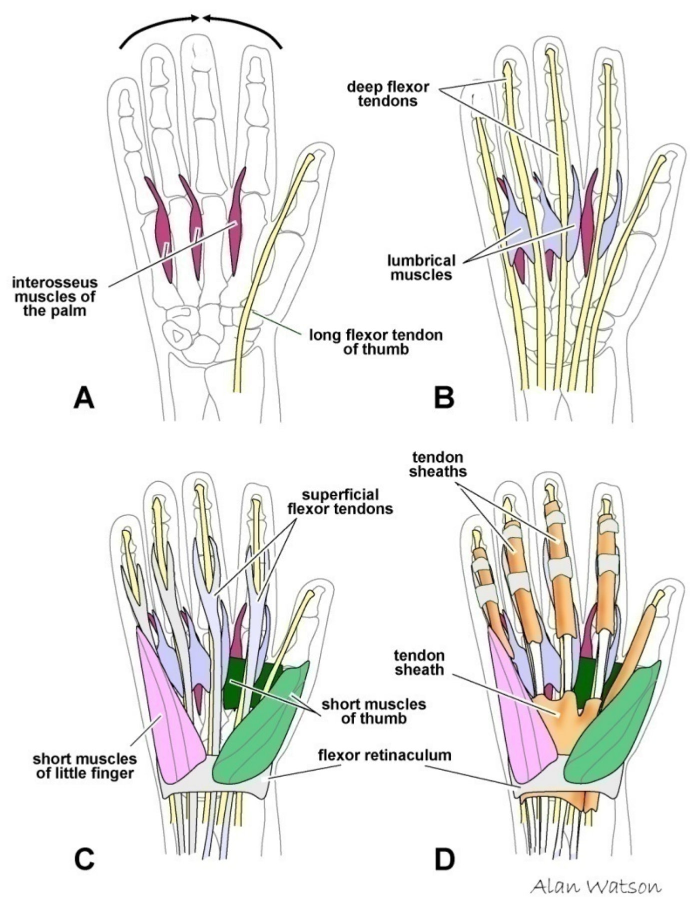


Illustration 30: Muscles and tendon of the palmar side of the hand. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 54, Scarecrow Press, Lanham, MD, 20706, with permission.

Patricia George recommends 'playing from the knuckles,' i.e., the MP joints. Let us investigate why this might be an easy, relaxing and healthy way of moving the fingers while playing the flute. In the necessary hand position of holding the flute, all digits except the left index finger can move from the MP joint. The left index finger must move from the PIP joint since the MP joint is involved in supporting the flute and must remain fixed. The lumbricals flex the MPs along with help from the FDP and the FDS. If only the IP joints bend, the MP joint must be stabilized, requiring a simultaneous contraction of the lumbricals and the finger extensors. A few minutes of sustaining this contraction and a hand cramp results. When moving the entire finger at the MP joint, less work is necessary. A small co-contraction of the finger flexors and extensors is required to keep the PIP and DIP joints from extending when the fingers touch the keys. If the flutist presses down hard, a stronger response from these muscles will have to occur to avoid the collapsing of a joint. Less work and ease of play is aided by a light touch as that will avoid the recruitment of unnecessary muscles.

James Galway recommends that flutists keep their fingertips of the right hand level with the knuckles while playing the flute. This idea is supported by functional anatomy as well. If the fingertips are below the MP joints, the fingers are flexed significantly more than what is found in the functional position. Even more effort is required to flex them more so they touch the keys. If the fingertips are above the MP joints, the forearm extensors are probably contracting to straighten the fingers somewhat. Keeping each joint close to its functional position allows it to operate within its best mechanical advantage. In this case, it means keeping the MP joint at about 30 degrees of flexion.

In addition to the compartments that contain the lumbricals and interossei, other muscles within the palm of the hand are also found in three other compartments. The thenar eminence, a fleshy mass on the thumb-side of the palm of the hand houses muscles that operate the thumb while the hypothenar eminence on the other side of the palm contains muscles that control the little finger. The adductor compartment contains the adductor pollicis, a muscle that brings the thumb alongside to the palm of the hand.

As distinct from the other digits, the thumb has a variety of actions and greater freedom of movement. It is important not only for precise movements, but also for gripping. Muscles controlling the thumb are located both in the forearm and in the thenar eminence, more commonly called the thumb pad. The thumb has a single flexor, the flexor pollicis longus, which lies in the forearm compartment alongside the FDP. On the back of the forearm, two extensors and one abductor draw the thumb away from the hand. The tendons from these muscles are easy to see between the thumb and forearm on the thumb-side of the back of the hand. When the thumb is held in abducted position, the more forward extensor pollicus longus tendon and the tendons of the abductor pollicis longus and extensor pollicis brevis create a slight indentation between them called the 'anatomical snuff box.' Gentlemen of earlier times would place a pinch of snuff in this spot prior to sniffing. The thenar eminence contains the short muscles of the thumb which include a flexor, an abductor, an adductor, and an opponens. The opponens pollicis draws the thumb to the center of the palm and rotates it so that the thumb pad faces the palm. In placing the right hand on the body of the flute, the thumb uses this action as it comes underneath the right hand fingers. The left hand thumb also uses this muscle as it rests on the B/B-flat keys.

Like the thumb, the little finger is supplied with short muscles within the palm to give it more independence. Muscles lying within the hypothenar eminence include an abductor, a flexor, and an opponens. The flutist makes frequent use of the abductor and the flexor of both little fingers as they operate multiple keys. The right hand little finger in particular is called upon to operate from three to five keys. In a similar way to the opponens muscle of the thumb, the little finger opponens muscle brings the little finger closer to the thumb and rotates it so that its pad can approach the thumb pad.

In holding and balancing a flute, flutists have frequently been observed to shake out one hand or the other during a break in the playing. The muscle aches and cramps in the hand probably result from the small muscles of the hand struggling to hold the flute and finger it. The flute can be most effectively balanced on the head of the second left metacarpal with the right thumb and lip providing counter-pressure to each. This three-point system almost eliminates the need for the small muscles of the hand to do any work in balancing the flute. The left hand is under the flute, so no intrinsic hand muscles are required to keep it there; the arm as a whole is supporting the flute. The right thumb is pushing forward and up slightly. To get it in the most balanced position, the flutist can imagine reaching from the tip of the right thumb to the tip of the third or fourth digit; the thumb should provide a pivot point upon which the right hand can rotate. To keep the IP joint of the right thumb straight, a co-contraction of its flexors and extensors must contract, but the actual work of pushing the flute forward and up is done by the right shoulder flexors and abductors. The connection of these muscles to the neck demonstrates the idea of a kinetic chain – a small action of the right thumb leads all the way to the neck.

Positioning the fingers on the keys however would involve the lumbricals, interossei, and short muscles of the thumb. Hands come in many sizes but flutes do not. The keys will always be the same distance apart so some fingers have to stretch more than others in order to cover the holes. Changes in fingering are accomplished by contractions of the finger flexors and extensors found in the forearm and the lumbricals in the hand. The interossei of the hand do more to position the fingers on the keys, not move them up and down. When hands are too small, fingers too short or little, or joints are hyper-extended, adaptations are in order. Young players can spend more time in the cross-hand position or work with their headjoints. They and adult players can benefit from the variety of devices that have been designed to make the flute easier to hold.

The innervations of the arm is provided by the median, radial, and ulnar nerves as they course through the upper and lower arm, branching out into the hand and fingers.[73] The radial nerve spirals around the back of the arm, through the triceps, around the outside of the elbow and then to the back of the forearm where it supplies the extensors of the elbow, wrist, and hand. It is the least injured nerve by musicians.[74]

The median nerve runs down the front of the arm under the biceps, in front of the elbow, and down into the forearm in between the two parts of the pronator teres muscle. When this muscle contracts, as it does when the wrist turns so that the palms are down, the median nerve can be compressed. The flexor muscles of this anterior compartment of the arm protect it on its way to the wrist. In the forearm, the median nerve supplies the flexor muscles of the wrist, fingers, and thumb. The median nerve then travels through the carpel tunnel on its way to the hand. The carpel tunnel is the most common site of entrapment for the median nerve and a major problem for musicians. It is the only nerve that passes through the tunnel; it supplies the short muscles of the thumb and the lumbricals of the index and middle finger. It provides sensation to the skin of palmar side of the thumb, the index and middle finger, and half the ring finger.

[73] See Illustration 19.
[74] Watson*, Biology of Musical Performance*, pp. 64-65.

Like the median nerve, the ulnar nerve runs down the upper arm under its muscles, but it instead of going in front of the elbow as the median nerve does, the ulnar nerve travels around the medial end of the humerus through the cubital tunnel (Illustration 22). Bounded by the olecrannon (what we call our ‘elbow’) and the humerus, the ulnar nerve is close to the surface at this point and is easily bumped, resulting in the name “funny bone.” In the forearm, the ulnar nerve runs between two heads of one of the wrist flexors. It supplies one of the wrist flexors and the deep finger flexors for the 4^{th} and 5^{th} fingers. It then passes through the wrist in a depression between two of the carpel bones (pisiform and the hook of the hamate) called Guyon’s canal. Here it is vulnerable to compression in a similar fashion as the median nerve has in the carpel tunnel. The ulnar nerve supplies most of the small muscles of the hand included the short muscles to the little finger, all the interossei, the lumbricals to the fourth and little fingers, and the thumb adductor. It provides sensation to the skin of the little finger and the adjacent side of the fourth finger.

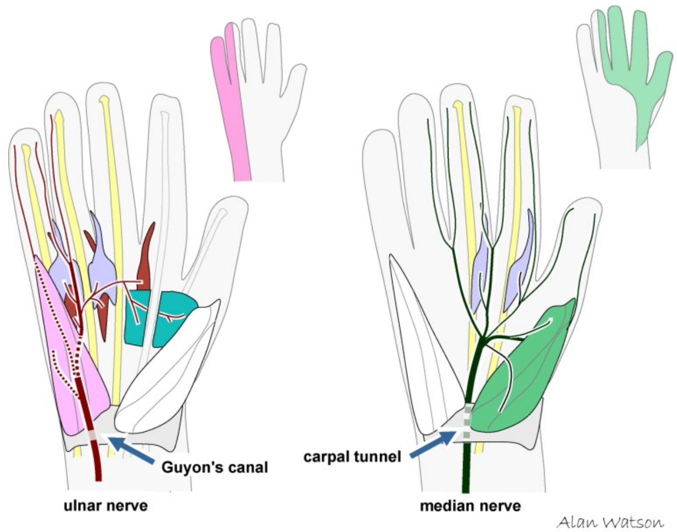


Illustration 31: Innervation of the hand. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 64, Scarecrow Press, Lanham, MD, 20706, with permission.

As first mentioned in the previous section covering the wrist, the nerves and tendons of the forearm must pass through the wrist on their way to the hand. In order to keep them lying flat against the wrist when they move, a strong band of tissue called retinacula surrounds the wrist. A similar set of retinacula binds the tendons of each finger. At the base of the palm, a large number of tendons and nerves pass through the carpal tunnel. A total of nine flexor tendons pass through the carpal tunnel. These tendons include the four tendons of the flexor digitorum profundus, four tendons of the flexor digitorum superficialis, one tendon of the flexor pollicis longus and one tendon of the flexor carpi radialis. Each tendon has its own narrow channel and is surrounded by a fluid-filled double-sided sheath that gives it freer movement. If a muscle and its tendon is overused, or stressed due to an awkward position or excess tension, the tendon and/or its sheath can become swollen. The inflammation of these structures is called tenosinovitis. Swelling of these tissues and the resultant loss of space causes an increase in friction, which causes more swelling - a vicious cycle which may lead to carpel tunnel syndrome. A simple way to avoid this condition is to keep the tendons and the median nerve in the tunnel by slightly extending the wrist during flute playing. A position of wrist flexion pulls the tendons against the retinaculum; this should be avoided.

Any or all of the fingers of the hand may exhibit hypermobility or double-jointedness. In this condition, the range of motion of a joint extends beyond that which is considered normal. An example of this 'trick' is when the last finger joint bends while the second-to-last joint is still straight. Each finger has a complicated extensor mechanism composed of tendons, ligaments and muscles. On the sides of each finger are oblique retinacular ligaments (ORLs) which are part of this mechanism. In normal flexion of the finger, the DIP and PIP joints flex along with the MP joints. But this can be overridden by the position of the ORLs. If they lie above the axis of motion of the PIP joint, these ligaments passively allow extension of the PIP joint. Tension in these ligaments is caused by the flexion of the DIP joint; to avoid it, the extensor tension at the PIP joint must be relaxed before the FDP muscle can effectively flex that joint.

Many flutists of all ages experience the collapse of one of the IP joints during playing, most frequently the right little finger. A common occurrence, whether or not to eliminate this action has been debated. But in order to achieve evenness of finger action, this extra 'waggle' can add unnecessary time while changing from one fingering to the next. Gustav Scheck addresses this issue in his method book in the chapter on technique and rhythm.[75] In his discussion on technique he calculates how fast the fingers must move for different note values at different speeds. When playing in 4/4 meter with a

[75] Gustav Scheck, *The Flute and its Music,* trans. by Christine Gustafson (Austin: University of Texas, 1993), pp. 330-331.

quarter note equal to 120 mm, the quarter note has a length of ½ a second. Sixteenth notes would then have a length of 1/16th of a second. Normal fingering changes take a fraction of a second, estimated at 1/25th – 1/32nd of a second. The more highly developed players can reduce the amount of time taken to make the fingering changes, but an extra waggle of an IP joint would lengthen this lag time significantly. So for a developing player, half of the time of a sixteenth note is used up in finger changing *already;* there is no time for any extraneous finger movements.

Other problems in joint hypermobility also must be considered. Playing with any joint in the hyperextended position places a higher work load on the muscles attached to it. A hyperextended joint leads to tension and a stronger grasp of the flute instead of a gentle, balancing of the instrument. Collapsed joints in the fingers also need to be avoided in order to develop a smooth technique as mentioned in the last paragraph.

When repertoire demands excessive use of the footjoint by the little finger, the thumb can be moved down towards the footjoint in order to shift the center of gravity of the hand away from the fifth digit. The little finger is therefore less likely to be bearing a large part of the load of balancing the flute, even though it never should, and will be freer in its movements. Relieving the little finger of its load allows the flutist to keep it in a more functional position of slight flexion. If the flutist seems to not have much independent control of the right little finger, slight wrist motions could help during the fingering changes of the keys on the footjoint. As the fourth finger might then be more likely to come off the hole of its key, placing a plug in that key hole might be a good alternative.

After this long and complicated discussion of the arms and hands of the flutist, the next step is to see what effect the alignment of the flute's joints has upon the human body.

Methods of Flute Alignment

Methods of aligning the headjoint of the flute can be divided into three camps: traditional, Rockstro, and modified Rockstro.[76] The traditional or classic method requires the embouchure hole in the headjoint to be lined up with the center of the keys of the middlejoint, and usually with the rod of the footjoint as well. The surface of the keys remains flat; they are not tilted forward or backward in any way. This simple alignment is the standard assembling instruction that the majority of American flutists have been taught. Important flutists who advocate this method include William Kincaid (1895-1967),[77] Frances Blaisdell (1912-2009), Michel Debost,[78] Nancy Toff,[79] and Theobald Boehm (1794-1881),[80] the original designer of today's modern flute.

Richard Shepherd Rockstro (1826-1906), a prominent British flute designer and maker, wrote an extensive volume on the flute with significant detail given to the proper method of assembling and aligning the joints of the instrument. In it, he stated that the adjustment of the headjoint was the most important adjustment and recommended that "the outer edge of the mouth-hole [i.e., the edge opposite the aperture where the air stream strikes the inner wall] shall be rather within than without the line of the centres of

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[76] Diagrams of the classic and Rockstro alignments are found in Appendix D.

[77] John C. Krell, *Kincaidiana*, second edition (National Flute Association, Inc.: Santa Clarita, California, 1997), xiv.

[78] Debost, *The Simple Flute*, pp. 18-20.

[79] Nancy Toff, *The Flute Book*, second edition (Oxford University Press: New York, 1996), pp. 31-2.

[80] Theobald Boehm, *The Flute and Flute-Playing in Acoustical, Technical, and Artistic Aspects* (Dover Publications: New York, 1964), p. 111.

the finger-holes."[81] The head-joint is turned further in than in the traditional method, with the outer edge of the embouchure hole lining up with the centers of the keys. The keys are therefore angled forwards so that the heavy rods that run down the length of the middlejoint remain on top. The reason for aligning the flute in this manner is to place the middlejoint in a position so that it is balanced without any pressure from any fingers. The heavy rods are on top instead of toward the back. Rockstro recommends that the footjoint be arranged so that the little finger can reach the keys without causing the rest of the hand to move. He cites a long line of flutists who advocate this approach: Johann Joachim Quantz (1697-1773), Francois Devienne (1759-1803), Antoine Benoit Berbiguier (1782-1838), Louis Francoise Drouet (1792-1873), Raphael Dressler (1784-1835), Thomas Lindsay (1828-30?), Jean-Louis Tulou (1786-1865), Charles Nicholson (1795-1837), and Victor Coche (1806-1881). A long-standing antagonism between Rockstro and Boehm could have motivated Rockstro to propose and support any idea that would contradict Boehm, this alternative method of alignment being one of them.

