Understanding Contributing Factors and Optimizing Prevention and Management of Flute Playing-Related Musculoskeletal Disorders

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ABSTRACT

The flute playing position is essentially quite static, with the instrument being held uni-laterally, against gravity, often for extended durations. The nature of this position, especially when fatigued, involves unavoidable muscular imbalances. If these are not counterbalanced through stretching, conditioning, or rest, discomfort, tension or pain may result. Major studies have documented the prevalence of playing-related musculoskeletal disorders and a comparison of these has shown that flutists report pain typically in the neck, middle/upper back, shoulders, wrists and hands. Many contributing factors may lead to playing-related musculoskeletal disorders, such as postural flaws, physical and psychological characteristics, incorrect technique, fatigue, intensity and type of practice, discrepancies between instrument size and physical stature, stress, lack of conditioning, and lifestyle choices. Some studies indicate that playing in an asymmetrical position may be more likely to cause more upper body musculoskeletal symptoms, which leads to the question of why the modern flute was initially built as a transverse instrument, rather than a vertically held instrument.

Due to limited data specifically on the rate of injuries in the flute community, new research was necessary to help establish areas of concern to the flute community. Central to this research is a study undertaken in 2007 which characterizes these problems more clearly. The survey presented herein is the only large-scale study of musculoskeletal problems facing flutists since some major studies undertaken at National Flute Association Conventions in the United States of America in the 1990s. In the current survey, members of the international flute community were invited to participate in an anonymous online survey entitled *Injury Prevention and Management for Flute Players.* The survey was specifically designed to "establish the injury concerns of flute players and teachers of all backgrounds, as well as their knowledge and awareness of playing-related injury prevention and management." The survey

provides new insight into how practice habits, education, lifestyle, and playing background impact on the prevalence of musculoskeletal disorders in flutists.

To gain an increased understanding of the effects of flute playing on the body's anatomical structures, a number of methods are available, one such being electromyography (EMG). A 2 x N=1 EMG study is described, comparing the playing by a professional and university undergraduate student, and was designed to measure upper body muscular responses in the playing of standard repertoire pieces. EMG evidence suggests that there are physical and equipment-related factors of flutists that contribute to increased strain on musculoskeletal elements of the body.

Historical perspectives can assist in understanding why ergonomic considerations have not been paramount in previous eras. The modern flute is based on the 1847 model by Theobald Boehm, a technological breakthrough in design which addressed the inadequacies of earlier flutes: poor projection, inconsistent intonation and a multiplicity of fingering systems. While the demographic of flutists has since changed dramatically, irrespective of physical size or background, most modern flutists play instruments that are of similar length.

Through a better understanding of the physical characteristics of playing and applying principles from other disciplines such as ergonomics, performing arts medicine, physiotherapy and exercise science to practice, technique and positioning, flute players will be able to better prevent and manage playing-related musculoskeletal disorders.

STATEMENT OF ORIGINALITY

The work contained in this thesis is that of Karen Lonsdale and has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself. Selected material drawn from this thesis that is the original work of the author has been previously published in a selection of conference proceedings and flute journals throughout the course of completing this work.

Karen Lonsdale, August 2011

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August 2010	*Physical Considerations for Teaching Beginner Flutists*	Anaheim, California, USA	38th National Flute Association Convention
April 2011	*The Thumbport - Pros and Cons of a Flute Modification Device http://www.flutefocus.com/437-the-thumbport.html*	Auckland, New Zealand	*Flute Focus* Online Journal Article
May 2011	*Injury Prevention for Musicians*	Brisbane, Queensland, Australia	"My Life as a Musician" course for first year students at Queensland Conservatorium Griffith University

FOREWORD: A PERSONAL JOURNEY FROM PLAYING-RELATED PAIN TO ITS SUCCESSFUL MANAGEMENT

An Autoethnography

After learning recorder from age 7, I was introduced to the flute at age 9 through my school's concert band program. My flute lessons were in small group situations, with a teacher who was primarily a clarinet and saxophone player. At the age of 12, I took up private lessons with a specialist flute teacher. In my youth I was an inconsistent practicer, approaching my solo pieces in a fairly intense manner, continually re-starting each until I could play them through without errors. I have distinct memories of my father telling another parent that I was an 'all or nothing' practicer - either I couldn't be heard practising at all, or I played virtually non-stop for up to two hours, especially just prior to auditions, exams and concerts. The inconsistency of my practice routine was partly due to my nature of becoming easily bored when not sufficiently challenged, but I was also a very proficient sight-reader to such an extent that teachers didn't seem to notice whether I had practised or not. I knew this was not the best way to practice, however, not understanding anything about how muscles work, I could not foresee any long-term physical repercussions of practising this way.

In Year 12 at high school, when I was preparing for university entrance auditions, my solo practice increased dramatically, regularly playing up to ninety minutes without breaks, in addition to school rehearsals. As a result I started to experience muscular tension around my neck, shoulders and upper back, though this could be described more as discomfort, rather than pain – certainly nothing debilitating at that point. Despite this, I successfully entered a degree program at the Queensland Conservatorium of Music, commencing in 1985, where I became enthusiastic about practising, and challenged by learning new flute repertoire. Playing-related discomfort was not a

problem in my first year at the Conservatorium, but began to set in early in my second year.

At Easter of 1986, I attended the Australian National Flute Convention, where one of the presenters, Dr Hunter Fry, spoke about "How to avoid injury while practising". At the time, Dr Fry was internationally known for his research into overuse syndrome in musicians. After his lecture, I spoke personally with Dr Fry about concerning radiating nerve pain into my hand, his response leaving me with the impression that the long-term outlook for me as a flutist may not be positive. Despite this, the high level of playing at the convention inspired me to pursue a career as a performer. Within a year, I was a state finalist in the national *ABC Young Performers Awards*, my first major solo competition. It was in the lead up to this competition that I experienced the first onset of serious, debilitating pain, so much so that I couldn't practise regularly for the event. My symptoms were significantly worse than the initial onset of playing-related tension in high school, including extreme tension in the neck, shoulder and back, as well as a sharp neural pain referral into my fingers and hands. Unfortunately the physiotherapist who I sought out for treatment focused solely on my neck without addressing other areas of concern, such as stiffness in the thoracic spine area or playing factors. I performed in the competition, under-prepared as a direct result of the pain I was in.

Disappointed, I sought treatment from sports physiotherapist, Victor Popov, and after only a few treatments, experienced a massive reduction in pain. He pointed out some postural flaws in my playing, including excessive internal rotation of the shoulders, lifting the left shoulder when I lifted my flute to my face, excessive head tilting and sometimes jutting my chin forward while playing. At 19, having played flute for a decade, this was the first time anyone had explained the need for improving and counterbalancing my playing position. Specific changes included activities stretching

overtaxed muscles (chest, shoulder, arms and neck), and strengthening muscles in the middle and upper back. I regained full playing capacity and could practice again without pain. Over the next four years I went on to win many competition prizes and whenever pain manifested, I returned to physiotherapy treatments, ensuring that I could continue intensive playing.

A change of teacher in 1989 brought about new insight into my playing. While studying in Munich, my teacher, Professor Paul Meisen introduced new practice concepts. He taught me the value of slow, careful practice, focusing on sound quality and musicianship above speed. He pointed out that one should never "practice-in" stress, rather the joy of the music, especially in tricky technical passages. He also pointed out when my shoulders were lifting too much during playing. It was a different approach to my previous routine of learning notes as quickly as possible, often not taking the time to ensure a quality sound, or being aware of muscular tension building.