The modified Rockstro alignment is just that – anything between the traditional method and the true Rockstro position. Walfrid Kujala, Professor of Flute at Northwestern University and retired piccoloist of the Chicago Symphony, alludes to the modified designation another way:

> 'Modified Rockstro,' just for clarification, refers to the fact that since my right thumb is double-jointed, I can press the pad of my thumb against the flute tube instead of the tip of my thumb, and is much more comfortable for my thumb.[82]

[81] Richard Rockstro, *A Treatise on the Construction, the History, and the Practice of the Flute,* second edition (Musica Rara: London, 1928), p. 418.
[82] Email dated 9/29/2008.

The purpose for the survey investigation of these different methods of aligning the flute is to see whether they are related to any physical problems flutists may experience. The Rockstro position requires more involvement of the right arm due to the over-reach of the right hand in order to set the fingers on the forward-slanting keys. The classic alignment allows the flute to easily fall backwards when few fingers are engaged; the fifth digit of the right hand frequently takes on the role of balancing the flute instead of just pushing down its key. Tension to maintain this position can lead to more serious musculoskeletal problems. In the investigative section of this document, the online survey asks questions related to these and other relevant issues.

To review, the scientific position of function for the hand is with the wrist slightly extended (20 – 30 degrees) with slight ulnar deviation (10 degrees). The fingers are moderately flexed at the MP joints (45 degrees) and PIP joints (30 degrees) with the DIP joints slightly flexed. This position provides the best mechanical advantage for actions of the fingers, i.e., the flexors of the finger can operate with the least possible effort. In the Rockstro position, the right wrist is bent more than recommended, pulling the tendons out of the carpel tunnel, causing undue strain. With an over-flexed wrist, the fingers are at a mechanical disadvantage. The tightness of spaces under the retinacula of the wrist depends on the joint angle.[83] If the wrist is straight, the space is at its largest. The more the wrist is bent, the more the flexor tendons get pushed together. On the opposite side, the extensor tendons are stretched and therefore must work harder to raise the fingers.

In the Rockstro position, the right arm must be raised slightly higher or the flute drooped lower to accommodate the greater flexion of the wrist. This awkward angle not

[83] Watson, *The Biology of Musical Performance,* p. 59.

only causes excess stress on the finger flexors, it sets up a bad kinetic change that reaches all the way to the spine.

Of the 181 respondents to the online survey, only 11 flutists or 6.2% used the Rockstro alignment. A slightly higher number, 42 flutists or 23.6%, used the modified Rockstro method. Sixty percent of the Rockstro flutists reported neck pain, a much larger margin than the modified Rockstro users (32.5%) or the traditional alignment flutists (43.4%). Since this 60% was only six people, care should be taken in drawing conclusions. But with such a large percentage of flutists reporting neck pain (41%), it bears looking into every possible cause. Holding the right hand in a position of increased wrist and MP (knuckle) flexion puts the fingers at a disadvantage and increases the load of the right shoulder musculature.

When the joints of the flute are assembled in the traditional alignment, the embouchure hole is in line with the center of the keys of the body. The starting point for lining up the rod of the footjoint with the rest of the flute is also having it be aligned with the center of the keys of the body. As the flute is balanced in the hands and against the lower lip, the keys are flat to the ceiling. The flute itself is not to be held parallel to the ceiling; rather it is the keys that are to be held so that they aren't tipped forward or backwards. The end of the flute droops downward and is forward enough so that the right shoulder does not elevate. The neck is straight because the embouchure plate can lay across the lip in an asymmetrical fashion.

Emmanuel Pahud has been observed during performances to lean forward at the hips when playing more technically difficult passages. In this position the hands become freer because now the rods of the flute are pointing towards the ceiling, balancing the flute a little better. Although not a position anyone would use permanently, a temporary move to this stance is a great way to manage difficult technical passages *and* treat the audience to a clear view of quickly moving fingers.

A review of the Patricia George method for teaching hand placement on the flute is appropriate at this point. Beginning with the left hand, place the ring finger first (the most difficult finger to manage), then the middle, then the index finger. Turn the flute over with the palm up and let the flute roll onto the hand. This motion positions the flute on the palmar aspect of the MP joint of the left index finger where it can rest as a fulcrum point. By balancing the flute here instead of pushing it against the edge of the index finger, pressure on the nerve traversing up the side of the finger can be avoided. After settling the flute on the base of the MP joint of the index finger, the thumb can be dropped onto the thumb key. The contact point of the thumb will not be on tip, but rather further down near the joint crease. The thumb should remain straight, not flexed; it is easier to move the thumb on and off the key when it is straight as opposed to when it is flexed. Keeping the IP joint of the thumb flexed during playing involves co-contractions of the flexor pollicis longus, extensor pollicis brevis and abductor pollicis longus. Keeping the IP joint of the thumb straight is a relaxed and more functional position. If the left thumb is bent, it is all too easy to let it support part of the weight of the flute; this is turn limits the free action of the thumb. The flutist should place the left hand completely under the flute (not alongside), allowing the second MP joint of the left hand to bear the entire weight. Not only is the left thumb freed from this weight-bearing role, the wrist can also avoid the excessive radial deviation required when it approaches the flute from the side.

Before placing the right hand on the flute, make a fist in order to place the wrist in a position of function, i.e., in about 20-30 degrees of extension. This angle can also be estimated by making a fist and laying the forearm on a flat surface such as a table; the wrist will naturally assume a small angle of extension. Place the little finger on the E-flat/D-sharp key, then the ring finger, the middle finger, and finally the index finger. As a small degree of ulnar deviation is part of the functional wrist position, take care to bend the wrist toward the thumb (radially) as little as possible. One way to check this during playing is to occasionally direct attention to the end of the middle digit of the right hand where it strikes the key; it should be in line with the forearm as much as possible. So part of positioning the right hand involves avoiding ulnar deviation of the wrist and pronation of the forearm as much as possible.

The thumb of the right hand can be opposite the index or middle finger, or be placed in opposition between them. The natural placement varies from individual to individual and should not be static. A visual cue for what is natural can be seen by grasping a Coke can; notice where the thumb naturally aligns with the fingers and replicate that on the flute.[84] Another image that may help thumb placement is to imagine the tip of the right thumb and fourth finger reaching for each other. In considering the thumb as a axis for rotation of the hand, placing it under the third finger has its advantages. If not kept there always, the thumb can be shifted down to this spot when playing notes that require frequent use of the keys on the footjoint. This action shifts the center of gravity of the hand downward as well, putting it in a better position to perform the small movements required by the little finger.

[84] George, *Flute Spa.*

In fitting the flute to the hands of young beginners, the challenge is truly great. Their small stature needs modifications in body position and on the flute itself to keep them from developing bad habits with hand position. Playing in the cross-hand position eliminates right hand problems since it is holding the barrel; many tunes can be played in this position by using harmonics. Another excellent solution for young players is using a curved headjoint. Other modifications can be either purchased or made at home. Thumbport, Bo-Pep, StediRest, and other devices are all designed to help the hands grasp the flute more efficiently. Less expensive ideas are to use pencil cushies (cut and opened out), mole skin patches, or air conditioning pipe cut to fit for the right thumb and/or the base of the left metacarpal.

In adult flutists, silver ring splints or theraplast splints, which are medically prescribed devices, can help with the hypermobility of the IP joints mentioned earlier. Players have used everything from Band-Aids to paper clip splints to keep the 5^{th} digit in a flexed, functional position.

CHAPTER NINE

THE JAW, EMBOUCHURE, AND VOCAL TRACT

When presented with the idea of anatomy as it relates to flute-playing, many flutists would probably think of the embouchure and jaw first. Much of the time in private lessons and practicing is spent working on tonal quality, with flute teachers giving directions about how to form a good embouchure and how to set-up the oral cavity and throat. Jaw movement has been a much-discussed topic on the Flute List, an online email discussion group. Documentation of temporomandibular dysfunction (TMD) in flutists is small, but symptoms of the disorder appear to be significant in trombone, trumpet, tuba, violin, and viola players.[85] Problems of the jaw are more prevalent in individuals with joint hypermobility, or double-jointedness, and since flutists are represented in this group, extra attention should be given to understanding the workings of the jaw.[86]

Unlike the arms, it is a little more difficult to visualize exactly what is going on in the throat while playing and the fine control that governs the lips is frequently a stumbling block to developing players. A good understanding of the anatomy in this area of the body will not only help teachers communicate clearly and accurately with their

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[85] J. Taddey, "Musicians and temporomandibular disorders: prevalence and occupational etiologic considerations," *Cranio: the journal of craniomandibular practice* 10:3 (1992), pp. 241-4.

[86] Nicolas Patrone, Richard Hoppman, Judy Waley, and Beatrice Chauncey, "Benign Hypermobility in a Flutist: A Case Study." *Medical Problems of Performing Artists* 3:4 (1988), pp. 158-61.

students, but it will also provide a scientific mental image of what is going on inside the body during flute-playing.

The Jaw

The skull, or the cranium, is composed of several bones whose borders fuse in early childhood. The lower edge of the front of the cranium is bordered by the zygomatic bone, or cheek bone, the top row of teeth and the mastoid process of temporal bone, a palpable bump felt immediately behind and slightly below the ear. It may be surprising to find that so much of the face, i.e., the lower half, is hanging below the skull rather than being a part of it (Illustration 32).

The jaw bone, or mandible, is a horse-shoe shaped bone that hangs below and slightly in front of the cranium. Its articulation with the skull at the temporal process is a modified hinge joint called the temporomandibular joint (TMJ). As jaw movement occurs during the playing the flute, the complicated movements of this joint are relevant. Each of the two TMJs has a disk that separates the articulation into two separate joints, upper and lower, that function slightly differently. The lower joint, which is formed by the mandibular condyle[87] and the bottom surface of the disk, is a simple hinge joint. This type of joint operates much the same as a door hinge. The upper joint is formed by the articular eminence and the top of the disk; it is a plane or gliding joint.

The TMJ is one of the most frequently used and strongest joints of the body. Even though the joint provides the action of chewing, most TMJ movements are empty-mouth movements. The cartilage covering the articular surfaces is designed to tolerate repeated action and high-levels of stress. Muscles acting upon the TMJ are designed to provide

[87] The mandibular condyle can be felt by placing a finger in the ear canal and pressing forward.

power but also the intricate control required for speech, singing, and other similar activities.

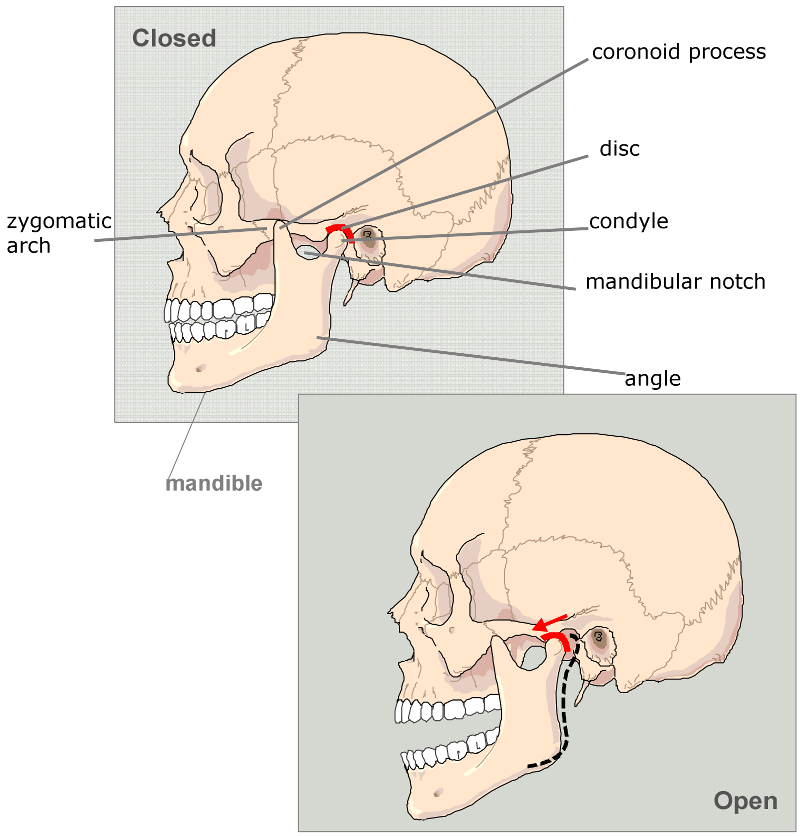

Illustration 32: The skull and jaw.

The five basic motions of the TMJ are opening and closing the mouth, jutting the chin forward, sliding the teeth forwards and backwards, and sliding the teeth to either side. These motions can be combined in a myriad of ways, effecting the fine control alluded to earlier. Opening the mouth involves a rotation and gliding of the TMJ. The amount the mouth can open is considered normal if the flexed PIP joints of two fingers can be inserted between the teeth. A normal range of motion for jutting the teeth forward would be that the upper and lower teeth touch edge to edge. When the teeth slide to either side, a normal amount would be movement the full width of one of the central incisors in each direction. Normal resting position of jaw is with 1.5 to 5.0 mm of free space between the upper and lower incisors; this small gap is important for rest and repair. Note that in the normal resting position, the teeth are not touching.

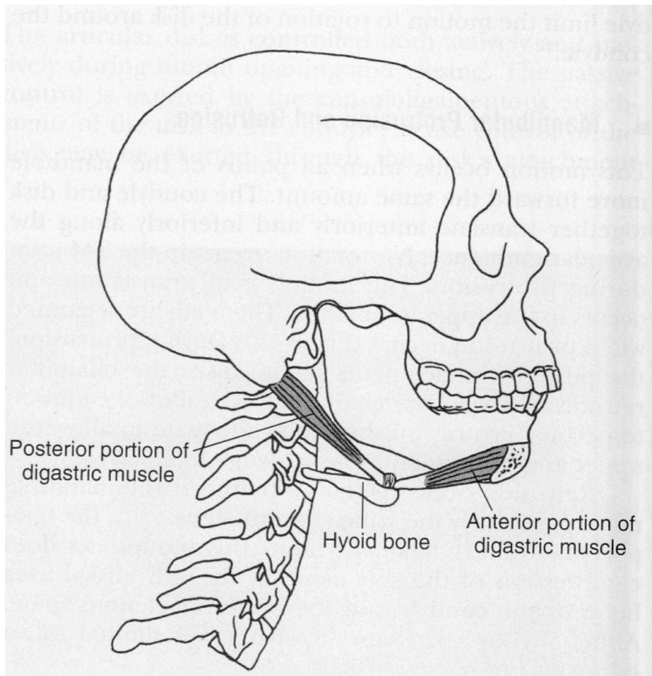

Illustration 33: Digastric muscle and hyoid bone. From *Joint Structure & Function*, 4th Edition, Pamela K. Levangie and Cynthia C. Norkin, 2005, p. 222, F. A. David Company, Philadelphia, PA, 19103, with permission.

Major muscles acting upon the TMJ include the digastrics, temporalis, masseter and pterygoid muscles (Illustration 33 and 34). The digastric muscle is the main action muscle in opening the mouth and lowering the jaw, which is of prime importance to flutists. It is actually composed of two muscles that extend from the hyoid bone. The hyoid is firmly attached above the thyroid cartilage at the level of the third cervical vertebra and is suspended by ligaments that reach from internal processes of the temporal bone above it. A U-shaped bone, the hyoid serves as an attachment for anterior neck muscles and a prop to keep the airway open (Illustration 34).

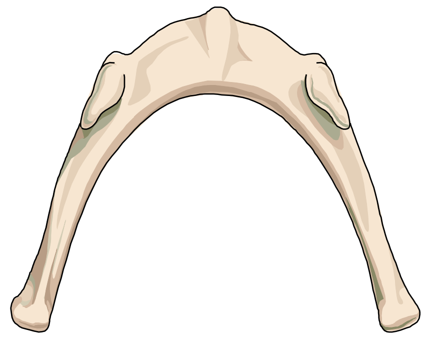

Illustration 34: The hyoid bone, inferior view.

The forward portion of the digastrics muscle runs from the sides of the chin to the hyoid bone and the back portion connects the hyoid to the mastoid process of the skull slightly behind and below the ear. These muscles are also assisted by the inferior portion of lateral pterygoid, a triangular two-headed muscle. It lies inside of the back molars on the lower surface of the skull. The lateral pterygoid then inserts into the TMJ.

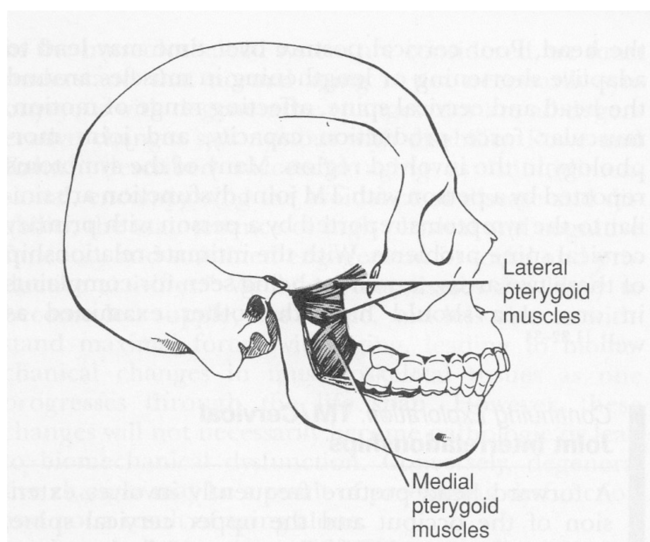

Illustration 35: Pterygoid muscles. From *Joint Structure & Function*, 4th Edition, Pamela K. Levangie and Cynthia C. Norkin, 2005, p. 223, F. A. David Company, Philadelphia, PA, 19103, with permission.

The jaw is raised by the temporalis, masseter, and medial pterygoid muscles. The medial section of the pterygoid muscle is also two-headed and connects the undersurface of the cranium with the interior aspect of the mandible. It flanks the masseter muscle, which lies parallel to it but on the outside of the mandible. When clenching the teeth, the masseter is easy to feel as it protrudes out to the sides. The temporalis muscle begins on the side of the head above the ears in the temporal bone and goes under the zygomatic arch, extending down to insert on the coronoid process of the jaw (Illustration 36).

The rest of the motions of the mandible use the same muscles but in different sequences. A bilateral action of the masseter and pterygoids brings the jaw forward while a bilateral action of the posterior fibers of temporalis with assistance from anterior portion of digastrics brings the jaw back.

The TMJ has a close relationship with the cervical spine in that many muscles that attach to the TMJ also attach to the cranium, the hyoid bone and the clavicle. These same muscles have actions on the cervical spine and the joint between C1 and the base of the skull. Abnormal positions of the head and neck can therefore have an affect the position or function of the jaw and the TMJ. Poor posture, most commonly a forward head, can upset the balance of the muscles that support the weight of the head. The cervical extensors can become shortened by disuse or lengthened by over-stretching and the forces they normally exert during correct posture are diminished. Thoracic vertebrae may adapt to oppose the forward position of the head by assuming a larger kyphotic curve. All joints and vertebrae, the TMJ included, and the muscles and tissues that attach to them suffer extra wear and tear when they are not in proper alignment. The symptoms of TMD mimic those of patients whose primary problem is in the cervical spine area. These include headaches, decreased range-of-motion of the cervical spine, and referred pain from the TMJ to the neck.

Studies indicate that TMJ degeneration is not an expected part of aging.[88] However, the TMJ is affected by aging to the extent that all joints are by becoming less supple and elastic, and losing biomechanical clarity. But more extreme degenerative changes in the TMJ postmortem may well be a result of preexisting problems and not just aging alone. So we should not expect TMJ problems as a natural course.

TMDs are primarily the result of mechanical stress whether it is an acute problem such as whiplash or a chronic problem brought on by long-term poor posture. The most common forms of TMJ problems are inflammatory conditions, capsular fibrosis, joint hypermobility and dislocation, articular disk displacement, and other degenerative conditions. Inflammatory conditions include inflammations of the joint capsule and/or its synovial lining, rheumatoid arthritis being the primary culprit. Capsular fibrosis occurs when repeated episodes of inflammation lead to adhesions and a restriction of movement. Long periods of immobility, trauma or arthritis can cause capsular fibrosis. Articular disk displacement is signaled by an audible click during opening and closing indicating that the disk does not relocate normally. Degenerative conditions of TMJ include rheumatoid arthritis and osteoarthritis. Eighty to ninety percent of the population over 60 years old has some symptoms of osteoarthritis,[89] a condition caused by repeated trauma to the joint, particularly between articular surfaces. In the case of TMD, the joint space narrows, erosions and bone spurs form, and scarring and remodeling of the joint occur.

All of the information above serves as an important reminder for flutists to maintain a neutral posture of the head upon the cervical spine. Forward head should be

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[88] U. Nannmark, L. Sennerby, T. Haraldson, “Macroscopic, microscopic and radiologic assessment of the condylar part of the TMJ in elderly subjects. An autopsy study,” *Swedish Dental Journal* 14 (1990), pp. 163-9.

[89] Levangie and Norkin, *Joint Structure & Function,* p. 227.

discouraged strongly, even though this position enhances the opening of the upper respiratory passageways. Not only are the bones and muscles of the neck compromised by a forward head, but the TMJ is also next in line to sustain injury. As the percentage of flutists with neck pain ranked first in the survey accompanying this document, the priority of this issue is clear. Many flutists also tilt their heads to the right in their playing positions in order to avoid raising their right shoulder. A forward leaning, rotated cervical spine is in a compromised position and provides a biomechanical predisposition for musculoskeletal problems and extensive pain.

An example of childhood asthma given in the *Joint Structure & Function* has direct bearing on the playing position of the head for flutists.[90] The authors explain that the difficulty a child with asthma has in breathing through the nose may lead him/her to hyperextend the cervical spine to more fully open the upper respiratory tract. This position puts added strain on the TMJ and surrounding tissues. With asthma, the child may call in the accessory muscles of respiration to assist with inspiration – the scalene and sternocleidomastoid muscles. Overuse of these muscles contributes to a forward head posture as well. The TMJ becomes inflamed due to the strain; repeated inflammation causes fibrosis, a much more difficult condition to treat. This very same position can describe a typical posture of a flutist – a hyperextended cervical spine with a forward head. The asthmatic's neck position to increase air flow is mimicked by many flutists. Although not the only cause of neck pain, this stance certainly predisposes one to it. If lack of adequate air is the flutist's problem, then more emphasis should be put on

[90] Levangie and Norkin, *Joint Structure & Function,* p. 224.

improving the speed and control of the exhalation instead of sacrificing a healthy neck posture. The forward head posture is listed as one of the signs of TMD.[91]

Much discussion of jaw movement among flutists centers upon embouchure adjustments. The normal resting position for the jaw works well for playing the flute. As the jaw is attached to the skull by ligaments and muscles; these can be relaxed and the jaw can hang below the front half of the skull, creating a large oral cavity. Muscle tension resulting from any number of things – nerves, effort, etc. – can bring the jaw up so that the teeth are closer together. Also, some individuals just naturally have a deeper bite than others; that is, their teeth fit into each other with a greater overlap resulting in a smaller oral cavity. If the tongue is held high as well, the oral cavity becomes even smaller, restricting the air space necessary for a resonant sound. In order to counteract these problems, flutists are rightfully instructed to drop their jaw as far as they can. But muscle tension can also occur from pulling and holding the jaw down too far. A healthy equilibrium should consist of a hanging jaw, a lowered tongue, and a balanced head over a properly aligned cervical spine. Flutists should be aware that TM joint dysfunction is more likely to occur from a forward head posture than from the small movements we make during embouchure changes.

Face

The muscles of the face are innervated by the facial nerve, which is the seventh of twelve cranial nerves (Illustration 36). Cranial nerves exit directly from the brain stem, the lower part of the brain above the spinal cord, whereas spinal nerves exit the spinal

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[91] Levangie and Norkin, *Joint Structure & Function*, p. 228.

cord. This discussion will be limited to the muscles of the mouth as they are responsible for the flutist's embouchure.

The shape of the mouth and lips is controlled by four main groups of muscles: (1) elevators, retractors, and evertors of the upper lip, (2) depressors, retractors, and evertors of the lower lip, (3) the orbicularis oris, and (4) the buccinators. Elevators, retractors, and evertors of the upper lip include the zygomaticus major and minor and the levator labii superioris. The zygomaticus minor along with the levator labii superioris both retract and/or evert the upper lip. The zygomaticus major elevates the labial commissure, the corners of the lips, in order to smile. The depressors, retractors, and evertors of the lower lip are the depressor anguli oris, depressor labii inferioris, and mentalis. The depressor anguli oris depresses the labial commissure bilaterally to frown. Retraction and/or eversion of the lower lip are accomplished by the depressor labii inferioris, which shows the emotions of sadness or pouting. The mentalis elevates and protrudes the lower lip, elevating the skin of chin, showing the emotion of doubt. It can also turn the bottom lip inside out. The orbicularis oris is the sphincter that encircles the entire mouth. In the following illustration, it is labeled the purse string muscle. It can totally close the lips in a thin line, contract in a brief contraction to produce a kiss, or it can resist distension as when blowing. The last group of muscles acting on the mouth and lips are the buccinators, the check muscles. In their relaxed position, they press against the molar teeth. These muscles can resist expansion when blowing.

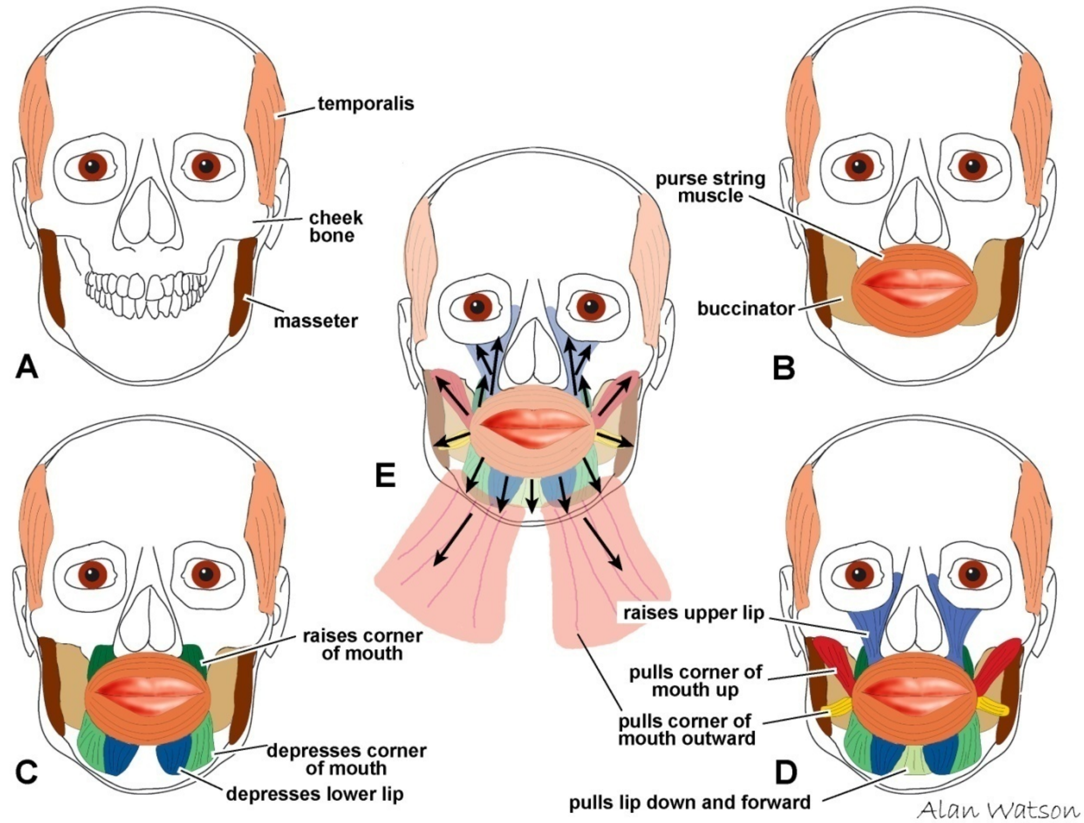

Illustration 36: Face muscles. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 194, Scarecrow Press, Lanham, MD, 20706, with permission.

The formation of the flutist's embouchure is of paramount importance in producing a beautiful sound. Renate Unger describes two typical ways of forming the embouchure.[92] In any case, the tongue should be flat and wide, which is *not* its normal resting position. Having the oral cavity form the 'ö' in the German language or in English, 'ew,' causes the back of the tongue to drop down, out of the way. Also helpful is to have the back sides of the tongue touching the molars. The first typical embouchure is the 'stretched wide' formation with the buccinators and smiling muscles stretching the lips wide so that they flatten and lie taut against the teeth. The mouth cavity itself is unconsciously widened laterally as well.

[92] Renate Unger, *The Flute; A Tutor and Study Book I,* trans. by William Waterhouse (Leipzig: Deutscher Verlag für Musik, 1988), pp. 41-2.

In the ‘turned out’ embouchure, the mouth cavity is narrowed and the cheeks are laterally laid against the teeth. Lips are slightly curved outward; this is accomplished by the contraction of the obicularis oris, the muscle that encircles the lips. The lips are elastically tightened at the same time by the buccinators and depressor anguli oris. The blowing aperture is formed from the moist mucus membrane immediately adjoining the lips in both embouchures. In the ‘stretched wide’ embouchure, the taught lips have less flexibility than in the ‘turned out’ embouchure.

James Galway recommends that flutists place their index finger horizontally underneath their bottom lip, letting the bottom lip come forward over the finger, in order to discover where the headjoint should rest. In doing so, the flutist will be using the depressor anguli oris and probably the mentalis muscle as well. Both are used in producing the ‘turned out’ embouchure. Suzuki methods use the image of a ‘horse face’ to get the same turn-down corners.

The aperture width must equal or be less than the width of the embouchure hole in order to make efficient use of the air stream.[93] If a student has a tear-drop upper lip, that is a lip with a dip in the center, they are not necessarily ineligible to succeed as a flutist. They must be directed to play off the side of their lips, preferably to the left so that the flute will be able to naturally angle forward from the plane of the body.

A group of scientists has studied the embouchure of the flutist as it related to the air pressures and flow of the respiratory apparatus. Because it also focused of breathing, the discussion of this study is found in Chapter Ten.

[93] George, *Flute Spa.*

Oral Cavity and Tongue

The oral cavity is bordered by the cheeks on the sides, the tongue on the bottom and the palate on the top. The first $\frac{2}{3}^{\text{rds}}$ of the palate is hard; posteriorly the last $\frac{1}{3}^{\text{rd}}$ is without bone and is called the soft palate. In the center of the posterior of the soft palate is the uvula, the small projection downward of tissue (Illustration 37C). The soft palate may be elevated so that it is in contact with the posterior wall of the pharynx. When this passageway is closed off, breaths are taken through the mouth. The soft palate may also be drawn to contact the back part of the tongue. In this case, expired air is kept from entering the mouth and any substance in the mouth is blocked from entering the pharynx. The soft palate is moved by five separate muscles that arise from the base of the cranium.

The tongue is a mobile organ composed of striated muscles partly in the oral cavity and partly in the oropharynx, which is the area between the uvula and the hyoid bone (C3). Four intrinsic and four extrinsic muscles make up each half of the tongue. The intrinsic muscles by definition are not attached to bone; they *are* the tongue and control its shape. The extrinsic muscles originate outside the tongue and attach to it. They come from the mandible, the hyoid bone, the styloid process of the temporal bone, and the soft palate. These muscles mainly control tongue placement. The resting placement of the tongue is up against the roof of the mouth.

Underneath the tongue is a strip of tissue that connects its inferior surface to the floor of the mouth. If the frenulum of the tongue, as it is called, is overly large it may interfere with speech and other actions. The labial frenula are similar folds of tissue that extend from the gums above and below the upper and lower front teeth; they connect the gum area with the inner walls of the lips. Both the frenulum of the tongue and the labial frenula can be clipped if too large.

A resonant flute sound comes in part from a large oral cavity. In order to achieve a rich sound, flutists have been instructed to do many things including drop their jaw, allow their cheeks to puff out, and to ‘play from the upper nose.’ The later clearly refers to the raising of the soft palate, which in turns does create a larger oral cavity. Allowing the cheeks to slacken may enlarge the oral cavity, but the power of the air stream may be diminished as the lips work harder to maintain the correct aperture. Dropping the jaw is another way to increase this space, but care must be taken to do so only as far as possible without undue exertion. The jaw should hang down relaxed, not by strong muscle contractions.

Since the resting place of the tongue is against the roof of the mouth, the flutist must learn to be aware of where it is and use it to support and not hinder their flute playing. The tongue can be pulled down flat and kept out of the way of the airstream. It can also be bring upward in order to change the angle of the air stream. Different parts of the tongue are used for articulation.

Pharynx, Larynx, and Trachea

The pharynx encompasses the upper expanded part of the digestive and respiratory system which is posterior to the nasal and oral cavities. It extends downward behind the larynx to the upper border of the esophagus. The widest part of the pharynx is opposite the hyoid bone and the narrowest section occurs as it changes into the esophagus.