I developed a consistent daily practice routine, with scheduled breaks for rest and physical stretches, regular exercise, and Alexander Technique classes, which made me more aware of tension building while playing, and how to release it. Students performed in a mandatory weekly *Klassenvorspiel*, a performance workshop. On one occasion, after all performances of the set orchestral excerpts, my teacher announced that famous conductor, Sir Colin Davis, would be conducting the *Hochschulorchester* in a concert a couple of months later, and that I was chosen to play principal flute for Beethoven's *Leonora Overture No.3*. In the ensuing weeks, I developed a strange "condition", whereby I felt incredible weakness and muscle soreness, for weeks on end. Like the ABC competition a few years earlier, musculoskeletal pain seriously inhibited my ability to play flute. Thankfully the concert was postponed and after further physiotherapy treatment in Australia, I was able to play the concert the following year,

without physical issues. In retrospect, I don't think I made the connection between my performing anxiety levels and the timing of the onset of pain.

By the end of 1992, I had won two successive auditions to perform with the *Music By the Red Sea International Youth Symphony* in Israel, under renowned conductors Lorin Maazel and Yoel Levi. Despite nine hours a day of rehearsals throughout the three-week event, filled with greater physical self-confidence, I was able to play for long stretches without suffering discomfort or pain. Within 5 years, I became Acting Principal Flute with the Queensland Philharmonic Orchestra, the first time that I had earned a full-time income from performing. Despite the heavy playing load, I did not experience any serious playing-related pain or tension at all. Anxiety issues lessened dramatically, as I was on stage regularly, with a stable income, performing consistently without sudden bursts of high-pressure engagements, and exercising which put me in a good place physically. Thereafter, I spent several months working on shorter principal flute contracts where the orchestras often called upon me at very short notice to play challenging flute parts, especially for opera and ballet, but also major symphonic works. I became used to sight-reading under pressure, with little time to practice. The inconsistency of not having a full-time playing job, led at times to a sudden onset of playing, for which I was not physically prepared, and therefore discomfort resulted.

Some of the most physically demanding performances have been ballet, particularly those by Tchaikovsky, as the Principal Flute parts tend to be very soloistic with almost no opportunity for rest throughout the performance, except at interval. In 2002, during a season of *Sleeping Beauty*, which has a demanding flute part, I took heat packs into the pit to help ease the discomfort in my shoulders and back, and stretched during interval. Discomfort developed into pain the longer I played, to the extent that I convinced myself that this could be the end of my career. I feared discussing the issue

with colleagues, particularly as I had been given advice by professional musicians and university music teachers in the past such as: "well, you'd better not talk about it, because you might stop getting work"; "every musician needs to expect a certain amount of pain"; and "if you're in that much pain, then maybe you shouldn't be a musician at all"!

Shortly after, in May 2002 while playing Principal Flute for the Brisbane season of *Swan Lake* with the Royal Ballet, I needed a cortisone injection to get me through the season because the pain was so great. The stress of freelancing, along with the pressure of two major ballet seasons, and a professional audition, all in succession, had definitely taken their toll on my mental and physical well being. These problems were inevitably exacerbated around major performances, and it was becoming quite clear to me that stress and anxiety were playing a significant role in the onset of my pain.

In 2002 I enlisted the help of an exercise physiologist, who designed a program in collaboration with Victor Popov, which included both strength and aerobic training. Popov recommended alternating pushing and pulling exercises, and contraindicated exercises involving pushing up from the shoulders, because of the existing muscle tension around my neck and upper trapezius area. Yet, despite a substantial weight loss, as well as a significant increase in strength and cardio-vascular fitness, it was confusing to me that I would still occasionally experience playing-related pain and tension. In addition to anxiety, or general fitness levels, there still must have been postural or technical flaws in my playing to cause these symptoms.

To understand these issues better, I enrolled in a Certificate III in Fitness at Southbank TAFE (Technical and Further Education) College. From my first week of lectures in anatomy and exercise programming, the reasons I was experiencing pain became clearer. I had not understood basic concepts about how movement occurs, such as that

the primary characteristic of skeletal muscle is that it has the ability to contract, and in order for one muscle to contract, an opposing muscle must lengthen (submit to the movement). Similarly, I hadn't grasped the concept that if one muscle is overused at the expense of another, it increases the load at the joint, potentially causing instability. In other words, if I was continually playing in postures that strayed from the normal anatomical alignment for extended periods, such as the neck tilting to one side or shoulders rolling forwards, the stability at those joints was compromised. However, if appropriate alignment was maintained during a particular activity, the risks of injury were minimized. Additionally, counterbalancing the overused muscles in flute playing increases the chance of greater joint stability. These principles are required knowledge for gym instructors and sports trainers, who understand that exercise prescription needs to balance muscle groups to minimize the risk of injury. Since musicians are involved in physical performance activities for extended periods of time, it follows that knowledge of even basic functional anatomy could assist in preventing unnecessary injuries.

I completed a Certificate IV in Fitness in 2005 and it became a quest to translate the principles learnt in the fitness course, into a language that was directly applicable to flutists. In 2007, I enrolled in a Doctor of Musical Arts at Queensland Conservatorium Griffith University to research the topic of injury prevention and management for flutists. Through exploring the literature I came to realize the serious extent of flute-playing-related musculoskeletal disorders. The statistics showed me that I was one of many flutists experiencing typical symptoms such as neck, upper back and shoulder pain. At the time I was experiencing playing-related injuries, I had felt very alone. As I now came to realize, I was not alone at all.

There is no doubt that in addition to any postural flaws or poor practice techniques (such as not taking breaks), high levels of anxiety before major performances were greatly exacerbating my symptoms. Over the years, I sought out counselling from two

sports psychologists who worked with elite athletes, as well as a performing arts counsellor in the USA. They assisted me in gaining a focus on the technique and the music, rather than a focus on the fear of what might happen in a performance.

While my university education was outstanding in terms of the musical elements of performance, I don't feel that I was provided with the knowledge to prevent injuries occurring. Yet athletes, especially those at an elite level, are routinely given advice on injury prevention from the earliest training sessions. Trainers use the principle of periodization, whereby an athlete initially trains to achieve basic strength and stability, before progressing to sport specific exercises. At an elite level, sports psychologists assist an athlete to mentally prepare for major events. Musicians are involved in intense physical and mental activities, yet many only become educated about their bodies and minds for the first time when something goes wrong. Certainly, in my case, I learned the hard way.

More recently I played for several ballet seasons, including *Giselle* with the Australian Ballet, and *A Streetcar Named Desire* with the Queensland Ballet, which both featured wonderful flute parts which require almost constant solo playing. Unlike earlier ballet performances, with my cumulative knowledge, I have learnt how to play through a season without physical concerns. At the end of 2009 the Queensland Symphony Orchestra needed me to replace the principal flute for one performance of the current season of *Sleeping Beauty*. I vividly remembered my last experience playing the ballet, when I thought my career was ending. Fortunately, there were still two days to re-learn the flute part, but for the first time in years, I felt muscular pain during my practice. Long hours were required to prepare the flute part, yet, after years of researching injury prevention and management, I knew how to put into practice a few steps that kept me pain free. For example, at the first sign of any muscle tension, irrespective of how much music I had learnt or had still to learn, I took a break and rested. I was also aware

of the need to optimize the muscular imbalances in the playing position, and not overload joints, as my practice was necessarily intense. Also, my anxiety levels were understandably high. The responsibility of playing a soloistic part in a ballet performance, without a rehearsal, in front of a paying public, was enormous. My self-talk necessarily reinforced feelings of confidence, not fear.

My contention is that every musician and teacher, like every sports trainer and athlete, should understand basic principles of movement and contributing factors to injury. This is especially true for any musician involved in intense playing activities, whether that is a student, adult amateur or professional. The causes of injuries can be multifactorial and a single solution may not be appropriate. In my case, there were several contributing factors, including basic instrument ergonomics (asymmetrical nature of the flute playing position), postural flaws, lack of rest breaks, poor body positioning, sudden onset of intense practice, stress, anxiety, poor posture in computing, and at times, a lack of conditioning. Each of these factors has been reported in the literature as a potential contributor to playing-related injuries. Yet, formal education programs on injury prevention and management are still not standard practice in the training of music teachers, or students, even at university level. Through writing this thesis, I hope to provide greater insight into how flutists can better prevent and manage playing-related discomfort, tension and pain.