Different terms are used to describe the different sections of the pharynx and familiarity with their usage is helpful (Illustration 37A). The nasopharynx is the area behind the nose and above the soft palate; its function is solely respiratory and is non-collapsible. The soft palate at the back of the roof of the mouth provides a flap that separates the nasopharynx from the next section, the oropharynx, which is posterior to mouth. The oropharynx and the laryngopharynx below it, are passageways that handle food and air. The later is posterior to larynx and extends from the top of epiglottis to the cricoid cartilages at the level of C4-6. Its sides and back walls are formed by muscles. Another way to understand the pharynx is that its segments are determined by three openings on its anterior wall; these openings are the nose, mouth, and larynx. The soft palate is the flap that regulates openings to the nasopharynx and the oropharynx, and the epiglottis serves as the valve guarding the entrance of the larynx. Muscles of the pharynx include layers of voluntary muscles that constrict the area during swallowing and elevate, or shorten and widen, the pharynx and larynx during swallowing and speaking.

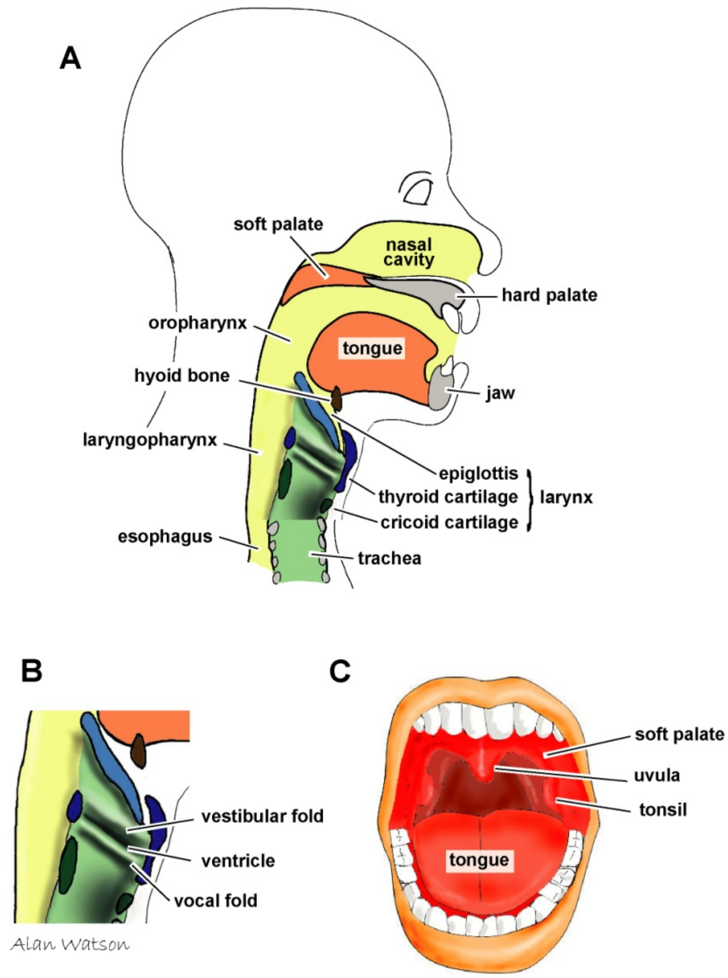

Illustration 37: The larynx and pharynx. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 140, Scarecrow Press, Lanham, MD, 20706, with permission.

The larynx, or as it is commonly called, the voice box, is a complex organ of voice production (Illustration 37B). Located at the front of the neck at the level of C3-6, it is composed of nine cartilages connected by membranes and ligaments and connects the inferior part of the pharynx with the trachea. The function of the larynx is to serve as the mechanism for voice production. It also guards the air passages especially during swallowing and serves as the valve of the lower respiratory tract.

The laryngeal skeleton is composed of nine cartilages, three single and three paired. The thyoid, cricoid and epiglottic cartilages are single while the arytenoid, corniculate, and cuneiform cartilages work in pairs. In the interior of the larynx, the glottis is the actual vocal apparatus of the larynx. Inside it, the vocal folds are the true vocal cords which control sound production. Each fold contains a vocal ligament and a vocalis muscle. During normal breathing, no muscular action is required to open the vocal folds; the air pressure alone pushes them back. The folds produce audible vibrations when their free margins are closely apposed (but not tightly) and air is forcibly expired intermittently. When the vocal folds are completely closed, they act as the main sphincter of the larynx and prevent entry of air.

Rima glottidis is the name given to the aperture between the vocal folds (Illustration 38). When the vocal folds are relaxed, they assume a narrow, slit-like position that is slightly more open at the bottom than at the top. With deep inhalation, the vocal ligaments are abducted by muscular contractions and the rima glottidis opens widely into an inverted triangle shape. When speaking and singing, the vocal folds are very close together but not closed. Air is forced through them and the ensuing vibration of the folds determines the pitch of the tone. During whispering, air passes through an opening created at the lower end of the vocal folds where the arytenoids cartilages lie. The vocal folds allow the formation of vibrations, but without the usual air flow that would increase the sound.

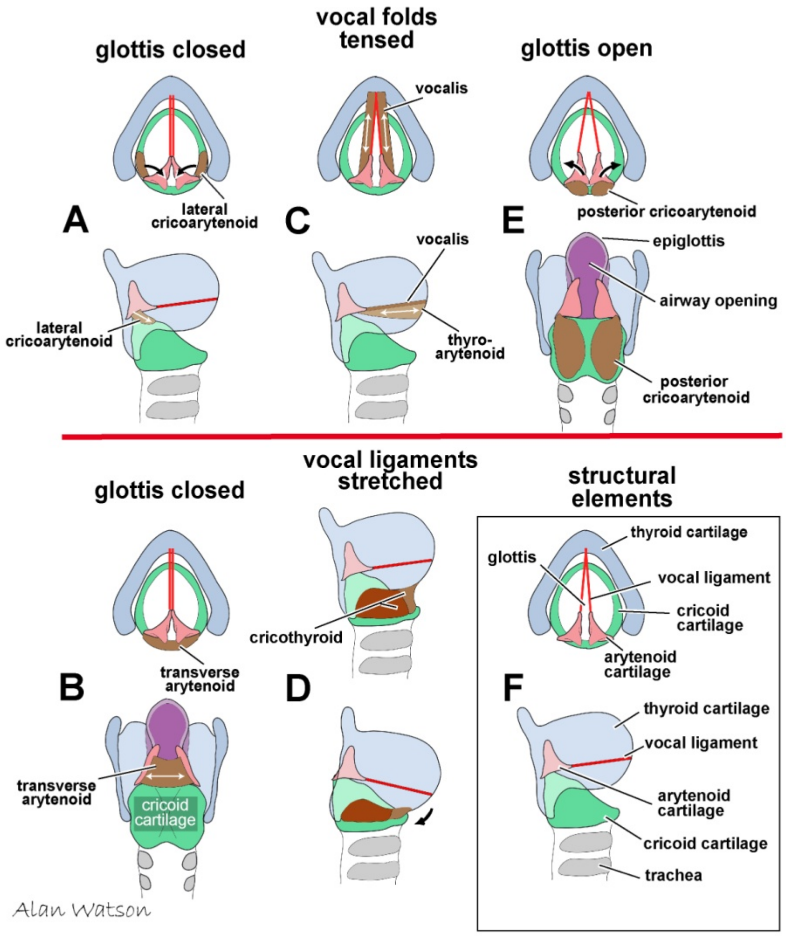

Illustration 38: Structure and movements of the larynx. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 149, Scarecrow Press, Lanham, MD, 20706, with permission.

Since the vocal folds are a gateway for the breath, delineating the muscles that control them is helpful. The extrinsic muscles of the larynx move the structure as a whole. Intrinsic muscles move the parts of the larynx, altering the length and tension of the vocal folds and therefore the size and shape of the rima glottidis. Functional groups of the laryngeal muscles include the adductors and abductors, the sphincters, the tensors, and the relaxers. Adductors and abductors move the vocal folds to open and close the rima glottidis. The adductors are the lateral cricoarytenoid muscles, and the transverse and oblique arytenoids muscles. The abductors, which open the rima glottidis, are the posterior cricoarytenoid muscles. Sphincters include the lateral cricoarytenoids, the transverse and oblique arytenoids, and the aryepiglottic muscles. The cricothyroid muscle pulls the thyroid cartilage anteriorly and raises pitch of the voice, and is therefore a tensor. The relaxers of the larynx are the thyroarytenoid and vocalis muscles. The thyroarytenoid pulls the cartilages anteriorly toward the thyroid angle, relaxing the vocal ligament and lowering the pitch of the voice. The vocalis muscle produces minute adjustments of the vocal ligaments, tensing and relaxing the vocal folds during animated speech and singing.

Flutists have often been told to open their throat. A more accurate directive would be to open their pharynx and vocal folds. While the pharynx is sensed as the back of the throat, the vocal folds are slightly more anterior and take up a much smaller space. As noted previously, the folds open automatically during normal breathing, but during a deep inhalation such as flutists frequently take, the folds can be pulled to the side even more so. Since the pharynx is equipped with voluntary muscles, it can be enlarged as well in order to expand the oral cavity, but this should be done without extending the cervical vertebrae in the neck or bringing the head forward. The problems of a forward head posture have already been discussed but the importance of avoiding it bears repeating.

All air exhaled from the lungs must pass through the small area between the vocal folds in the larynx. Speech and singing are created by the rapid opening and closing of the vocal folds in a closely juxtaposed position. The larynx is modifying the air flow as it exits the lower respiratory tract. During a singing, it is responsible for the pitch of the tone. Vibrato is an oscillation of the pitch and volume of a tone produced by a singer or an instrument. Since the diaphragm, an involuntary muscle designed to move with the speed of breathing, is incapable of the rapid repetitions heard in the sound of a flutist’s vibrated tone, it would seem to be a reasonable inference that the spinning vibrato so valued by flutists as an integral ingredient of their sound is produced by the rapid fluctuations of the vocal folds. These folds are clearly under voluntary control, and since they were trained to produce speech and singing, they can be also trained to produce vibrato.

Vibrato is sometimes seen in flutists who use their cheek muscles (buccinators) to make the oscillations. While this is certainly possible, it is a rather clumsy way of making vibrato. A more efficient way of causing a regular pulsation in the air column is by moving the vocal folds. However, there is still a place to use cheek vibrato and that is when playing an exceptionally high note. It is difficult to vibrate the vocal folds when the air is already moving so swiftly and a larger problem still when approaching the end of a phrase and running out of air. Here, vibrating the cheeks slightly can produce a vibrato that otherwise might not be possible.

Summary

The jaw, embouchure, and the vocal tract are very complicated structures of the human body and integrally tied to the action of flute-playing. While the advantages of the ‘turned out’ embouchure make it a better choice than the ‘stretched wide’ configuration, changing an embouchure is difficult whether doing it yourself or helping a student. Anecdotally, changing an embouchure has had some unexpected consequences in some players, leading to problems as serious as focal dystonia. Therefore, it is crucial that beginning flutists get it right the first time. Band directors and flute teachers must place a high priority on starting their flutists out with a turned-out, flexible embouchure. They can do this by spending more times, i.e. several weeks, having students play with the headjoint only and then adding the body in the cross-hand position much later.

The TMJ is so very complicated that the material presented in this chapter is just the barest of essentials. The movements of the jaw during flute-playing are problematic and yet necessary. The topic of much discussion on online chat lis ts, this is an area that should be researched more fully.

CHAPTER TEN

BREATHING

The mechanisms of breathing are perhaps among the most confused and misunderstood topics among musicians. Even though the flute is a wind instrument, the way the exhaled air is controlled is more akin to a vocalist than to any other instrumentalist. Brass instruments and all the other woodwind instruments have a mouthpiece upon which the player blows, meeting resistance in the process. The flutist, on the other hand, must use their embouchure along with muscles of respiration to moderate the flow of air. So where brass and other instrumentalists work within a stopped condition, the flutist's set-up is unstopped.

Singers use their vocal folds and muscular actions in the thorax and abdomen to control the air. The main difference between them and flutists is that the flutist provides resistance to the air flow through her/his lips instead of the vocal chords. When producing vibrato, the vocal folds also exert an effect upon the air flow, much like a singer's. So the mechanisms of breathing should be more similar to that of singers than to other instrumentalists.

An investigation into the structure and function of the respiratory system will clarify the differences between how flutists use their air versus other wind players. By learning the correct terminology and functional anatomy, flutists and their teachers can talk clearly and accurately about the breathing techniques that are so integral to their playing. New studies by scientific researchers have reinforced what some flute method books have discussed and flute instructors have taught about breathing; both studies will be summarized in the following chapter.

The Thorax and Respiration

The thorax is the area of the body between the neck and abdomen. Sometimes referred to as the ribcage, the skeleton of the thorax consists of the thoracic vertebrae (T1- T12), the ribs and the breastbone. They function as the base for attachment of the arms, the head and neck, the rest of the vertebral column, and the pelvis. The most important role of the thorax is its role in ventilation. A secondary but vital role of the skeleton of the thorax is the protection it affords the heart and lungs. The sternum, or the breastbone, lies in front and is composed of the following three parts listed from top to bottom: the manubrium, the body, and the xyphoid process. Twelve pairs of ribs surround the thorax. These curved but flat bones increase in length from the first to the seventh rib, and then shorten from the eighth to the twelfth rib. Connecting the ribs to the sternum at the front of the chest are costal cartilages. Several ribs at the bottom of the thorax are not connected anteriorly and are termed ‘floating ribs.’

The respiratory tract begins with the nasal cavity where oxygenated air is taken in and ends in the alveolar sacs where the oxygen is passed into the blood stream. On its way from the nose through the oral cavity and pharynx, the air is warmed up and takes on water vapor. During its passage in the pharynx, the epiglottis prevents air from entering the esophagus. After moving through the opening of the larynx, or voice box, the air enters the trachea, or wind pipe.[94] The trachea divides into two bronchi, and they further divide into bronchioles which eventually end up as individual alveolar ducts and sacs of the lungs.

The actions of the thorax during breathing can be compared to an old-fashioned water pump and a bucket. During inspiration, the upper ribs and the sternum move upward and outward, like the handle on a water pump. The upward motion is more pronounced than the outward motion. The lower ribs also move up and out, but the action is mostly outward and resembles the raising of a bucket handle.

Muscles associated with breathing are striated skeletal muscles but they are different in several ways. These muscles are more resistant to fatigue than regular skeletal muscles and can take in oxygen easier to take care of whatever needs may arise. Because they are involved with the vital process of breathing, the respiratory muscles contract rhythmically throughout life rather than episodically. Skeletal muscles work primarily against gravity; the respiratory muscles work against the elastic properties of the lungs and airway resistance. The neurologic control of this system is both voluntary and involuntary. Breathing goes on without our notice, but overlay voluntary control can be exerted at will.

Primary Muscles of Breathing

The primary muscles of breathing are the diaphragm, the intercostals, and the abdominal muscles (Illustration 39). Of these, the diaphragm is the foremost, handling 70-80% of respiratory forces during quiet breathing. It is a circular set of muscle fibers

[94] See Illustration 37.

that arise from the breastbone, the cartilages that connect the front of the ribs to the breastbone, the ribs themselves and the vertebral bodies of L1-L3. These fibers all insert into a central tendon. The diaphragm separates the thoracic cavity from the abdominal cavity and moves about one centimeter during normal breathing. During forced breathing, this movement can increase to as much as ten centimeters. It is innervated by the phrenic nerve which descends from C3-5. During inspiration, the diaphragm contracts and pushes downward. The space inside the rib cage increases and the resulting negative air pressure causes an inflow of air into the lungs. Expiration at rest is virtually passive, with the diaphragm returning to its original position (Illustration 40).

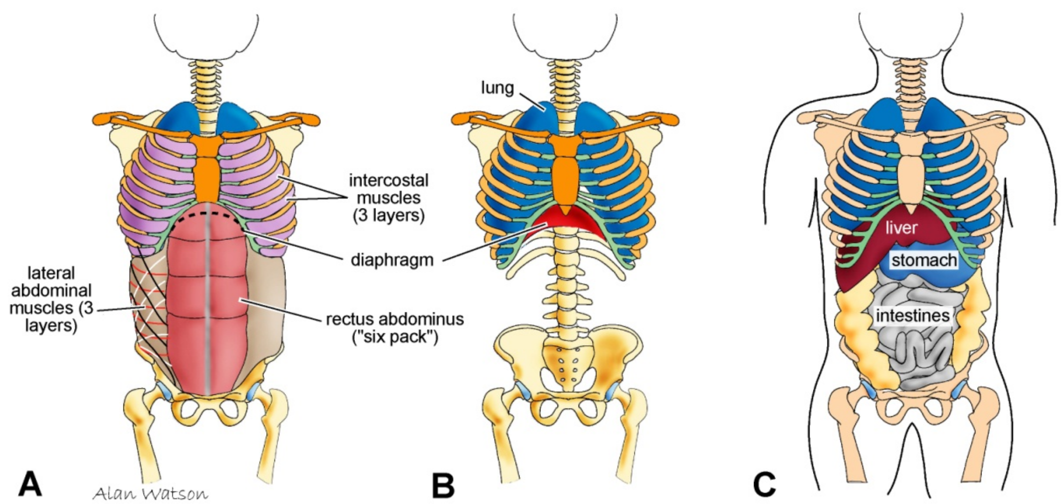

Illustration 39: Major respiratory muscles. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 105, Scarecrow Press, Lanham, MD, 20706, with permission.