1. INTRODUCTION

1.1 Background to the Research

The flute has been in existence in its essential form for thousands of years. In its current form, the modern flute, based on a design by German maker Theobald Boehm, has the capability of playing lyrical, legato phrases, crisp articulation and technical passages at great speed. One of the challenges for any flutist is to play with beauty of sound, while controlling the output of large volumes of air. Refining the art of matching air speed, direction and volume is every flutist's central focus, as this affects intonation, tone quality, tonal projection, articulation and phrasing. Composers often write melody lines for the flute, so considerable emphasis in a player's education is placed on stylistic interpretation of those melodies, and finding the most effective, meaningful ways of communicating the intentions of composers. Underpinning a musician's ability to achieve these goals is their physical capacity to undertake the tasks required. Musically speaking, poor positioning and excess muscle tension can lead to a loss of tonal quality and fluidity of technique, poor tonal projection and intonation problems. It is tempting to think purely in terms of musical outcomes, but physical awareness, inclusive of the flute playing position, is hugely important in flutists staying free of discomfort, tension, and pain.

This thesis will examine in detail the challenges of the physicality of the flute playing position, incorporating an historical evolution of flute making technology and performance traditions, to illuminate demands on flute performers. Central to this research are two components. Firstly, a comprehensive international survey of flutists was undertaken in 2007 that sought to verify earlier findings of concerning levels of playing-related musculoskeletal disorders (PRMDs) in the flute community. This survey provides extensive feedback from players and teachers about contributing factors to injury, including lifestyle, education, practice habits, instrument choices, positioning,

and what methods of treatment and management that flutists find to be effective. Secondly, a better understanding of the physical demands on flutists through an electromyography (EMG) study, helping to establish which positions may be functionally best for flutists.

1.2 The Research Questions

There is little flute-specific advice on injury prevention and management strategies, despite the availability of good general reference material on both the technical aspects of playing and performing arts medicine. Linking the two central studies (EMG and survey results), and the historical contextualization of the development of the flute, the objective of the research is to address the following key research questions:

1. What are the musculoskeletal problems suffered by flutists?[2] (Survey outcomes will inform this question.)
2. How can flutists and flute teachers better understand the physical characteristics of playing, so that they can position themselves and/or their students optimally in order to minimize the possibility of playing-related injuries, discomfort, pain and/or tension?
3. Can physical playing characteristics and demographic data from both the EMG study and the international survey be used to inform flutists and teachers about positioning themselves and/or their students optimally in order to minimize the possibility of playing related injuries, discomfort, pain and/or tension?

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[2] "Flute players" will be referred to as "flutists", both for the sake of brevity, and because of an increasing trend to use this terminology in Australia. Additionally, several major studies on the subject of playing-related conditions and injuries use the term flutist (Fain, 2009; Norris, 1996; Spence, 2001; Thompson, 2008). Flutist refers to flute players from any western music background, except where otherwise mentioned.

4. Based on ergonomic principles and knowledge from other disciplines such as exercise science, performing arts medicine and physiotherapy, are there flute playing techniques, preventative measures, and therapeutic exercises that flutists can utilize to prevent and manage playing-related injuries, discomfort, pain and/or tension?

This research will address the physical considerations of flute playing, with the flutist's well-being as the focal point. The results of previous studies on flute playing-related musculoskeletal conditions will be summarized to highlight some of the main issues experienced by flutists. The limitations of those studies will be discussed, demonstrating the need and justification for a new study which more comprehensively investigates possible contributing factors to injuries, as well as current flute performing and educational practices.

1.3 Research Rationale

The literature suggests that the notion of flutist health and well-being was largely ignored prior to the 1980s, and specific flutist research was not undertaken until a decade later. Prior to the commencement of this research in 2007, very few specific studies focusing exclusively on the musculoskeletal health of flute populations existed. Comprehensive studies relevant to this research include:

> 1991 NFA Survey (Norris 1996): investigating the prevalence of neuro-musculoskeletal disorders in attendees at the National Flute Association Convention in Washington (n = 420 flutists)
>
> Flute Health Survey (Spence 2001): a questionnaire on musculoskeletal and non-musculoskeletal problems, distributed at the 1999 Texas Flute Festival (n = 40 flutists)
>
> University of North Texas Musician Health Survey (Spence 2001): a survey on the medical conditions of all musicians (n = 329 flutists)

A number of other studies include flutists, but group flute playing-related statistics with the woodwinds in general, a limitation that will be discussed in greater depth later in this thesis. Some of the earliest studies to include flutists were undertaken in the 1980s by Dr Hunter Fry in Australia (Fry, 1986a, 1986b, 1986c, 1987, 1988a, 1988b). Fry (1986b, p.54) provided a few brief flute-specific comments in his reports, including that flutists "are vulnerable to overuse anywhere in the upper limb and in the cervical, upper thoracic, and lumbar spines." The International Conference of Symphony and Opera Musicians (ICSOM) survey of 48 orchestras in the USA included 95 flutists (Fishbein, Middlestadt, Ottati, Straus, & Ellis, 1988). This survey investigated the medical problems among professional musicians. While there was no flute-specific data reported, the findings indicated that 76% of musicians "reported at least one medical problem that was severe in terms of its effect on performance" (p.7). Wu (2007, p.43) reported that "musculoskeletal disorders present a significant health problem to musicians. The reported prevalence of playing-related musculoskeletal disorders in musicians ranges from 39 – 87%, which is consistent with the prevalence of work-related musculoskeletal disorders for other workers."

A number of studies on musculoskeletal conditions of musicians included flutists, but there was either very little flute-specific data (e.g., Fry, 1988), and/or the statistics were grouped together with other wind instrumentalists (e.g., Davies & Mangion, 2002; Fishbein, et al., 1988; Fry, 1986). Some flute-specific results were reported by Nyman, et al. (2007) but only for a small group of players (10 out of 235 professional Swedish musicians.) There have, however, been some surveys which have exclusively studied flute-playing populations, especially in the United States of America. A brief review of the results of these surveys is outlined here.

1.3.1 National Flute Association and University of North Texas Surveys

In the 1991 National Flute Association (NFA) Survey, 420 participants at the National Flute Association Convention indicated areas of pain or numbness on anatomical diagrams (Norris, 1996). It was found that the largest number of complaints (31.5%) was in the neck and upper back regions, but other problematic sites were the fingers, wrists and shoulders. The author of the NFA Survey (a flutist and a specialist in Physical Medicine and Rehabilitation), outlined the problem areas, and suggested ways to alleviate the pain, such as improvements in ergonomic set-up, hand positions, instrument modifications and technical adjustments. Spence (2001) compared the responses of the University of North Texas (UNT) Musician Health Survey (n=329 flutists) with the Flute Health Survey at the 1999 National Flute Association Convention (n=40). Flutists reported problems in several anatomical sites, including the hands, wrists, forearms, elbows, shoulders and neck, as well as the upper and middle back. Spence concluded that "medical problems do exist among flautists to a degree that warrants further attention and study" (p.101).

1.3.2 Surveys included in Theses and Dissertations

Thompson (2008, p.11) surveyed 30 high school and college age flutists, reporting that "an average of 42.77% of subjects experienced pain while playing, 33.68% experienced pain after playing, and 29% reported pain that caused them to stop playing flute". Participants reported an average of five "musculoskeletal pain spots", among those being hands, wrists, neck, shoulder, and forearms. More recently Fain (2009, p.27) reported that over half of 181 flutists surveyed either sometimes or always experience pain while playing. The highest rates of playing-related complaints in Fain's survey related to the neck (41%), shoulders (right 26.7%; left 29.2%), left upper back (28.6%), right upper back (24.8%), as well as the wrists (right 25.5%; left 21.2%). A comparison

of some of the most typical pain sites from all of the forementioned studies is listed in Table 1.