The intercostals muscles fill up the spaces between the ribs. They connect the ribs to each other, forming the semi-rigid rib cage so that the area between the ribs isn't pulled in or pushed out during respiration. Made up of three layers, theses muscles include the internal intercostals, the external intercostals, and the innermost intercostals muscles. The diagonally aligned external intercostals are the outermost layer and assist in raising the ribs up and lifting them out during inspiration. Beneath and at right angles to them lie the internal intercostals. Along with the innermost intercostals, the deepest layer, the internal intercostals pull the ribs down and in during expiration. The subcostal muscles are found in lower rib cage and exert actions similar to internal intercostals. The parasternal muscles are the part of the internal intercostals that are next to the breastbone at the front of the chest. They appear to assist in rotating the ribs and therefore raise the breastbone and ribs, but their main function is to stabilize the rib cage against pull of the diaphragm.

Electromyographic (EMG) studies show that external intercostals are active during inspiration and internal intercostals are active during expiration.[95] Both sets become more active as minute ventilation, the amount of air breathed in (or out) in one minute, increases. The activation of these muscles during respiration is from the top down, that is, the recruitment of fibers begins in the higher intercostals spaces early in inspiration and moves downward as inspiration progresses. The lower intercostals muscles appear to be activated only during deep inhalation. On the sides of the rib cage, the lateral intercostals, both internal and external, are active during ventilation and trunk rotation. Their role in rib cage expansion is not as active as the diaphragm and the intercostal muscles that are closer to the breast bone. The major role of the lower lateral intercostals is the axial rotation of the thorax.[96]

The intercostals muscles, external and internal, on the sides of the rib cage are also used to turn the upper trunk to the right or left. No matter which way the rib cage is

[95] EMG stands for electromyography or electromyographic. It is a test involving the insertion of needles that record the electric activity of muscles.

[96] Levangie and Norkin, *Structure & Function,* p. 205.

turning, these lateral intercostals on both sides are working synchronously to produce the action. Because the proposed healthy stance of the flutist involves rotation of the body to the left, the possible left rotation of the thorax must be considered. But by avoiding rotation of the rib cage, the flutist can excuse the lateral intercostals from this rotational function and let them focus instead on assisting the deep breathing necessary for playing the flute. As a reminder, rotation in the lumbar spine is also to be avoided in order to avoid injury. The bulk of spinal rotation in the flutist therefore occurs in the neck or cervical region.

Along with the diaphragm and the intercostals, the abdominals play a major role in respiration. The transverse, oblique and rectus abdominal muscles form layers around the abdominal cavity of the trunk below the rib cage. Their role as flexors and rotators of the trunk is more commonly acknowledged, but they also serve as primary muscles of *forced* expiration. In normal exhalation, no muscular activity is needed; it is virtually passive. So to be exact, the abdominals might be better explained as accessory muscles of respiration; they are not required in normal quiet breathing. But in the playing of wind instruments and singing, the exhalation must be prolonged and therefore altered somehow. In their role as respiratory muscles, the abdominals are active during forced expiration and they also can increase the volume and speed of exhalation.[97]

During inspiration the abdominals have two important roles. They increase the pressure inside the lungs by contracting at the end of a forced expiration. When the end of this cycle is reached, air rushes into the lungs to equalize the pressure. Secondly, as the pressure in the abdomen is increased when the diaphragm is lowered during inspiration, the abdominals provide the muscular contraction that counters this tension. This action

[97] Levangie and Norkin, *Joint Structure & Function,* p. 206.

stabilizes the central tendon of the diaphragm and allows the lateral wall of the rib cage to expand. When the breathing rate increases, the abdominal muscles assist both in exhalation and inhalation.[98] Therefore, in breathing that is deeper or faster than normal, the abdominals play an active role. In normal quiet breathing, they play a smaller role as described in this paragraph, allowing them to be grouped with the primary muscles of respiration.

The scalene muscles are also primary muscles of quiet ventilation.[99] These muscles originate on the sides of the cervical vertebrae C3 – C7 and attach on the first two ribs. They lift the breastbone and the first two ribs in the pump-handle motion of the upper rib cage. Their activity begins at start of inspiration and increases as the amount of air breathed in approaches total lung capacity. The scalenes generate a greater force late in inspiratory cycle as the force from the diaphragm is decreasing[100] – a factor critical to the ending of almost every phrase a flute player plays. The scalenes also stabilize the rib cage along with the parasternal muscles when the diaphragm contracts. Some sources list the scalenes as accessory breathing muscles[101] while others consider them prime movers;[102] in any case, their actions are crucial considerations for the flutist because of the effort required for a quick, deep inhalation and a controlled, long exhalation. Their action of tilting the head to the side becomes problematic to flutists though, as that posture is closely associated with the playing of our instrument. If the flutist adopts this tilted head posture, presumably to avoid raising the right shoulder, the scalenes on the

[98] Levangie and Norkin, *Joint Structure & Function,* p. 206.

[99] A De Troyer and M. Estenne, "Coordination between rib cage muscles and diaphragm during quiet breathing in humans," *Journal of Applied Physiology* 57:3 (1984), pp. 899-906.

[100] Levangie and Norkin, *Joint Structure & Function,* p. 205.

[101] *Clinically Oriented Anatomy* and *The Biology of Music* list the scalene muscles as accessory muscles of respiration.

[102] *Joint Structure & Function* lists the scalenes as prime movers of respiration.

right side are contracting to tilt the head with gravity. This action requires the left scalenes, and other neck muscles on that side, to contract as well to keep the head from tilting too far. The tension found in the neck, working with and against gravity, can be fatiguing. The muscle tension in the scalenes can be strong enough to impinge the brachial plexus as it exits between the front and middle parts of these muscles. The resultant numbness and tingling in the arm or hand, and perhaps neck pain is a signal to the flutist that something is wrong. More detailed actions of the scalenes during the respiratory cycle are a subject of a research study that will be discussed in the later part of this chapter.

The basic mechanism of breathing is summarized in the following illustration (Illustration 40). During inhalation, the diaphragm contacts and pulls downward. The rib cage is drawn upward and outward by the intercostals muscles. This enlargement of the thoracic cavity causes the pressure of air inside the body to be less than the pressure outside; thus, air rushes into the lungs. When bigger breaths than normal are taken in, accessory inspiratory muscles are recruited. Exhalation is primarily a passive event where the body relaxes and deoxygenated air is released into the atmosphere. The diaphragm and intercostals muscles relax. The abdominals can be recruited to push out even more of the used air.

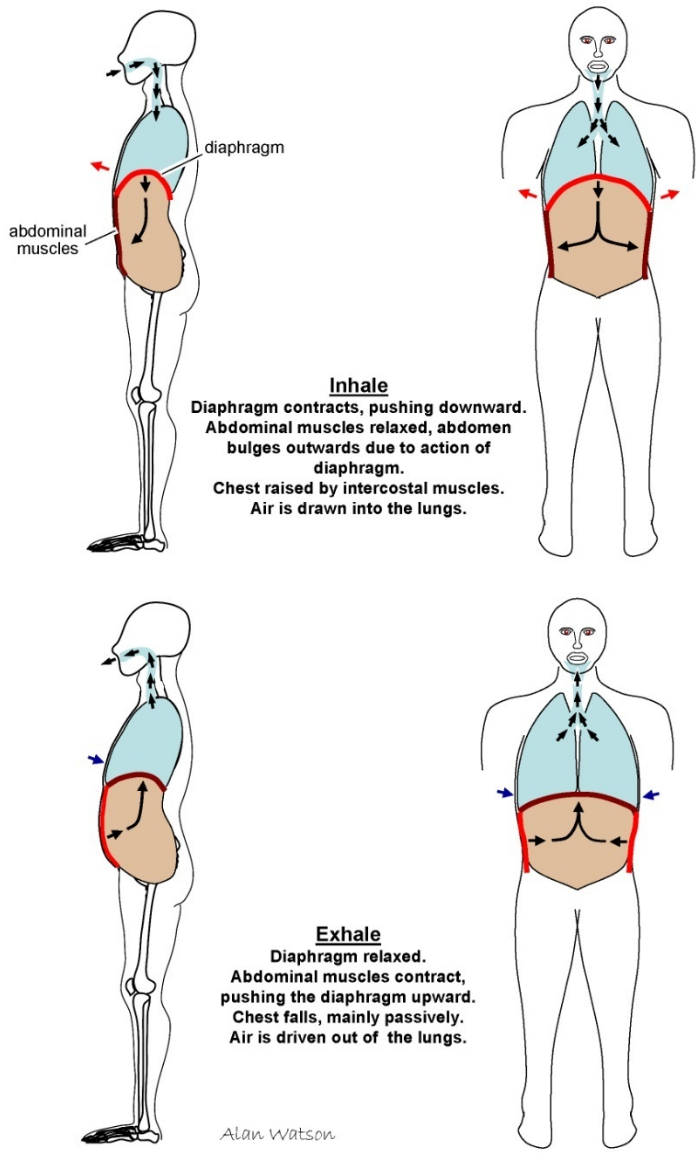

Illustration 40: Summary of breathing. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 106, Scarecrow Press, Lanham, MD, 20706, with permission.

Accessory Muscles of Breathing

Accessory muscles of breathing attach the rib cage to the shoulder girdle, head, vertebral column and pelvis. They assist with breathing in situations of stress such as increased activity (playing a musical instrument or singing) or respiratory disease by moving the rib cage upward and outward during inspiration and moving the diaphragm upward and the thorax downward and inward during expiration. From this group of muscles, those that are part of the trunk include the serratus posterior, pectoralis, subclavius, levatores costarum, transverses thoracis, and abdominals. The accessory breathing muscles in the neck are the sternocleidomastoid, scalenes, and trapezius.[103] The scalenes and abdominals are listed both as primary and accessory muscles of respiration; different sources treat them differently as previously noted. For singers and wind instrumentalists, it seems logical to treat them as prime movers since those muscles are almost always engaged during music making.

The serratus posterior has separate lower and upper parts (Illustration 41). Their role in breathing is assumed but there is no EMG evidence to support this.[104] Both sets of these muscles are on the back; the superior serratus is at the junction of the neck and the ribcage while the inferior is lower where the thoracic and lumbar vertebrae meet. When considering their location and the oblique angles of their fibers, the action of the serratus posterior superior would be to raise the top four ribs, increasing the front-to-back distance of the rib cage and raising the breastbone. Likewise, the serratus posterior inferior's action would be to depress the bottom ribs. Because of the lack of evidence that these muscles have a physical action, it is thought that they are primarily proprioceptive in nature; that is, when they are stretched, they send signals to the brain to report what is happening. The muscles in the back might be stretching and even though the serratus posterior muscles are not doing any physical work to help, they are reporting the action to the brain.

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[103] The way of organizing the accessory breathing muscles presented here was inspired by Dr. Alan Watson's text, *The Biology of Musical Performance.*

[104] Levangie and Norkin, *Joint Structure & Function,* p. 206.

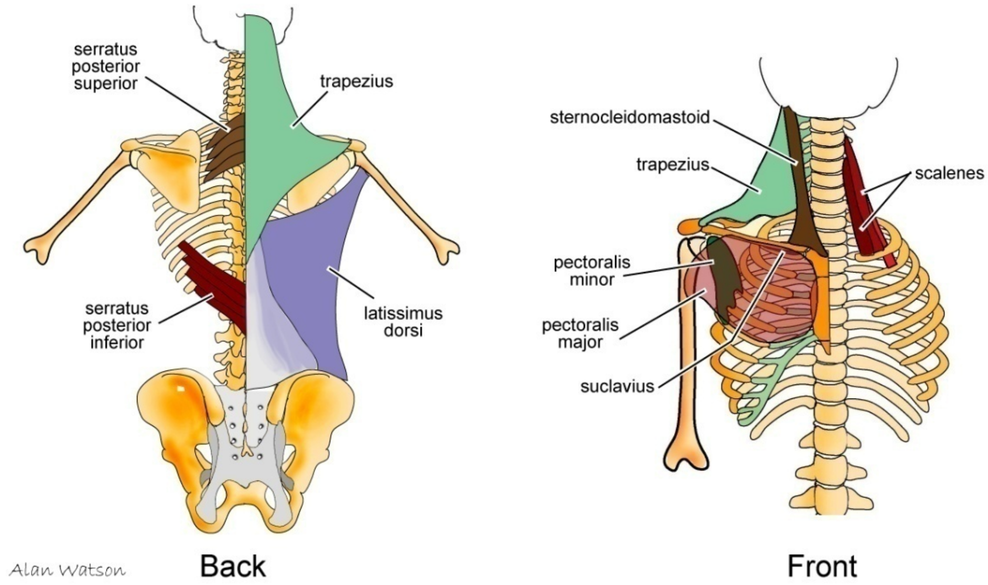

Illustration 41: Accessory respiratory muscles. From *The Biology of Musical Performance,* Alan H. D. Watson, 2009, p. 110, Scarecrow Press, Lanham, MD, 20706, with permission.

More commonly known muscles are the 'pecs,' the muscles on the upper part of the chest. The fibers of the larger pectoralis major begin on the sides of the breastbone and collar bone, converging onto the outside upper edge of the humerus. The pectoralis major adducts the arm, pulling it in toward the middle of the body. It also medially rotates the arm, turning it about its long axis toward the center of the body. In this later function, it works along with the deltoid, latissimus dorsi, subscapularis, and teres major. As the flute playing position requires the arms to hold the flute up against gravity, these muscles work in co-contraction with the external rotators of the shoulder to hold it in place. If the flutist is holding the flute close to the frontal plane, as in the marching band position, the left pectoralis major will be working maximally to pull the left arm across the chest. During regular playing, the flutist can rotate the trunk forty-five degrees to the right, thus releasing the pectoralis major from its load.

The pectoralis minor lies underneath the pectoralis major. It is triangular in shape with its base arising from the third-fifth ribs; the apex of the muscle inserts onto the coracoid process on the underside of the shoulder blade. Assuming the ribs to be stabilized, the pectoralis minor stabilizes the shoulder blade by pulling it down and forward. If the shoulder blade itself is stabilized by other muscles, the pectoralis minor can pull the 3rd-5th ribs upward, an action that would aid inspiration. Here is an example where a good body position of the shoulder blade might provide an advantageous set-up for breathing; with the shoulder blade in as neutral a position as possible, the pectoralis minor would be poised to elevate some of the ribs, assisting in inspiration or in a slow releasing contraction during expiration.

The subclavius is a small muscle that lies immediately below the collar bone, connecting it to the first rib. If the rib is stabilized, the subclavius pulls down and stabilizes the collar bone. If the collar bone is in a fixed position, this muscle can raise the first rib. 'Clavicular breathing,' a technique using the trapezius, pectoralis muscles and the subclavius to raise the shoulders and thus the chest, brings air into the upper lobes of the lungs. This type of breathing is frequently seen in asthmatics, individuals with COPD,[105] or in other conditions in which an individual is struggling for adequate breath. The common body position is sitting or standing with straight arms and the hands on the knees. With the arms and shoulders fixed, the accessory breathing muscles can lift the rib cage and allow the person to inhale more air. Flutists may mimic this rounded shoulder and forward head position in hopes of increasing the amount of air they can inhale. But, when they do so, their arms cannot be leaning on something as an asthmatic's would; they must hold up the flute. Instead of improving the mechanisms of breathing, the body

[105] COPD stands for chronic obstructive pulmonary disease.

must expend extra energy maintaining this position; the rib cage may have even less room for expansion. Scant scientific literature covers this topic and none is related to flute-playing; more study and research needs to be done.

The levatore costarum are twelve small, deep muscles that connect the sides of C7 and T1-11 vertebrae to the ribs. These short, fan-shaped muscles are thought to assist with elevation of the ribs, movement of the vertebrae and/or proprioception.

The transversus thoracis muscles are a flat layer of muscle that runs beneath the parasternal muscles. They connect the breastbone with the 3rd-7th ribs. These muscles pull the rib cage downward along with the abdominals during active expiration such as in coughing, or laughing, or when blowing out more air than a normal exhalation. It would seem that the action of the transverses thoracis during flute playing would be crucial when the flutist uses up the last bits of air in the lungs.

Because the latissimus dorsi, the large muscle that covers the lower half of the back, is attached to six thoracic vertebrae and the bottom three or four ribs, its potential role in breathing has been debated. Since the distal attachment is at the upper end of the humerus, the primary action of this muscle is to adduct, or pull down, the arm. The only way the latissimus could have an action on the vertebrae or ribs would be if the humerus was fixed, as when climbing. With this posture not a part of the musician's stance, it would be reasonable to conclude that the latissimus has no formal role in respiration.