Table 1: Common Sites for Musculoskeletal Problems in Major Flute Surveys

	Neck	Shoulder	Upper Back	Middle Back	Wrist
1991 NFA Survey Norris (1996) n=420	15.7%	8.4%	15.5%	Not reported	9% R 7.5% L
University of North Texas (Spence 2001) n=329	24% R 27.1% L	29.5% R 27.1% L	24.6% R 24.6% L	13.1% R Left Not Reported	38.6% R 36.2% L
Flute Health Survey at 1999 NFA Meeting (Spence 2001) n=40	37.5% R 37.5% L	35% R 37.5% L	32.5% R 32.5 % L	22.5% R Left Not Reported	35.0% R 27.5% L
Thompson (2008) n=30	26.7%	46.7%	Not reported	Not reported	36.7% R 20% L
Fain (2009) n=181	41%	26.7% R 29.2% L	24.8% R 28.6 % L	Not reported	25.5% R 21.2% L

Fortune (2007) also included a survey in his Masters research on the relationships between anxiety and muscle tension, however as his focus was only on one muscle, the left upper trapezius, this will be discussed as part of the literature review (Chapter 2) and electromyography chapter (Chapter 5).

1.4 Limitations in Previous Surveys

Almost all of the major surveys on flute-playing populations were undertaken in the USA (Fain, 2009; Norris, 1996; Spence, 2001; Thompson, 2008), and there is no demographic data available for Fain's online survey, which the author acknowledges is an unfortunate exclusion in her study. This can be contrasted with the international survey central to this thesis which includes respondents from 25 countries, with very

strong representation from Australia and the USA, as well as a number of participants from the UK, New Zealand and Canada. In the previously mentioned flute surveys, there is little information about the playing background and experience of respondents (Fain, 2009; Norris, 1996; Spence, 2001). Matejka (2009) and Thompson (2008) focused exclusively on a comparatively small group of high school and/or college students (Matejka: n=11 flutists; Thompson: n=30 flutists). Many other studies or surveys reported exclusively on the injuries of specific demographics, such as children (Ranelli, Straker, & Smith, 2008), orchestral musicians (Abreu-Ramos & Micheo, 2007; Fishbein, et al., 1988; Fry, 1986; Kaneko, Lianza, & Dawson, 2005), music schools (Fry, 1987), students (Ackermann, Adams, & Marshall, 2002; Fortune, 2007; Roach, et al., 1994; Zaza, 1992), orchestral players and students (Fry, 1988), music teachers (Wahlström Edling & Fjellman-Wiklund, 2009), and "high-level musicians" (Caldron et al., 1986).

Other studies on the musculoskeletal problems of musicians did include a significant number of musicians, but only a very small sample of flutists, such as: Bengston & Schutt (1992) and Wahlström Edling & Fjellman-Wiklund (2009). The current study, described in Chapter 4, represents flutists from a range of ages and backgrounds, including professionals, amateurs, students, teachers and flute technicians. It adds to the available information through its focus on musculoskeletal problems specific to flutists and is the only large-scale study of musculoskeletal problems facing flutists since the surveys conducted at the National Flute Association Convention in the USA during the 1990s.

The grouping of all of the woodwinds together in many previous studies means that key physical challenges involved in maintaining the flute playing position and their potential consequences have not been highlighted to any great extent in the reporting of survey results. Issues pertaining to flutists are very different to those of other wind

instruments, and warrant specific attention. Firstly, the playing position of the flute is asymmetrical, while the positioning of other wind instruments such as the oboe and clarinet are closer to the midline of the body. Secondly, the flute is not a reed instrument and by nature, requires less lip pressure, and generally much greater airflow. Finally, the flute is not only held against gravity, but unlike other wind instruments in which the hands are positioned at trunk level, such as the oboe and clarinet, flute players are exposed to a greater load due to the elevation of the arms. This thesis will detail the physical challenges in flute playing, and the relationship between flute design and playing position will be outlined in the next section.

1.4.1 Flute Design and Flutist Position as Predisposing Factors to Injury

One of the main factors purported to contribute to overuse injuries in musicians is instrument design. Stability of holding and balancing the flute is one of the key challenges of playing the instrument and is addressed widely in the flute literature (Debost, 2002; Moratz, 2010; Toff, 1996 and others). The playing position involves holding the left arm across the body (adducted) to reach the instrument. Both arms are held against gravity, away from the body (abducted) in an essentially static position. Sound is produced by blowing a centrally focused stream of air across the aperture in the flute's head joint. The flute is held unilaterally, to the right side of the body, for extended periods of time. In order to hold the head in a normal anatomical alignment, or neutral position, it is necessary to hold the hands above shoulder level. Alternatively, some players hold their arms lower, but may compromise the position of the neck. This position can be especially difficult to sustain for young beginners (ages 8 - 11) whose arms and shoulders tire fairly quickly, so a neck tilt to the right is commonly seen. As the weight and length of the instrument is large, compared to their body size, beginners often raise their shoulders as they bring the flute to their face, rest

the head joint on their left shoulder to lift the flute (Fain, 2009, p.192), or rest the flute on their left shoulder in order to lift the flute more easily (Fain, p.192). Some of these postural tendencies can also occur to some degree in intermediate and advanced students, as well as in both adult amateur and professional flutists.

Some controversy exists over which method of holding the flute is best, including a three-point hold, four-point hold, Rockstro position, and Modified Rockstro position being recommended by different authors. These positions will be discussed in greater depth later in Chapter 4, but questions might be raised over why early flute makers chose to construct the flute as an instrument to be held asymmetrically, against gravity, with the load held so far from the body. The rationale behind this apparent anomaly will be examined in a discussion on the flute making tradition in Chapter 3, revealing why pitch, tone, range, and other technical considerations were paramount in determining the length and general shape of the modern flute. While an in-depth examination of the history of flute construction will not be attempted, a brief overview of the musical developments, and the main technical reasons that lead to the flute being built in its current dimensions will assist when analysing the current survey and EMG data.

A number of surveys have shown that specific musculoskeletal sites including the shoulder, neck, upper back, wrist, and hand, are common for flutist injuries. The cause of these injuries and accompanying pain symptoms has received little attention in prospective studies, however, one could speculate that the playing position and other physical performance characteristics such as the personal physical condition of flutists may have some bearing. The position of the flute, which is held unilaterally away from the body and against gravity, often for extended durations, has potential for contributing to tension, discomfort and injuries. This is particularly so if the playing position is not counterbalanced by other activities, such as resting the arms during non-playing

sections of a piece, taking practice breaks, or by stretching and conditioning in preparation for performance. Such methods of counterbalancing the playing position are suggested in the performing arts medicine literature, though there is little flute-specific advice. There is also a wealth of good general advice to be found within the ergonomics literature, and this will be examined further in Chapter 6.

General ergonomic principles suggest that in order to reduce the load on the spine, it should be in a neutral position and hands should be held close to the body (Dul & Weerdmeester, pp.5-6). However, while holding a standard concert flute, adhering to such ergonomic guidelines is not possible, considering that in order for the head to be in a neutral position, the arms must be held away from the body. Conversely, if the arms are held close to the body then the head must compensate by tilting, unless using a flute with a modified head joint, which are generally only used on beginner, alto and bass flutes, as well as a small range of purpose built instruments. While research on "correct" flute playing position is limited, there is much knowledge available in other disciplines such as exercise science, physiotherapy, and ergonomics which could be integrated into flute performance and teaching methods to assist flutists choose a position and playing habits which optimize musical and physical outcomes.