Accessory muscles in the neck include the trapezius, the sternocleidomastoid (SCM), and the scalenes (Illustration 40). The trapezius is the large triangular-shaped muscle that covers a large part of the upper back and neck, connecting the humerus, shoulder blade and collar bone to the body. Beginning from the back of the head and all the cervical and thoracic vertebrae, the trapezius inserts onto the shoulder blade and the collar bone. Because of the different directions of its fibers, the trapezius has several different actions depending upon what part of the muscle is considered. The trapezius can raise, lower or pull the shoulder blade toward the spine. In singers, contraction of the trapezius is generally avoided and seen mostly in inexperienced singers.[106] Its role in assisting respiration may be more closely linked with the sternocleidomastoid. This pair of strap-like muscles extends from a protrusion on the skull behind and below the ear to the top of the breastbone. Usually the SCM turns the head, but in the context of respiration, the SCM can move the ribs in an upward direction. With the trapezius holding the head stationary, both pairs of the SCM can contract together and lift the front of the rib cage up and out, especially at the end of a deep inspiration.[107]

Long phrases on the flute are almost always preceded by a deep inspiration. The head is turned to the left in part by action of the right SCM. This motion is a simple rotation on an axis that is not against gravity. But the SCM is also an accessory inspiratory muscle, so in addition to turning the head, the right SCM also helps to raise the front of the rib cage. The left SCM is in a shortened position, not the best mechanically advantaged position from which to work, but it too will assist with deep inhalations. To keep these muscles in their neutral state would avoid rotation of the head, which puts the onus on the shoulders and upper back to rotate and make room for the flute. A good compromise would be to get the trunk and shoulders neutral and turn the head only the necessary amount and no more. This position combined with stretching and frequent breaks makes the asymmetrical set-up of the flutist less deleterious. The actions

[106] Watkins, *The Biology of Musical Performance*, p. 111.
[107] Levangie and Norkin, *Joint Structure & Function*, p. 206.

of the scalenes are similar to the SCM in this case. They have already been discussed but will be explored further in the summation of the two respiratory studies done on flute players.

Air Volumes of the Lungs

Because the flute is a wind instrument and breathing is an important component of our playing, it is worthwhile to understand the different air volumes scientists and medical personnel use when they discuss pulmonary function. The following chart clarifies these designations:

Table 2. – Air Volumes of the Lungs

Designation	Description	Volume
Tidal Volume	normal, quiet breathing	500 mL[108]
Inspiratory Reserve Volume	deepest inspiration	2500-3500 mL
Expiratory Reserve Volume	deepest expiration	1000 mL
Vital Capacity	greatest volume of air that can be moved in a single breath	sum of tidal, inspiratory reserve and expiratory reserve volume; 4000 – 5000 mL
Residual Volume	remaining air after a maximum expiration	1000 mL
Functional residual capacity	resting volume; volume of air in the system just before a normal respiration	sum of expiratory reserve and residual volume; 2000 mL
Total lung capacity	lung volume at its maximum (after a maximum expiration)	sum of vital capacity and residual volume; 3000 mL

In applying this knowledge to playing the flute, the amount of air flutists use is obviously larger than the tidal volume. During our large intakes of air, we fill up the inspiratory reserve volume. It's interesting to note the huge difference in tidal volume, 500 mL, and the great range of air available in the inspiratory reserve volume, 2500-3000 mL. Many flute teachers have taught their students to take in only the air that they need; to not fill up with every breath. This idea is backed up by science. We can take just a little bit more than the normal tidal volume or up to 3000 mL extra, depending on the

[108] mL is an abbreviation for milliliters.

need. With respect to exhalation, we are able to blow out 1000 more milliliters than what we usually do during normal breathing. In this case, there is a little less extra air. In summary, there is more extra air to inhale than there is to exhale.

Another breathing technique used by flute instructors is for the student to exhale deeply before drawing in the first breath prior to playing. In doing this, the flutist is getting rid of the expiratory reserve, which is in actuality stale air, and replacing it with fresh, oxygenated air. Again, another great idea supported by science.

Organizing the Air

Organizing the breath is an integral part of the flutist's experience as a musician. All wind instruments except the flute require the player to place their lips against or around a mouth piece, creating firm contact. Brass players' lips buzz and reed players cause a reed to vibrate against a mouthpiece, but flutists alone blow freely against the inside wall of the embouchure hole of the headjoint. Large amounts of air are required and learning how to manage that air is a lengthy process for most players. Since inspiration and expiration make up the breathing process, they are the two actions that the flutist can learn to manage in order to become a better player.

The flutist creates the sound of the instrument during a long exhalation. The lungs are used as a reservoir for the air that is used to make the sound and when the flutist is able, to set up the vibration of the larynx in order to create vibrato.[109] Each player has a certain amount of air that he or she can inhale (inspiratory reserve volume) which can be improved to a certain point. The spine and rib cage must be mobile during the intake of

[109] Watson, *The Biology of Musical Performance*, p. 103.

air in order for the lungs to reach their full capacity. Any tension in muscles surrounding the rib cage, shoulders and spine limits the mobility of the rib cage and spine. The tension can come from a number of sources: performance anxiety, pain, or poor posture. A balanced and flexible spinal alignment provides the framework upon which the upper limbs and respiratory apparatus can accomplish their tasks. The upper thoracic vertebrae are able to rotate, but if the flutist is positioned correctly, the rotation of the vertebrae in the trunk will be minimized; this frees up the rib cage to expand as much as possible.

Creating a sound with the flute occurs with a long controlled exhalation; therefore the importance of organizing how this air is expelled is crucial to our music-making. Dr, Moshé Feldenkrais, founder of the Feldenkrais Method, coined the idea of organizing body movement and the application of this to the exhalation involved in flute-playing makes sense. Flutists can improve their phrasing, dynamics, etc., by learning how to better *organize* their air. The rate of exhalation is controlled by what we musicians call support. Gustav Scheck (1901-1984), a German flutist, and Director of the Musikhochschule in Freiburg, Germany (1946-1964), defines support as the "retention of the inhalation position of the ribcage, the sides and the antagonistic diaphragm-abdominal muscle system during the actions of singing and playing." He observed that flutists must maintain a low position of the diaphragm, expansion of the sides of the rib cage and a fixing of the abdominal muscles.[110] Scheck explains the link between breathing and phrasing, turning a disadvantage of the flute into an advantage:

> While string players or keyboard players can occasionally ignore a phrasing problem, the wind player is continually forced to make decisions by the necessity of making breathing cuts. This disadvantage can be transformed into an advantage. With the help of the breath it becomes

[110] Scheck, *The Flute,* p. 179.

> possible to shape themes, to structure sequences and meters eloquently, and to make melodic and harmonic structures of compositions clear to listeners, and even to reach a higher level of interpretation.[111]

Scheck goes on to recommend that "knowledge about anatomical facts and physiological functions, together with intuitive instructional imagery…can lead to quicker innervations and with it to the correct guidance of all the muscular forces, effecting an enhancement of breathing technique." He eloquently makes a case for a strong connection between functional anatomy and expressive musicianship.

Renate Unger, in her method book, *The Flute, a Tutor and Study Book,* discusses the idea of support in the following paragraph:

> …the deliberately controlled discharge of air used in wind-playing technique requires that a short pause be made. This serves to mobilize instantaneously the necessary effort to counter the natural tendency of the air to flow out. Here it is the inhalatory muscles that are the determining factor: after inhalation is completed, they remain activated and form a check to the forces of exhalation and thus to the air trying to escape. Through the addition of a further regulating factor in the form of the resistance to the air offered by the lip aperture, this state of tension between the breathing muscles working antagonistically against each other is increased in effect and expands the entire respiratory tract. The combination of all these forces acting together forms the so-called *support* of the air-column within the respiratory tract; at the same time it allows a proper ratio between the forces of out-flow effort and out-flow resistance to be produced and thus to regulate the breath-pressure. This is a determining factor in wind-technique, and its strength must be programmed in relation to its pitch and intensity. The player will in the course of time acquire a kind of 'pressure memory.'[112]

[111] Scheck, *The Flute,* p. 183.
[112] Unger, *The Flute; A Tutor and Study Book I*, p. 36.

Unger's ideas are supported by recent scientific studies done using flute players as subjects. The two studies found below are among the few done on flute playing, so they will be discussed in detail.

Research Studies

The researchers of the 2000 study "Respiratory parameters during professional flute playing" begin the presentation of their work by outlining the three mechanical processes required to produce a note on the flute:

1. The movement of the lips and orofacial structures which control sound frequency, loudness, and timbre,

2. The action of the respiratory system which provides the driving pressure and air flow required to produce the sound, and

3. The action of the fingers on the fingerings which determine the changes of the notes.[113]

The purpose of the study was to determine which parameters of flute playing are controlled by mouth pressure as opposed to variation in embouchure of the lips, and to investigate how the flutist controls mouth pressure. Three professional flutists were used as subjects to determine what respiratory parameters they used to control note changes and loudness during flute playing. Abdominal and rib cage changes during playing were so large that the researchers found them unreliable from which to measure volume. Instead they used transpulmonary pressure as a measure of lung volume during flute playing.

[113] Isabelle Cossette, Pawel Sliwinski, and Peter Macklem, "Respiratory parameters during professional flute playing," *Respiratory Physiology* 121 (2000), pp. 33-44.

The same flute was used for all subjects – a Sankyo, Etude model, with a RS1 Cooper headjoint. The flutists were asked to sustain different tones as long as possible at different loudness. They played D4, B5, G6, and C7 both *forte* and *piano*, with and without vibrato, *piano* crescendoing to *forte*, and *forte* with a diminuendo to *piano*. The flutists also performed staccato without tonguing in three different registers at a *mezzo forte*. The researchers measured esophageal pressure, gastric pressure, mouth pressure, diaphragmatic, antero-posterior and lateral rib-cage dimension, antero-posterior abdominal dimension, and sound.

In the results of their study, the researchers found that pitch and loudness increased with mouth pressure. When switching from a high C to a low D the flutists had to make a fast switch between expiratory muscle recruitment to inspiratory muscle braking. "Inspiratory muscles are recruited for a longer period when a low and soft note is played than when a high and loud note is played."[114]

With respect to thoraco-abdominal motion, inspiration was very similar among the three players: an initial outward abdominal displacement followed by decreasing abdominal dimensions while the rib cage expanded and an initial diaphragmatic contraction followed by a strong contraction of inspiratory rib cage muscles. But there the similarities ended.

The thoraco-abdominal motion during expiration varied widely. The first subject's rib cage volume diminished with constant abdominal dimension, followed by an abrupt change with decreasing abdominal dimensions at nearly constant rib cage volume. The third subject did the opposite – initial decrease in abdominal dimensions while rib cage volume was constant followed by decreasing rib cage volume at nearly constant

[114] Cossette, et al., "Respiratory parameters," p. 37.

abdominal dimensions. And the second subject decreased the volume of both compartments simultaneously – a compromise between the two. The researchers concluded that "professional flute players use different strategies and employ different muscle groups in different sequences while playing the same note at the same intensity."[115]

This study also looked at the role of respiratory muscles in playing vibrato and staccato. In playing vibrato, two of the subjects used non-diaphragmatic inspiratory muscles for the braking of air in producing the vibrato; inferring that the diaphragm played no role. One of the subjects had some phasic diaphragmatic activity but it stopped halfway through the tone (the vibrato did not stop); the researchers inferred that this flutist used non-diaphragmatic inspiratory braking at least part of the time to produce vibrato as well. I disagree with the authors of this study and their assertion that vibrato could have been created by the accessory inspiratory muscles. It occurred during the contraction of these muscles; that in itself does not prove that those muscles created the vibrato itself. The researchers did point out that variation in the glottis aperture produced by laryngeal muscles would also produce the observed pattern.

In the three subjects, staccato, played without tonguing, was initiated by abdominal muscle contractions and terminated by diaphragmatic contraction. Although the paper does not provide exactly how the flutists carried out this task, it is reasonable to assume that they played a note on the flute using the syllable 'tah' with a strong burst of air. The researchers outlined four steps to the production of staccato:

1. Pressure to play the note was provided by a contraction of abdominal muscles,

[115] Cossette, et al., "Respiratory parameters," p. 38.

2. The diaphragm was then recruited which limited sound intensity and stopped flow,

3. The abdominal muscle relaxes and the sound was over, and

4. The diaphragm was reactivated and air was inhaled.

In monitoring the control of pitch and loudness, it was found that for any given note, an increase in loudness was produced by an increase in flow. Air velocity increased mainly with pitch. As loudness increased there was smaller increase in velocity; this effect was more evident during low notes than high ones. Mouth pressure increased when playing *forte* notes by 1.5 – 2.0 times.

To clarify the role of mouth pressure and area of embouchure in sound production, the researchers proposed that the flutist must coordinate four variables in order to play the flute:

1. The flute tube length, by fingering, and the nominal pitch of the note being played,

2. The lip-to-flute jet length (sometimes referred to as the 'air reed'),

3. The velocity of the jet (speed), and

4. The jet flow (amount of air).

The velocity and jet flow are controlled by two respiratory parameters over which the flutist has direct control, mouth pressure and the area of the embouchure of the lips. Therefore, the strategy for playing a note softly but in tune is to either reduce the aperture in order to reduce the flow while keeping the mouth pressure constant, or to reduce them together in order to reduce the flow but also decrease the jet length (air reed) and coverage of the embouchure hole, thus counteracting the flattening effect of the reduced blowing pressure. The opposite applies to very loud playing.

In summary, regarding the respiratory muscle action during flute playing, the flutist controls the mouth pressure directly which determines jet velocity and therefore the pitch. The results of this study indicate that coordination of the respiratory muscles to produce mouth pressure in not particularly important; each player differed. The braking of the expiration could be by inspiratory muscles or narrowing of the glottis (closing the throat). The research team stated that the term 'support' was used to describe which muscles accomplish this during flute playing. In the public domain this is often erroneously described as diaphragmatic. None of these subjects used their diaphragms tonically while playing long tones and the second subject used his/her only during part of vibrato. The diaphragm acted only to stop the note. The researchers were bold enough to say that "This is important for flute teaching as it contradicts what is generally taught to flautists, namely that 'support' is accomplished by the diaphragm."[116] It is important to note that the diaphragm cannot be detected by EMG, but its recruitment can be inferred from the analysis of motion and pressure.

"Respiratory parameters during profession flute playing" concluded that although the flutists used much the same lip apertures and mouth pressure, the muscles they used to regulate mouth pressure can differ markedly. The pattern of respiratory muscle coordination did not seem to be an important determinant of sound quality. Markedly different coordination of respiratory musculature produced the same mouth pressure.

The implications for playing and teaching of the flute from this study are numerous. There is not just one 'right' way to teach breathing while playing; there may

[116] Cossette, "Respiratory parameters," p. 43.

be in fact several different ‘correct’ breathing patterns. The researchers recommend that flutists focus more on the control of pressure and area of the aperture than on a specific muscle activity. They further state that it is important to teach how to control flow and velocity independently by mouth pressure and the area of the embouchure in order to play in tune and precisely control loudness. Pitch and loudness must be controlled independently. They are controlled by velocity and flow, which in turn are controlled by pressure and aperture. And finally, the team addresses the fine control of intonation. To increase loudness without going sharp, the transit time (the time the air takes to pass through the air reed) must stay the same while the flow must increase. The transit time is controlled by both velocity and distance; therefore by altering the distance, the length of the air reed is modified to prevent sharpness.

The second important study of ventilation and flute playing is “Chest wall dynamics and muscle recruitment during professional flute playing.”[117] Two of the authors were also listed as authors for the previous study. This study is a more recent work, completed in 2007. In this project, the researchers began with the following working definition of ‘support:’

> Physiological processes used by the player to control precisely the sound production which is directly linked to the control of air flow, air velocity and pressure required to play a specific note or a musical passage.[118]

The authors explain that the flute is a low-pressure wind instrument; during playing flute and singing, both low pressure activities, inspiratory muscles are recruited as antagonists to the expiratory act of playing or singing. At high lung volumes, the

[117] Isabelle Cossette, Pierpaolo Monaco, Andrea Aliverti, and Peter Macklem, “Chest wall dynamics and muscle recruitment during professional flute playing,” *Respiratory Physiology & Neurobiology* 160 (2008): pp. 187-95.

[118] Ibid, p. 187.

elastic recoil of the respiratory system is too high for most notes produced on a flute; there has to be a counterbalance to slow down the exit of air from the lip aperture. This action is provided by an inspiratory muscle contraction by non-diaphragmatic inspiratory muscles. The authors state that the diaphragm has been shown to be active during staccato, some vibrato and abrupt decreases of pressure, such as when going from a high note to a low note. The goal of the study was to find some features that are common to all flute players that would lead to a definition of support. The researchers sought to identify:

1. The rib cage and abdominal kinematics associated with support,
2. The muscles that were recruited to produce support,
3. How these muscles were coordinated to achieve the respiratory patterns associated with support, and
4. How this allowed better control of the required pressures and flows to play the flute.

Because elastic recoil of the respiratory system decreases continually during the playing of a phrase, measurements were performed as a function of lung volume. The scientists measured chest wall displacements, EMG of respiratory muscles, mouth pressure, and recorded sound with and without support in four young professional flutists. The EMG measurements were taken of the lateral abdominals, scalenes, parasternals, rectus abdominus, and sternocleidomastoids. The same flute, an Etude model Sankyo with a RS1 Cooper headjoint, was used by each of four players. They each played an excerpt from the second movement of the Poulenc Flute Sonata, a movement known for its long *pianissimo* melodic lines in all registers of the flute. No definition of support was given to the flutists; they were all asked to play with and without support, but always without vibrato.

In the results of the study, the researchers looked at flows, chest wall volumes and thoraco-abdominal coordination. They found that average flows per phrase were smaller during playing with support and that flow tended to be higher and started more abruptly without support than with it. The amount of air left in the lungs after each phrase was played was consistently higher in players that used support as compared to those who did not.

The researchers observed that the main contribution to total residual capacity behavior (air left in the lungs) was provided by the pulmonary rib cage, implicating the non-diaphragmatic inspiratory muscles in the provision of support. These are the muscles which act directly to expand the pulmonary rib cage; the diaphragm acts on the abdomen and abdominal rib cage. All subjects showed greater rib cage expansion during support.

Results concerning respiratory muscle activation showed that non-diaphragmatic inspiratory muscles (scalene and sternocleidomastoids) were more activated during support. A summary of the pool of data showed that scalene activation decreased as volume decreased whereas the opposite was the case for the lateral abdominals. The scalenes experienced a higher activation during support playing regardless of volume and the strong lateral abdominals are recruited at the end of phrases played without support, right after functional residual capacity level is reached. They conclude that both volume (rather than time) and condition (support versus without support) are determinants of muscular activation.

When studying mouth pressures and sound analysis, the researchers found variations in mouth pressure that seemed greater during support than without, indicating that more vibrato occurred during support than without. Previous studies have shown that there is no noticeable difference in flow, the major determinant of sound intensity, between support and without support.

In the authors' discussion of their study, they arrive at a new definition of support:

> Flute breath support is a mechanism to avoid the recruitment of expiratory muscles in order to decrease lung volume during playing so that they can best exert fine control over the mouth pressure modulations required for high quality playing without being encumbered by other tasks. This is achieved by inspiratory muscle recruitment as demonstrated by their greater electrical activation which keeps the rib cage expanded, lung volumes higher and the expiratory muscles relatively relaxed. This was demonstrated by their decreased activation during support playing at the end of the phrases.[119]

The authors state that these results may apply to singing as well because both are low-pressure expiratory activities. The study concludes by stating one of their aims – that music teachers will soon be able to teach support based upon sound physiological principles rather than intuition.

In a more general sense, Dr. Alan Watson's definition of support is as follows:

> …support is the regulation of air pressure and the velocity of airflow in the respiratory system during expiratory episodes underlying singing of wind playing and is generated by a dynamic interaction between expiratory and inspiratory muscles.[120]

Different flutists will use different strategies to achieve the long exhalation required to sustain their playing. The transition between the braking of inspiration to the active forceful expiration occurs at different times for each exhalation. Learning to sense this in themselves and in their students will provide flutists with more knowledge of how their body works and give them the tools to regulate it.

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[119] Cossette, et al., "Chest wall dynamics," p. 194.
[120] Watson, *The Biology of Musical Performance*, p. 114.

CHAPTER ELEVEN

SUMMARY AND CONCLUSIONS

Through this project, I sought to investigate the physical aspects of playing the flute through three separate avenues. Anecdotal evidence indicates that flutists are having physical issues, playing with pain, or even quitting because of their unspoken injuries. During many masterclasses, the atrocious posture of student after student goes unnoticed and/or uncommented upon by the otherwise excellent instructor. Yes, making beautiful music is the main thing, but the physical side of playing the flute is too quickly cast aside as secondary and therefore, unimportant. Even though there is great variety within the human race, there is still enough commonality among us to clarify certain anatomical principles that would benefit all flutists. By surveying a large sample of flutists, interviewing selected professional flutists, and investigating the functional anatomy of flute playing through a study of scientific literature, this document makes a significant contribution to the current body of knowledge concerning the physical aspects of playing the flute.

This study began with an online survey with questions related to the choice of flute specifications and alignment, hand and body set-up, incidences and location of pain, amount of education concerning the body, and self-reporting of fitness levels. Although shoulder and perhaps arm problems were anticipated, most flutists indicated the neck, upper back, and shoulders as their most painful areas with respect to flute-playing; further research in this project was therefore focused in that direction. Many respondents described turning their bodies to the right for their playing stance both in sitting and standing positions, which is encouraging. Two other surprises were the large majority of flutists that used the traditional classic alignment and the smaller than expected number of flutists that had trouble keeping the joints of their right little fingers from collapsing.

The limited use of technology is troublesome; we should be recording ourselves and our students more, both in sound and visual media. This area could be readily addressed at our state and national conventions with more workshops designed to teach amateur and professional flute teachers and their students what the latest equipment is and how to use it.

Interviewing six professional flutists, while interesting and informative, became for some of them a deeply revealing and emotional journey. To a flutist, these brave people were incredibly open with their own experiences; their life stories can teach us much about what to do and what to avoid in our lives as professional and amateur flute players. Four out of the six had experienced serious injuries related to their flute playing that had a dramatic impact on their career, taking us 'behind the scenes' in an issue that is typically verboten in the music world. Hopefully, this more open attitude will continue to grow and spur others to share their stories as well. We do not want to be like sheep and blindly follow one another off a cliff; if we have done something wrong in our playing that had disastrous consequences, sharing it may help others avoid the same fate. Likewise, if a flutist comes back from a seemingly impossible injury, should we not all rejoice and learn how they fought their way back to health? The more open our communication can be in the arena of performance-related health disorders, the more we will be able to learn how to avoid these problems in the first place.

Investigating the functional anatomy of the body from head to toe as it plays the flute involved a review of standard scientific concepts plus the creation of many new connections between music-making and medicine, resulting in several small but significant revelations. The multiple demands placed upon the scalene muscles are a case in example. Pierced by brachial plexus, these muscles turn the neck and lift the top two ribs; such multi-tasking can lead to overuse problems. But by rotating on a properly aligned skull, we can avoid recruiting the scalenes at least in this one respect; the highest scalene goes to C4 and the ‘no’ head motion occurs higher, between C1 and C2. Another important concept is the overlap of symptoms and the connection between temporomandibular joint dysfunction and forward head posture. Also helpful for flute teachers to use with their students was the investigation of the two muscle groups attached above and below the hyoid bone. To enlarge the oropharyngeal cavity, the infrahyoid muscles need to contract to pull down the larynx. Even though the jaw and vocal tract were studied in this document, they are very complicated subjects, requiring more study and research.

The investigation into the muscles of breathing clarified the methods flute players use to play their instrument and pointed out the dual function of some of those muscles. Flutists must learn to organize their breathing; another way to put this is that they have to figure out how, when and in what order they are going to switch from braking the accessory inspiratory muscles to contracting the accessory expiratory muscles – all the time keeping the air speed at a particular level. To my way of thinking, this is the most accurate definition of support.

Another epiphany under the subject of breathing is the dual use of some of shoulder muscles. The pectoralis minor and the serratus anterior are examples of two muscles that are used for the greater-than-normal breathing demands of the flutist and also for stabilizing the arms in their position of holding the flute up against gravity. Both these muscles connect the ribs to the shoulder blade. They work to brake or slow down the relaxing of the inspiratory action of the rib cage; in this action the shoulder blade is the fixed end of the muscle. But the shoulder blades are also working to support the arms against gravity. If the elbows are out, the arms then are internally rotated and the shoulder blades are even further from their neutral position. Other muscles must support the shoulder blades while they support the arms and helps the ribs move during breathing. The muscles that do that, including the rhomboids, levator scapulae, trapezius, etc., are all connected to the spine. This kinetic chain is why we as flutists have neck and upper back problems.

One last point about muscles with a dual function during flute playing bears repeating. The intercostal muscles between each rib assist in trunk rotation in addition to their respiratory function. This fact, plus the need to keep the rib cage at a point where it can expand the most, and the tendency for the spine to incur more injuries when twisted, leads me to recommend a non-rotated body position, except for the upper neck, when playing flute.

In considering the shoulders and arms during flute playing, the importance of the weaker and smaller external rotators and abductors of shoulder holding arms up against gravity is central to motivating flutists to keep their elbows down. The left hand should avoid radial deviation and supination but its wrist can be extended. The left thumb should be kept straight and not used to support the flute; instead the ‘natural crutch’ of the head of the 2nd metacarpal should be used as a fulcrum for the flute. The right hand wrist can be slightly extended but it should be deviated radially as little as possible. The right thumb should be placed under the 2nd or 3rd digit to provide a central axis for the right hand.

The great variety in humans of the different levels of interconnections in extensors and flexors of hand is something we all should explore individually; knowing what your fingers can and cannot do can prevent frustration and injuries. Hyperextension in the right little finger, though not as big a problem as originally thought, is caused by loose lateral bands of the tensor expansions of the fingers. Positioning and/or splinting can help solve the problem. In the pressing of the keys of the flute, a co-contraction of flexors and extensors of fingers is required; less pressure, less muscle fiber recruitment and therefore, less tension. The lumbricals bend the MP joints during the many changes of fingering; they work together with the deep forearm flexors.

The underlying theme to all these muscular functions is summarized by the idea of the kinetic chain. A small, seemingly insignificant action of the little finger can have ramifications all the way back to the spinal column. Any distal action is undergirded by proximal support. Therefore it is not only important to pay attention to what our fingertips are doing when we play the flute, but we must also consider other anatomical structures that makes that action possible.

This investigation into the actions of the body during flute playing did provide a more thorough overview of the kinetic chain triggered by playing the flute; more details are still needed but they are beyond the scope of this project. There is much more work to be done in research on flutists including the effect of fitness levels on playing, the effectiveness of different methods of learning in small muscles, how the brain deals with the asymmetrical stance required of flutists, recovering from focal dystonia, the mechanisms of vibrato and continued work in the area of pain and its relation to the stance of the flutist.

In addition, an international effort to develop a standard education of flute instructors as well as their students in the physical aspects of flute playing is needed. We should make better use of marketing principles and figure out how to 'make it stick;'[121] that is present material in such a way that it makes sense immediately and is memorable. We need to be more aware and well-versed in different learning styles, using research studies to guide what methods to use not only in the classroom but also during the private lesson.

We need to begin serious work with band directors concerning the marching band flute stance. Although beyond the scope of this study, the contorted spine of this stance needs to be documented through x-rays and surveys of a large sample of high school and college marching band flutists. Information concerning the percentage of bands that use piccolo instead of flute on the field would also be interesting.

The National Flute Association could take the lead in many of these recommendations. The National Convention as well as state festivals could provide standardized pedagogy workshops to standardize teaching practices and make good

[121] Chip Heath and Dan Heath, *Made to Stick*, New York: Random House, 2007.

principles of teaching available to all.[122] The purpose is not to make cookie cutter teachers, but to assure a certain level of expertise that would guarantee that flute students would be taught accurately.

[122] NATS, the National Association of Teachers of Singing, does this already, providing standards, teaching practices and a code of conduct for its members.

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APPENDIX A

ONLINE SURVEY QUESTIONS

Online Survey Questionnaire

1. What position of flute head-joint alignment do you yourself use?
    a. Rockstro
    b. Modified Rockstro
    c. Classic
    d. Other

2. What position of flute head-joint alignment do you teach?
    a. Rockstro
    b. Modified Rockstro
    c. Classic
    d. Other

3. What type and make of head-joint do you have?
    a. Brand ____
    b. High wall or regular? __________________________
    c. Wings? ____

4. What weight tubing is your flute?
    a. .014 (thin-walled)
    b. .016 (regular thickness)
    c. .018 (thick-walled)

5. Does your flute have a C or a B foot?
    a. C foot
    b. B foot
    c. I have both but use the C foot more often
    d. I have both but use the B foot more often

6. Is your flute open or closed-hole?
    a. Open
    b. Closed

7. Does your flute have an in-line or off-set G key?
    a. In-line
    b. Off-set

8. Does your flute have a C# trill key?
    a. Yes
    b. No

9. What is the position of your right pinky during playing?
    a. All joints slightly bent
    b. Straight
    c. Some or all joints collapsed (or hyper-extended)

10. What is the position of the most distant (furthest from your palm) joint of your left thumb when playing?
    a. Bent
    b. Straight

11. What is the position of your left elbow during playing?
    a. Raised significantly
    b. Slightly raised
    c. Down

12. What is the position of your left wrist during playing?
    a. Bent
    b. Straight

13. Do you usually sit or stand when practicing?
    a. Sit
    b. Stand
    c. Alternate

14. When you sit (performing or practicing), describe the relationship of your chair to the stand.
    ____

15. Describe how you adjust your stand height.
    a. When sitting ____
    b. When standing ____

16. How much time do you spend practicing daily? Estimate the number of hours. An example would be 2.5. ___________________________________

17. How much time do you spend practicing weekly? Estimate the answer in hours. An example would be 7.0 or 7.5. _______________________

18. Do you practice with a mirror?
    a. Yes
    b. No

19. Do you ever videotape your practicing?
    a. Yes
    b. No

20. When you play/perform, how much do you move?
    a. A lot
    b. Some
    c. A little
    d. Not at all

21. If you do move while playing, check all that apply.
    a. Shift weight from back to front
    b. Bend and straighten your spine
    c. Raise and lower your head
    d. Move your arms
    e. Other (please specify) ______________________

22. Where do you usually perform?
    a. In a pit
    b. On stage
    c. Chamber hall
    d. Other (please specify) _________________________

23. Do any of your fingers ever uncover a key when playing? If so, which ones?
    a. Yes
    b. No
    c. Left middle finger
    d. Left ring finger
    e. Right index finger
    f. Right middle finger
    g. Right ring finger

24. Do you wear glasses?
    a. Yes
    b. No
    c. Bifocals
    d. Trifocals
    e. Reading
    f. Music-reading only glasses

25. Do you wear earplugs when you play or practice?
    a. Yes
    b. No

26. Do you experience pain while playing?
    a. Never
    b. Seldom
    c. Sometimes
    d. Always

27. Do you experience pain after playing?
    a. Never
    b. Seldom
    c. Sometimes
    d. Always

28. Does pain ever stop you from playing the flute?
    a. Never
    b. Seldom
    c. Sometimes
    d. Always

29. How much of your practice and performance time is affected by pain?
    a. None
    b. 20%
    c. 40%
    d. 60%
    e. 80%
    f. 100%

30. Place a check in the box before each area where you experience pain associated with flute playing.
    a. Neck
    b. Jaw
    c. Right upper back
    d. Left upper back
    e. Lower back
    f. Right shoulder
    g. Left shoulder
    h. Right upper arm
    i. Left upper arm
    j. Right elbow
    k. Left elbow
    l. Right forearm
    m. Left forearm
    n. Right wrist
    o. Left wrist
    p. Right hand thumb
    q. Left hand thumb
    r. Left hand index finger
    s. Right hand pinky
    t. Other (please specify) ____________

31. Have you ever experienced any of the following?
    a. Trembling of the lips?
    b. Trembling of the chin?
    c. Trembling of the cheeks?
    d. Loss of muscle coordination in fingers?
    e. Loss of muscle coordination in embouchure?