1.5 Thesis Overview

There have been few scientific studies which would help flutists to better understand the physical characteristics of the playing position, with a view to preventing and managing injury. Chapter 2 will review a range of literature relevant to flute posture, hold and alignment, as well as injury prevention and management as it relates to flutists. Literature to be discussed will include flute reference books, pedagogical texts, online flute journals and websites, books on body awareness such as Alexander Technique and Body Mapping, as well as performing arts medicine literature, written both from the

health or medical practitioner perspective or from the musician's perspective. Previous surveys of flute populations or including flutists will also be examined.

By using quantitative and qualitative approaches this thesis will answer the research questions, and fill the gaps in the literature through a discussion on the historical considerations pertaining to flute making traditions, and performance practices (Chapter 3), highlighting the key reasons the flute was built in its current form, gender issues related to flute playing, and how they are significant with respect to current patterns of musculoskeletal disorders.

A statistical method of analysis in the form of an international survey of over 400 flutists in Chapter 4 shows correlations between personal history of injury and many other factors, such as types of flutes played, education, playing experience, lifestyle, education, early teaching, health and fitness, medical history, postural tendencies and practice routines have been made. There is a strong focus on teaching methods, early education, providing a rich source of qualitative data about what strategies flute teachers use to prevent and manage injuries. Respondents provided a great deal of information about how they personally prevent, manage and treat their conditions. Flutists offered their own definitions of posture and discussed concerns about their own history of injuries and the prevalence of injury in the flute community. Additionally, a significant amount of qualitative data provides insight into teaching methods and views on common practices in education, including rehearsal traditions.

The descriptive study presented in Chapter 5 is a scientific approach which evaluates muscular activity during flute playing. The outcomes of EMG analysis are used to provide quantitative information to help understand some of the possible causes of flute symptoms reported in surveys. The results will provide data on the extent of playing-related musculoskeletal disorders in the flute community and the nature of the physical characteristics of the playing position itself. This will be married with a qualitative

analysis through interview and survey comments of members of the flute community and associated health professionals.

In Chapter 6, there is an application of existing knowledge in the fields such as performing arts medicine, health science, physiotherapy, and ergonomics to flute playing. Advice based on sound ergonomic principles and performing arts medicine will be presented with a set of suggestions designed to assist flute teachers and players create healthy and sustainable playing environments for themselves and their students.

This thesis examines the interrelationship between posture, pedagogy and pain. While breathing and embouchure influence posture directly, this subject has been covered in detail by others such as Fain (2009) who discusses the anatomy and physiology involved in respiration. Therefore, the potential contribution of breathing and embouchure to PRMDs is beyond the scope of this thesis.

A large body of literature from standard flute texts, including pedagogical material, Alexander Technique, Body Mapping, to performing arts medicine literature forms the backbone of this research and will be examined in the following chapter.

2. LITERATURE REVIEW

2.1 Introduction

Playing-related musculoskeletal problems of musicians have been well documented since the 1980s, but this is not generally reflected in the flute literature, which includes textbooks, pedagogical material and tutor books. The purpose of this literature review is to outline the relevant existing knowledge about injury prevention and management for flutists and where gaps in knowledge exist. This review will focus on the flute and general music pedagogy literature, performing arts medicine literature, as well as surveys and other studies involving flutists.

2.2 Traditional Flute Reference Books, Posture and Playing-Related Injury

The initial section of the literature review will show how the advice offered in the flute literature is often inconsistent with, or silent, regarding research in performing arts medicine and related fields. It is in the pedagogical setting where lifetime habits are formed. An important part of playing any instrument is the basic set-up, positioning, and contact points, as they are known to influence many aspects of music making, including intonation, tonal production and technical fluency. While this is made very clear in the flute literature, it is less clear what affect posture may have on playing-related discomfort, tension and injuries. This section will provide an overview of flute reference materials, which provide information on key aspects of flute playing, and the importance placed on posture within that context.

Central to a flutist's education are the exercises found in Taffanel & Gaubert's *Méthode Complète de Flûte* (1958), a seminal work which continues to influence flute pedagogy until the present day. This eight-part method was written by two of the leading exponents of the French School of Flute Playing, Paul Taffanel and Philippe Gaubert,

who were both flute professors at the Paris Conservatoire. The method provides a wealth of tone, articulation, ornamentation, and technical exercises, as well as studies. Each exercise is preceded by a set of instructions on how to perform the music. Taffanel & Gaubert (pp.3-4) outline the method of assembling the flute, as well as positioning the body, instrument, fingers and hands, stating:

> The position must be comfortable and the body in a natural position. A stiff attitude must be guarded against; it is fatiguing, harmful to the performance and distracts the listener. The elbows should be held away from the body to avoid compressing the lungs, but, however, not held too high.
>
> From the start it is necessary to assume the habit of looking in a mirror while playing. This will avoid a faulty posture. (p.3)

They recommend that the fingers "rest naturally above the keys, slightly rounded in order to move without stiffness" (p.4) and suggest a classic alignment:

> The flute must be held in an absolutely parallel direction to the line of the lips; but as the flute ought to be inclined slightly downwards the head of the flutist must be a little tilted to the right, the face slightly turned towards the left shoulder. (p.3)

Beyond these suggestions, there is little mention on the physical ramifications of playing with incorrect posture.

Bate intended *The Flute* to be a "generally useful reference book" (Bate, 1969, p. xii) featuring a comprehensive guide to the history of flute construction, including insight into the historical and acoustical contexts for constructing the instrument in various sizes and materials. A number of technical aspects of playing are addressed, including embouchure, fingering, articulation, vibrato, care and maintenance of the flute (Bate, pp.229–250), but posture and the physical characteristics of playing are barely mentioned.

Published the following year, Putnik (1970) addressed the alignment of the instrument, as well as hand and arm positions, stating "the prime consideration in holding the flute

is to support it in the most natural and comfortable position compatible with finger freedom, steady support, and freedom to breathe properly." Scheck (1975) dedicated a chapter (pp.97-106) of *Die Flöte und Ihre Musik* to posture and finger technique also suggesting that the muscles of the shoulder and neck area should be relaxed, the shoulders should not be held too high and that the elbows should not be held too far from the body (p.97). Scheck makes little mention of the shoulder, chest or back areas which are so crucial in holding a stable flute position (Debost, 2002, pp.55, 141; Pearson, 2006, pp.38, 49, 51). Unlike other flute authors, even most recent ones, Scheck included detailed anatomical diagrams of the facial, respiratory, forearm and hand regions (pp.62-65, 97-101), as well as a discussion on the physiology of vibrato and breathing (pp.56-69). Putnik (1970) mentions that breathing and embouchure problems might arise if the arms drop, but Toff (1996, pp.91 & 124) states:

> Whether the flute should be parallel to the floor or tilted downwards is a matter of personal preference and comfort (p.91)…Theoretically, the head should be straight, that is, with lips parallel to the floor. However, many flutists prefer a slight downward tilt to the right. There is nothing wrong with this position, as long as the axis of the flute is parallel to the lips...The tilted position has become a habit for many band and orchestra players for a very practical reason – the lack of space between players in the ensemble. (p.124)

While Toff refers to reducing "muscular tension" (p.125), the author does not explain the potential for physical problems in any depth. However, Mather (1989, p.4) states: "Many flutists tilt their head to the right to keep their lip opening parallel to the flute while they carry their arms low. This overworks the neck and shoulder muscles on the left and under works those on the right; it prevents the full opening of the throat needed for maximum resonance…"

Mather devotes the first chapter of *The Art of Playing the Flute*, *Volume III* to posture, however, the language used is often vague and confusing, without adequate anatomical explanations or diagrams of particular muscles being discussed. For example, Mather states, "Aim instead for allowing the maximum distance between your ears and shoulder

tips. The shoulders are an exception to the rule of letting the body follow your head upward" (p.2). Similarly he advises, "For your head to float freely upward it must also be balanced from side to side" (p.4). Another example of vague language is "With practice your shoulders will be able to relax, fall, and broaden and your chest expand in all directions" (p.4).

Posture and good hand position are often discussed due to their impact on flute technique, sound and intonation, but not, however, on physical well-being. For example, in *Australian Flute Forum – A Discussion of Ideas Related to Teaching the Flute*, there are only a few references to posture and positioning, with this main advice:

> A good hand position and posture are very important in the development of technique. The most common problems are the right hand leaning on the flute, fingers not sitting squarely on the keys, and fingers bent back into a joint (especially right hand little finger and left hand second or third: A or G key). Another problem is the right hand thumb position: if it is too far under the flute it will not balance the instrument correctly and can encourage the flute to roll or tilt backwards. This can cause the embouchure hole to be covered too much (a major cause of intonation and tone problems), and for the balance of the flute to be incorrect. The little finger of the right hand is also a problem if a student cannot remember when if should be on or off the keys for various notes. Watch for poor posture, which can create problems in all areas of flute playing. (Reardon, 1998, pp.50–51)

Similarly, Soldan & Mellersh (1993) discusses positioning in terms of its effect on breathing, tone, technique and potential audience response, rather than on the body itself:

> Posture – the position you play in, either standing or sitting – makes a vital difference to breathing, tone, and technique. The posture of the whole body is important, not just the position of the arms. The flute is designed to be played at an angle; for comfort and ease the instrument must be held well away from the right shoulder, the head turned towards the left, the trunk and legs adjusting to accommodate this position. (p.20)
>
> Don't lean forward with hunched shoulders and a craning "tortoise" neck; your breathing will be affected, you will probably make a flat sound because you are blowing down too much, and the audience won't feel you are playing to them, but to the carpet! (p.23)

Hill (1995, p.i) claimed that *The Flute Player's Book* is "Everything you wanted to know about playing the flute" and shows "acceptable positions for holding your flute" (p.3). He only makes two references to the possibility of injury. Firstly, "Your wrists must not be angular. If they are, you run a very high risk of incurring severe muscular problems" (p.2). Secondly, "It is most important to insist that every flute player use a music stand when they are using sheet music. The alternative is a very sore neck or sore back." (p.4) Similarly to Toff, Hill does not address the potential for injury as a consequence of playing with poor posture.

Trevor Wye (1987) draws attention to the musical consequences of having poor posture, stating that the positioning of the body and the hands is "the most frequently recurring problem that teachers, at whatever level of teaching, have to contend with. A poor posture negatively affects breathing, tone and technique to a large degree" (p.9). While he very clearly outlines the importance of having good posture from the start in several of his books (e.g. Wye, 1987, p.9; 1988, p.12), and its relationship with musical outcomes, the potential for playing-related musculoskeletal disorders is not explained fully. However, he does advise to not continue playing if pain occurs and to check the posture and hand positions (p.11). Wye (1988, p.12) also warns flutists about the marching band position where the flute is held directly to the side of the body, instead of in front of it. He states that this position creates problems such as "back ache, arm ache and neck ache" (p.12).

Renowned French flutist, Debost, refers very specifically to the potential for injury:

> Imagine now that we are really pressing down hard on the surface with all our fingertips and that we try to lift one or two of them: the efforts of both the flexors and extensors is huge. It generates tension up and down our hands and arms.
>
> When we transpose this experience onto the flute, we find the main reason for cramped playing, painful shoulders, tendinitis, and many ailments that plague

> flute players. Add to that the constant jawboning, and you have a catalogue of miseries. (Debost, 2002, p.164)

Similarly, acclaimed British flutist Paul Edmund-Davies refers to the awkward flute holding position, and the possibility of injury, making specific mention of the implications for young players:

> The flute can be a remarkably awkward instrument to hold! Our arms are raised uncomfortably out to the right (the right arm, hand and fingers having to stretch a long way, particularly with the very young!). As we don't want to drop the instrument, we tend to over grip the tube, which in turn tends to cause repetitive strain related problems (along with anxiety). Fingers are also reluctant to be independent (particularly the little one and its neighbour), because they are too rigid. When the muscles are being forced into action, stress related issues can also become apparent. (Edmund-Davies, 2008, p.24)

While technique is not the focus of his work, Powell (2002) gives an insight into some of the early interest in the physical aspects of playing:

> As instrumental teaching became more organized, the content of lessons became more technical, so that for the first time flute teachers began to instruct their pupils in the physical aspects of embouchure, breathing, and sound production. Hans-Peter Schmitz, set the tone for a number of distinguished German writings aimed at flute teachers with his Flötenlehre (1955), uniting history, criticism, musical analysis, and technique in a quasi-scientific approach. He gave physiology unprecedented attention, illustrating the torso with X-ray photographs, and the embouchure with diagrams annotated with angles indicated by Greek letters." (p.264)

The music teacher's companion, Harris & Crozier (2000) offers teaching advice on lesson style, motivation, communication, sight-reading, improvisation, technical aspects, and practice habits, but information on posture or playing position is vague: "Check for a good posture – the way you stand or sit and (if applicable) the way you hold your instrument – using a mirror, if possible" (p.102). Even more at odds with the performing arts medical literature is this advice from Walker (1989, p.44):

> Student posture, whether in the general music classroom or in rehearsal rooms, is another requisite for good behavior and necessary to create an optimal physical situation for music performance. It's a known fact that students who maintain good posture in class are more alert and attentive and behave better than those students whose posture is poor. Music educators can simply not let their students slouch in their chairs or sit cross-legged during classes and rehearsals.

Written by a flutist, *Making Music and Enriching Lives – A Guide for All Music Teachers*, Blanchard (2007) is a good general reference guide for teachers, but the few comments on posture and positioning lack specificity. She briefly addresses neck and shoulder tension (p.227) but advice on posture is limited to: "Practice good posture and movement. The mirror is an honest teacher. How about an Alexander Technique lesson?" (p.142). She states, "tighten up your gut but not your shoulders" (p.142) but also to "be careful of becoming too stiff and tight while playing loud, dramatic music. The feeling of the music needs to be mirrored in the body but tightness will not only ruin the music, it will ruin your body too." (p.142)

Ely & Van Deuren (2009) devotes a 75-page chapter to the flute in *Wind Talk for Woodwinds – A Practical Guide to Understanding and Teaching Woodwind Instruments*. The book is "designed to provide instrumental music teachers, educators, practitioners, students and professionals with a quick and easy-to-us pedagogical resource for woodwind instruments…" (p.v.) Curved head joints are briefly discussed, noting that the shape is designed to "minimize the distance between the embouchure hole and the keys on the left hand" (p.102). 'Thumb rests' as ergonomic devices are also briefly discussed (p.147). Flutists are advised to "play with a relaxed embouchure", because a "tight embouchure limits pitch flexibility and negatively affects tone quality" (p.108), though the physical implications are not mentioned. Players are also advised to "move the head joint, not the head, to obtain the correct flute position for producing a tone" (p.108). Again, the musical consequences are discussed, without any anatomical

basis or explanation for the suggested position. “Maintaining proper playing position” is advised for musical reasons, such as “developing good technique, facility and ease of playing” (p.113), but it is suggested that a good position will “reduce muscle fatigue and help players avoid physical problems, such as carpal tunnel syndrome” (p.113). While issues such as balancing the flute and holding positions are discussed, the key points relate mainly to the positioning of the hands and fingers (pp.113–117). Among the suggestions for “appropriate” or “proper” playing positions are that the left wrist should “have an inward bend” and the right wrist should be “virtually straight; however, a very slight inward bend is acceptable” (p.116).