32. Have you modified your flute in any way because of pain or an injury? If yes, please explain what on the flute has been modified. ________________________

33. Have you ever consulted with a health care professional about anything related to your body and flute playing?
    a. Yes
    b. No

34. Have you ever studied anatomy, physiology, or neurology at the college level?
    a. Anatomy
    b. Physiology
    c. Neurology
    d. None of the above

35. Have you ever taken a college-level course in health issues for musicians?
    a. Yes
    b. No

36. Have you studied any of the following? Check all that apply.
    a. Yoga
    b. Alexander Technique
    c. Feldenkrais
    d. Pilates
    e. Delacroix
    f. Other (please specify) ________________________

37. When you began flute, did your teacher teach you about the asymmetrical nature of playing the flute?
    a. Yes
    b. No

APPENDIX B

ONLINE SURVEY DATA

Survey Results

Question and Choices	Response Percent	Response Count
1. What position of flute head-joint alignment do you yourself use?		
Rockstro	6.2%	11
Modified Rockstro	23.6%	42
Classic	**64.6%**	**115**
Other	5.6%	10
	answered question	178
	skipped question	3
2. What position of flute head-joint alignment do you teach?		
Rockstro	3.0%	5
Modified Rockstro	13.2%	22
Classic	**54.5%**	**91**
Various	29.3%	49
	answered question	167
	skipped question	14
3. What type and make of head-joint do you have?		
Altus	1.5%	2
Burkart	3.6%	5
Burkart & Phelan	2.2%	3
deMedici	2.2%	3
Gemeinhardt	5.8%	8
Howel Roberts	0	0
Haynes	7.3%	10
Jupiter	2.9%	4
Pearl	5.8%	8

Question and Choices	Response Percent	Response Count
Powell	**15.3%**	**21**
Tom Green	0	0
Yamaha	8.8%	12
Miyazawa	11.7%	16
Emerson	1.5%	2
Muramatsu	10.9%	15
David Williams	7.3%	10
Sankyo	1.5%	2
Mara Goosman	0	0
Dana Sheridan	7.3%	10
JF Lafin	3.6%	5
Trevor James	1.5%	2
Di Zhao	0	0
Richard Volet	0	0
Robert Bigio	1.5%	2
Emerson DeFord	0	0
Brannen	12.4%	17
McKenna	0.7%	1
Other		55
	answered question	137
	skipped question	44
4. Check all that apply to your head-joint.		
Wings	5.7%	10
High wall	6.4%	11
Regular wall	52.0%	89
Engraving	12.9%	22

Question and Choices	Response Percent	Response Count
Silver-plated	3.5%	6
Solid silver	**66.1%**	**113**
Gold-plated	8.8%	15
Aurumite	1.8%	3
Platinum	4.1%	7
Other		57
	answered question	171
	skipped question	10
5. What weight tubing is your flute?		
.014 (thin-walled)	14.5%	25
.016 (regular thickness)	**71.1%**	**124**
.018 (thick-walled)	13.9%	24
	answered question	173
	skipped question	8
6. Does your flute have a C or a B foot?		
C foot	9.4%	17
B foot	**81.8%**	**148**
I have both but use the B foot more often	3.9%	7
I have both but use the C foot more often	5.0%	9
	answered question	181
	skipped question	0

Question and Choices		Response Percent	Response Count
7. Is your flute open or closed-hole?			
	Open	**94.4%**	**169**
	Closed	5.6%	10
		answered question	179
		skipped question	2
8. Does your flute have an in-line or off-set G key?			
	In-line	45.6%	82
	Off-set	**54.4%**	**98**
		answered question	180
		skipped question	1
9. Does your flute have a C# trill key?			
	Yes	**53.9%**	**96**
	No	46.1%	82
		answered question	178
		skipped question	3
10. What is the position of your right pinky during playing?			
	All joints slightly bent	**82.3%**	**149**
	Straight	14.4%	26
	Some or all joints collapsed (or hyper-extended)	3.3%	6
		answered question	181
		skipped question	0

Question and Choices	Response Percent	Response Count
11. What is the position of the most distant (furthest from your palm) joint of your left thumb when playing?		
Bent	**51.4%**	**92**
Straight	48.6%	87
	answered question	179
	skipped question	2
12. What is the position of your left elbow during playing?		
Raised significantly	1.1%	2
Slightly raised	**53.9%**	**96**
Down	44.9%	80
	answered question	178
	skipped question	3
13. What is the position of your left wrist during playing?		
Bent	25.6%	46
Slightly Bent	**51.1%**	**92**
Straight	23.3%	42
	answered question	180
	skipped question	1
14. Do you usually sit or stand when practicing?		
Sit	17.1%	31
Stand	**49.7%**	**90**
Alternate	33.1%	60
	answered question	181
	skipped question	0

Question and Choices	Response Percent	Response Count
15. When you sit (performing or practicing), describe the relationship of your chair to the stand.		
	answered question	170
	skipped question	11
16. Describe how you adjust your stand height.		
When sitting	98.3%	169
When standing	98.8%	170
	answered question	172
	skipped question	9
17. How much time do you spend practicing daily?		
30 minutes	21.2%	38
1 hour	**23.9%**	**43**
1 ½ hours	16.1%	29
2 hours	15.0%	27
2 ½ hours	4.4%	8
3 hours	8.9%	16
3 ½ hours	0.6%	1
4 hours	5.0%	9
More than 4 hours	5.0%	9
	answered question	180
	skipped question	1

Question and Choices		Response Percent	Response Count
18. How much time do you spend practicing weekly?			
	1-3 hours	17.1%	31
	4-6 hours	24.9%	45
	7-10 hours	23.2%	42
	10 or more hours	**34.8%**	**63**
		answered question	181
		skipped question	0
19. Do you practice with a mirror?			
	Yes	16.3%	29
	Sometimes	**63.5%**	**113**
	No	20.2%	36
		answered question	178
		skipped question	3
20. Do you ever videotape your practicing?			
	Yes	4.5%	8
	Sometimes	14.5%	26
	No	**81.0%**	**145**
		answered question	179
		skipped question	2
21. When you play/perform, how much do you move?			
	A lot	9.0%	16
	Some	**59.6%**	**106**
	Just a little	30.3%	54
	Not at all	1.1%	2
		answered question	178
		skipped question	3

Question and Choices	Response Percent	Response Count
22. If you do move while playing, check all that apply.		
shift weight from back to front foot	**82.1%**	**138**
bend and straighten your spine	38.7%	65
raise and lower your head	41.1%	69
move your arms	45.8%	77
Other		
	answered question	168
	skipped question	13
23. Where do you usually perform?		
In a pit	16.7%	27
On stage	**90.1%**	**146**
chamber hall	34.6%	56
	answered question	162
	skipped question	19
24. Do any of your fingers ever uncover a key when playing? If so, which ones?		
Yes	23.6%	41
No	**50.6%**	**88**
Left middle finger	5.7%	10
Left ring finger	17.8%	31
Right index finger	9.2%	16
Right middle finger	8.0%	14
Right ring finger	31.0%	54
	answered question	174
	skipped question	7

Question and Choices		Response Percent	Response Count
25. Do you wear glasses?			
	yes	no	response count
Yes or no	**70.7% (123)**	29.3 (51)	174
Bifocals	29.2% (35)	**70.8% (85)**	120
Trifocals	16.2% (16)	**83.8% (83)**	99
Reading	36.7% (40)	**63.3% (69)**	109
Glasses while playing music	**62.5% (80)**	37.5% (48)	128
26. Do you wear earplugs when you play or practice?			
Yes		7.2%	13
Sometimes		43.1%	78
No		**49.7%**	**90**
If yes, please describe what type (custom, over-the-counter)			89
		answered question	181
		skipped question	0
27. Do you experience pain while playing?			
Never		14.0%	25
Seldom		33.1%	59
Sometimes		**48.9%**	**87**
Always		3.9%	7
Please describe the pain that you experience			137
		answered question	178
		skipped question	3

Question and Choices	Response Percent	Response Count
28. Do you experience pain after playing?		
Never	25.6%	46
Seldom	33.3%	60
Sometimes	**36.7%**	**66**
Always	4.4%	8
Please describe the pain you experience.		101
	answered question	180
	skipped question	1
29. Does pain ever stop you from playing the flute?		
Never	**54.2%**	**97**
Seldom	27.4%	49
Sometimes	16.8%	30
Always	1.7%	3
	answered question	179
	skipped question	2
30. How much of your practice and performance time is affected by pain?		
None	**46.4%**	**83**
20%	38.0%	68
40%	5.6%	10
60%	6.1%	11
80%	2.2%	4
100%	1.7%	3
	answered question	179
	skipped question	2

Question and Choices	Response Percent	Response Count
31. Place a check in the box before each area where you experience pain associated with flute playing.		
Neck	**41.%**	**66**
Jaw	13.0%	21
Right upper back	24.8%	40
Left upper back	28.6%	46
Lower back	14.9%	24
Right shoulder	26.7%	43
Left shoulder	29.2%	47
Right upper arm	3.7%	6
Left upper arm	4.3%	7
Right elbow	7.5%	12
Left elbow	6.8%	11
Right forearm	11.2%	18
Left forearm	8.7%	14
Right wrist	25.5%	41
Left wrist	21.1%	34
Right hand thumb	15.5%	25
Left hand thumb	10.6%	17
Left hand index finger	14.3%	23
Right hand pinkie	14.3%	23
Other (please specify)	15.5%	25
	answered question	161
	skipped question	20

32. Have you ever experienced any of the following?

Trembling of the lips	**58.1%**	**50**
Trembling of the chin	16.3%	14
Trembling of the cheeks	3.5%	3
Loss of muscle coordination in fingers	**34.9%**	**30**
Loss of muscle coordination in the embouchure	22.1%	19
Temporarily locked joints	25.6%	22
	answered question	86
	skipped question	95

33. Have you modified your flute in any way because of pain or an injury? If yes, please explain what on the flute has been modified.

	answered question	95
	skipped question	86

34. Have you ever consulted with a health care professional about anything related to your body and flute playing?

Yes	49.7%	89
No	**50.3%**	**90**
	answered question	179
	skipped question	2

35. Have you ever studied anatomy, physiology, or neurology at the college level? Check all that apply.

Anatomy (as a separate course; not biology)	**82.8**	**24**
Physiology	55.2%	16
Neurology	48.3%	14
	answered question	29
	skipped question	152

36. Have you ever taken a college-level course in health issues for musicians?		
Yes	7.5%	13
No	**92.5%**	**160**
	answered question	173
	skipped question	8
37. Have you studied any of the following?		
Yoga	**73.2%**	**90**
Alexander Technique	54.5%	67
Feldenkrais	12.2%	15
Pilates	30.9%	38
Delacroix	2.4%	3
	answered question	123
	skipped question	58
38. When you began flute, did your teacher teach you about the asymmetrical nature of playing the flute?		
Yes	18.8%	34
No	**81.2%**	**147**
	answered question	181
	skipped question	0
39. How would you rate your overall aerobic condition?		
Excellent	17.2%	31
Good	**38.0%**	**70**
Average	32.8%	59
Fair	8.9%	16
Poor	2.2%	4
	answered question	180
	skipped question	1

40. How would you rate your overall strength?		
Excellent	15.0%	27
Good	**41.1%**	**74**
Average	36.7%	66
Fair	6.7%	12
Poor	0.6%	1
	answered question	180
	skipped question	1
41. How would you rate your overall flexibility?		
Excellent	18.8%	34
Good	**39.8%**	**72**
Average	27.6%	50
Fair	11.0%	20
Poor	2.8%	5
	answered question	181
	skipped question	0

APPENDIX C

PERSONAL INTERVIEW QUESTIONS

Personal Interview Questions

1. Summarize resume.

2. What kind of flute, head-joint, foot-joint do you use?

3. How long have you used this set-up?

4. In your career, how many flutes owned? Which do you prefer now and why?

5. What wall thickness do you prefer? Metal?

6. Anything you would change? C# trill, roller D#, foot-joint stack closer/farther away?

7. Have you ever made any decision about your flute's design and mechanism in consideration of its weight?

8. Have you ever experienced any pain due to the way the flute was manufactured?

9. Flute alignment
    a. How do you line up the joints of your flute?
    b. Were you taught this as a student?
    c. Or did you just evolve to your present set-up?

10. Set-up
    a. How do you stand?
    b. How do you sit?
        i. Chair straight or to the right
        ii. Cello chair or foam wedge?
    c. How far from music stand?
    d. Glasses?
    e. Where does the flute touch on your left index knuckle?
        i. Side
        ii. On knuckle
        iii. Above knuckle
    f. Position of RH thumb
        i. Side
        ii. Under
        iii. Through
    g. Describe which words you use:
        i. Hold flute
        ii. Balance the flute
        iii. Equal handedness or equal hands
        iv. 3-point
        v. 4-point

h. Do you deal with hyper-extension of right pinky?

11. Do you sit or stand during practice? What percentage of each?

12. At what angle to you hold your flute? Neck angle? Right shoulder elevated? Spine rotated?

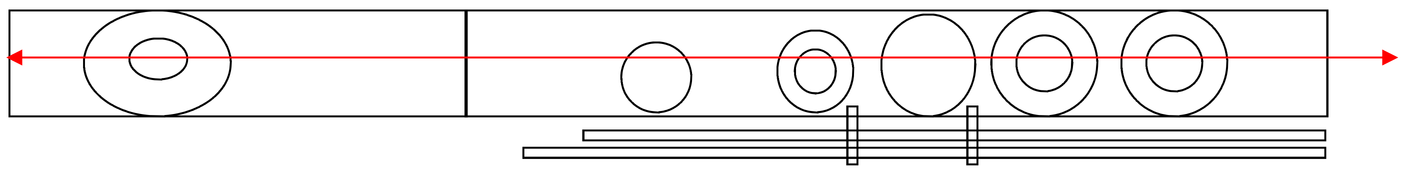
13. What have you done to avoid injury, especially considering the demands of your career?

14. General fitness emphasis?

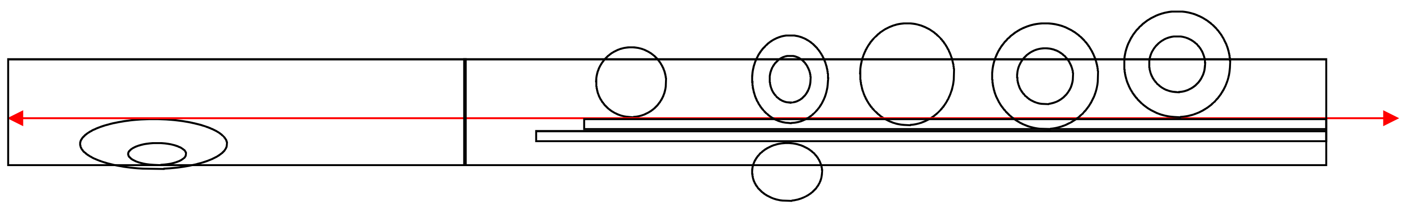
APPENDIX D

FLUTE ALIGNMENT

Classic or Traditional Head-Joint Alignment



Rockstro Alignment



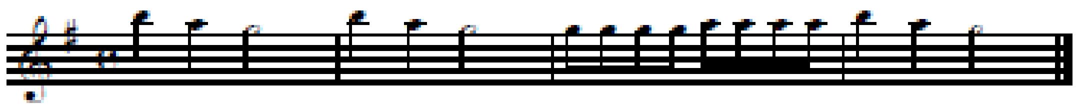
APPENDIX E

GEORGE LEFT-HANDED SONGS

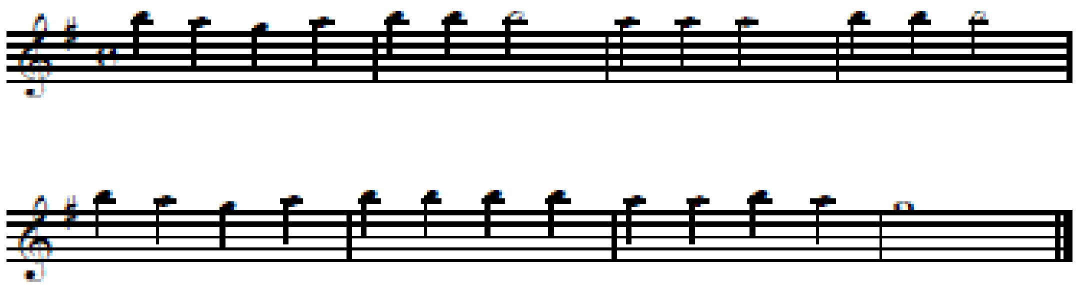
Melodies for the Left Hand

Patricia George

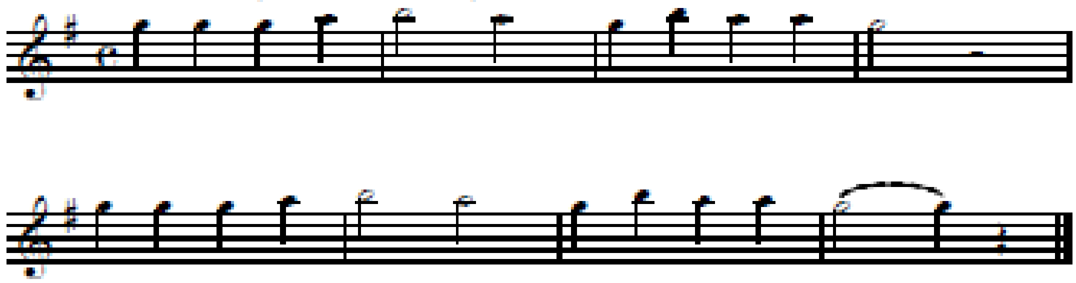
HOT CROSS BUNS



MARY HAD A LITTLE LAMB



FRENCH FOLK SONG (AU CLAIR DE LA LUNE)



OATS AND BEANS

PATRICIA GEORGE

2002 EDITION

APPENDIX F

RECOMMENDED EXERCISE BOOKS

Recommended Exercise Books for Flutists

American College of Sports Medicine Fitness Book, 3rd ed. Champaign, ILL: Human Kinetics, 2003.

Anderson, Bob. *Stretching.* Bolinas, CA: Shelter Publications, Inc., 2000.

Franklin, Eric. *Relax Your Neck, Liberate Your Shoulders.* Hightstown, NJ: Princeton Book Company, 2002.

Helson, Arnold and Jouko Kokkonen, *Stretching Anatomy*. Champaign, ILL: Human Kinetics, 2007.

Schnapp, Elma and Moacir Schnapp, *Young, Sexy and Healthy! The Ten Best Exercises for Your Posture*. Colletes and Sons, 2007.