Yet, ergonomics experts advise that “a continuously bent wrist can lead to local nerves becoming inflamed and trapped, resulting in wrist pain and a tingling sensation in the fingers.” (Dul, 2008, p.24) Van Deuren (2009) also advises to “Keep the elbows and arms out away from the body to encourage proper breathing techniques” (p.117) and to “Hold the head so that the lips are parallel to the embouchure plate. The head may be slightly tilted to the right to achieve this position.” (pp.117-119). The latter contradicts the earlier advice of keeping the head straight at all times (p.108). An example of a confusing instruction is to “Hold the right arm out from the body with the elbow pointing slightly downward and backward away from the music stand.” (p.119) There is a reference to seating positions in ensembles, though no specific comments as to the potential for upper body complaints: “Posture problems often result from players sitting too close together in ensemble settings. Players should have enough room to hold the flute at the proper angle. Turning chairs slightly can help players avoid hitting each other with their instruments.” (p.120)

Moratz (2010) advises on breathing and posture in *Flute for Dummies,* recommending not laying music flat on a bed or table, but using a music stand because “you don’t want

to be slouching over your music while you're playing the flute, because you won't be able to breathe well that way" (p.84). She doesn't mention the impact that such posture would have on the back, shoulders, or other upper body musculature. However, Moratz acknowledges the connection between posture and injury: "Good posture is important in your daily life. Carrying yourself properly helps you avoid discomfort, pain and even injury…" (p.95). She also makes a connection between good posture and positive musical outcomes, though the explanation is somewhat simplistic: "With good body alignment enabling a relaxed neck and unconstrained, open throat you automatically produce a more beautiful sound. With the absence of excess tension, your finger technique is more fluid." (p.95)

It has been a recent trend on international flute discussion lists and in flute workshops, particularly in the USA, to avoid using the term "posture", in favour of the word "alignment". Moratz (p.95) explains: "Personally, I don't like using the word posture, because when people start thinking about their own posture, they usually start pulling their shoulders back, sticking their chests out, and sucking their bellies in. But pulling, pushing, and forcing isn't really what efficient use of your body is all about." She goes on to discuss F.M. Alexander who "coined the term mechanical advantage, which is a more appropriate description of what most people would call good posture." Moratz seems to be contradicting her previous statement that "posture" brings to mind negative outcomes of "pulling, pushing and forcing". It is important to note that the word posture is a term that is very much accepted in the health science literature. Moratz does explain the importance of good alignment, though some language is quite vague, for example: "Your body already knows how to carry itself naturally. Unfortunately, most people get in the way of their body's built-in alignment mechanism." (p.96) A similar instruction is to "Extend the sensation of length through to your spine. Feel your back lengthening and widening." (p.98) Other confusing advice is to "relax your

hip bones" as well as "Imagine that you're a puppet dangling from a string attached at the top of your head. Allow your body to fall into place from the top." (p.98)

2.3 Conflicting Viewpoints on the Hold and Alignment of the Flute

There are several critical aspects to be considered regarding the flute playing position: the hold (or contact between the fingers, hands, head and the flute); the alignment of the instrument itself; and the alignment of the body in relation to the instrument. All of these factors impact on tone production, intonation, technical facility and physical comfort. Controversy exists as to the optimal holding position for the flute though most authors seem to suggest a "three-point" hold (Debost, 2002, p.101; Floyd, 1990, p.24; Hill, 1995, pp.2-3; Mather, 1989, p.12; Moratz, 2010, pp.120-124; Poor, 1983, p.10; Putnik, 1970, p.7; Toff, 1996, p.125). A three-point hold involves balancing the flute using three contact points of the body with the instrument: right thumb, left index finger, and chin. Hill (p.2) believes that this type of hold prevents the flute from "wobbling, even without any fingers touching the keys".

In relation to alignment, authors disagree as to whether a "classic alignment", where the centre of the embouchure hole is directly in line with the keys of the middle joint of the flute (Floyd, p.23), or the Rockstro or Modified Rockstro position is best. Floyd (p.23, after renowned flutist Geoffrey Gilbert) suggests a classic alignment, as does Putnik (1970, p.6). Debost (2002, p.18) suggests a classic alignment where the "outer edge of the embouchure hole, the leading edge on which we blow, should be roughly on a straight line running through the middle of the tone holes." Moratz (2010, p.116) advises lining up the far edge of the embouchure hole with the outer edge of the first key on the middle joint. Poor (1983, p.11) on the other hand, advocates the Rockstro position, where the right arm is held almost horizontally. She suggests that the embouchure hole is not lined up with keys, but turned towards the player about a

quarter of an inch (6 mm). Her justification for this alignment is that reaching the left hand keys is easier, though the arms must be raised higher to accommodate this position. Renowned American flutist Nyfenger (1986, pp.45-46) preferred a Modified Rockstro position, stating:

> Lifted as if to ward off attacks by other players, to block the view of jealous colleagues in the audience seeking the secrets of our perfect embouchure, or to guard against potential admonitions from the conductor, the left elbow often takes its place as a shield or assumes some sort of arty ballet position. The right elbow conforms to protect in the event of an attack from the rear!
>
> Far from aiding in the need to balance the flute, these cosmetic, stage-oriented poses are actually disease producing mechanisms. The arms tire, the right wrist tends to rise too high for maximum finger comfort, and the left first finger loses its ability to help hold up the flute.
>
> Ages ago, Mr Rockstro made an effort to release the right pinky from balancing duties by redesigning the flutist's position: first, the head joint was turned in considerably, and then the entire flute was rotated forward, while the left first finger joint cushioned the flute with the right wrist held very high and the left wrist much closer to the body. After some experimentation, I felt I was unable to incorporate fully this master's concepts into my own work.

Notably Fain (2009) found that "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". Fain (pp.23-24) reported that 64.6% of respondents used a classical alignment of the flute. A limitation of Fain's survey, however, is that there were only 11 Rockstro position users, or 6.2% amongst the total respondents (n=181). There were 42 (23.6%) Modified Rockstro users.

2.4 Factors Other Than Posture that Contribute to Flute Playing-Related Injuries

Some online sources provide useful articles on flute playing-related health. Apart from posture, other factors such as physical size in relation to the size of the instrument played, technique, and intensity of practice are important to consider. This section will

examine literature which discusses such contributing factors to flute playing-related musculoskeletal disorders.

The Larry Krantz website http://www.larrykrantz.com [Accessed 22 March, 2010] includes a few articles about performance health. *Make Life More Comfortable* (Still, 2003) is intended to assist flutists in discomfort. Still discusses differences in hand size and flute adaptations such as key extensions, thumb rests, as well as Drelinger's *UpRite* flute, an ergonomically designed flute. Similarly, Mancuso (2010) advises how to achieve comfort through playing with an offset G mechanism, home-made adaptations using cork, moleskin and corn plaster, "pearl sax buttons", *Bo Peps*, or even plastic hose. *Don't "Play" with Pain* (Hauser, 1998) directs musicians to "care for their body" (p.1) by addressing postural issues as well as doing stretching and strengthening exercises, and aerobic activity. Hauser also discusses diet and emotions, and advises musicians to consider using biofeedback to modify postural habits.

The *Hands On!* website at http://www.johnlunn.com/lunnflutes/ho.htm includes a newsletter *Online - Achieving a Healthier Relationship with your Flute* by John Lunn, an accomplished flute maker with a deep interest in musicians' health. Lunn states:

> Everyone has felt discomfort from playing the flute or knows someone who has. Whether a problem stems from small hands, an accident or flute related stress, the cause/effect cycle can be better understood and broken by separating the type of hand problems into these 3 root influences:
>
> POSTURE - Bad hand position and posture are the main cause of most hand problems. Through better teaching and awareness, you can develop good habits and correct bad ones to solve most problems.
>
> FLUTE - Playing position on the flute is very unforgiving on the body. Unlike most other instruments, such as the piano, there are a variety of ways to adapt flutes to better fit a player's hands.
>
> HEALTH CARE - Some conditions are unavoidable no matter what precautions are taken. Health professionals such as physical rehab physicians and neurologists are necessary to diagnose and treat serious conditions or cases involving non-music related trauma. (Lunn, 2010)

While performing arts medicine authors suggest that such factors as stress, a lack of conditioning and a sudden increase in intensity are contributing factors to injury (Brandfonbrener, 1991a; Dawson, 2008; Horvath, 2009 and others), one author is unique in explaining how emotion, and even the desire to be passionate or involved in the music can in themselves cause physical tension. In *The Art of Practicing - A Guide to Making Music from the Heart*, Bruser (1997) states: "Musicians create tension in a variety of ways. One of the most common is trying to play a piece fast before you are ready. When you push your body to move too fast, it tightens, which only prevents it from moving as fast as you want it to" (p.15). She points out that tension may be created from "trying to manufacture a special kind of energy, particularly if a piece is romantic or emotional" (p.16). Bruser discusses posture, body mechanics, and mental approaches to practice, all with a view to both avoiding injury and producing pleasing musical results. The book does contain a few words of advice on flute positioning. One of Bruser's teaching influences is Alexander Technique, and the survey described herein reports that flutists found that Alexander Technique and Body Mapping classes were both useful in injury prevention. Both methods will be investigated in the next section.

2.5 Alexander Technique, Body Mapping and Positioning

Literature that deals with body awareness across all instrument types, and indeed beyond the realm of music, include a method known as Alexander Technique and a closely related approach called Body Mapping. The survey described in Chapter 4 has found that both of these have been valuable in terms of their educative value, as well as in the prevention of playing-related injuries. This section will examine two of the key books available on Alexander Technique and Body Mapping.

2.5.1 Alexander Technique

Alexander Technique classes and workshops are offered at many music institutions internationally, and are often programmed in flute conventions, such as at British Flute Society and National Flute Association (USA) events. The application of this technique is discussed in detail in *Indirect Procedures - A Musician's Guide to the Alexander Technique* (De Alcantara, 1997). De Alcantara states that an Alexander teacher will provide "ideals of movement, gesture, thought and direction" (p.216). De Alcantara emphasises that "the word 'posture' does not imply a rigid body position, but a flexible, dynamic relativity of body parts." (p.117). De Alcantara does make a number of references to flute positioning in the book, including that "bringing the flute to your mouth need not and should not cause you to twist your head" (p.217). However, Fain (2009, p.19) challenges this advice and states that "the head has to be rotated to the left or the right shoulder and arm will be forced back beyond their normal position". The application of Alexander Technique to flute playing can be found in a small book by (Nausbaum, n.d.), though like other flute literature, the language used is quite vague. Nausbaum states, for example, "Be in your body" and "Instead of playing with your neck tensed, try thinking of gravity's effects within you" (p.3). Murray (2006) explains that Alexander Technique may assist with breathing, positioning, improving alertness in rehearsals, and decreasing anxiety (pp.35-38).

2.5.2 Body Mapping

Body Mapping is based on sound anatomical principles and suggests that "we move in the way in which we think we are constructed." (Conable, 2009) In other words, irrespective of whether our mental image is consistent with anatomical realities or not, we move according to the way we think the movement occurs. If a body map (mental representation of movement) is faulty, this can lead to an inefficient way of moving,

which could eventuate in injury. However, Conable states that, "as you correct the flaws in your body map, you begin to move gracefully, efficiently, and in balance, like someone whose body map was accurate in the first place." Conable (2000) explains that her writing is strongly influenced by her work as an Alexander Technique teacher (p.5) and she equates the word "posture" with a "stiff, military" stance, or "over-straightening in a 'posture' sort of way", rather than "centrality of weight bearing" (Conable, 2009). This seemingly negative interpretation of the word 'posture' is not reflected in either ergonomics or performing arts medicine literature.

Lea Pearson's *Body Mapping for Flutists - What Every Flute Player Needs to Know About the Body* (2006) is a flute-specific application of the principles of Body Mapping, written by a professional flutist and former sufferer of playing-related discomfort and injury. It addresses balance, arm position, structures of breathing, efficiency of movement and anatomical explanations of how the body works. It is a valuable source of information for flutists about the anatomical structures involved in flute playing. Pearson provides advice on practising, as well as exercises to improve movement. Weaknesses of the publication are that information on ergonomic devices to improve positioning is fairly limited, and the challenges of the asymmetric playing position are not fully explained. The cover of the book includes the wording "What Every Flute Player Needs to Know about the Body", whereas the inside covers pages use "What Every Flute Teacher Needs to Know About the Body". If this book was intended as a guide for flute teachers, there is limited information pertaining to young students. Topics such as how to achieve a good ergonomic set-up and instrument types suitable for young children are not addressed.

A review of the flute and general music pedagogy literature reveals very limited attention to PRMDs, and the advice on positioning is inconsistent among flute authors. While the Alexander Technique and Body Mapping literature both place an emphasis

on efficiency of movement and awareness, other important contributing factors to injury such as instrument ergonomics, lifestyle and practice habits are not highlighted.

2.6 Performing Arts Medicine

The most comprehensive reference books on preventing and managing musicians' injuries are to be found within the performing arts medicine literature. A number of high quality publications have become available in recent times and while they often contain minimal flute-specific advice, there is valuable general information about injuries, risk factors, preventative measures, and treatments. Watson (2009) states:

> Over the last two decades, arts medicine has emerged as a distinct discipline and a considerable number of treatment centers for it have sprung up, particularly in the United States and in some European countries such as Germany, the Scandinavian countries, and more recently Spain and the UK. This has arisen from the realization that not only do the intense physical demands made on professional musicians make them at least as vulnerable to injury as professional athletes, but their satisfactory treatment also requires a similarly specialized approach. (p.xii)

Roehmann & Wilson (1988) state that the 1984 *Biology of Music Making* conference "was conceived and organized to test the notion that music, medicine, and the behavioural and biological sciences are ready to forge a research and educational partnership in order to articulate and confront a set of questions of mutual concern." (p.1) They published the proceedings of the conference as a book, including most of the presentations which ranged from causes and cures for performance anxiety, neuropsychologic issues in music, to the use of technology such as biofeedback and high speed photography to study movement patterns in music making. One of the presenters at the conference, George Moore, Professor of Biomedical Engineering at the University of California stated: "For various reasons music performance has defied, resisted or just not invited the invasions of science and technology visited on almost every other aspect of our civilization." His presentation *The Study of Skilled Performance in Musicians* showed how electronic technical devices such as the

electromyogram could be used to "monitor patterns of movement" during the playing of musical instruments (Moore, 1988, p.80).

Chapter 5 of this thesis will include the results of a new EMG study focusing on the function of major muscles involved in flute playing.

2.6.1 Musicians' Health, Medical Conditions and Playing-Related Injuries

The first comprehensive publications on the topic of injury prevention and management for musicians appeared from the early 1990s. Brandfonbrener (1991a) stated that until then "few people outside the performance communities acknowledged the existence of performance-induced injuries" (p.25) and referred to this period as the "adolescence of performing arts medicine" (p.67). The *Textbook of Performing Arts Medicine* (Sataloff, Brandfonbrener, & Lederman, 1991) presents information pertaining to the causes, risk factors, prevention, treatment, and management of playing-related medical problems. It was written as "a response to the rapidly increasing demand for knowledge and training." (p.25) Also discussed are a range of playing-related musculoskeletal problems (Hoppmann & Patrone, 1991, pp.71–109); temporomandibular joint disorders (Howard, 1991, pp.111–169); and neurological problems (Lederman, 1991, pp.171-204). Contrary to the scant attention to injuries in the flute literature, Brandfonbrener (1991a) outlines typical manifestations of pain in flutists:

> Although there are exceptions, characteristically, the hand problems of these woodwinds are in the left-hand, fingers, wrists, arms and shoulders. The reason for this is the position used to support the horizontal flute, in which there is a tendency for marked hyperextension as well as radial deviation of the left wrist. Depending on many factors, including arm proportions and teaching, this may be more or less exaggerated. The thumb is involved not only in support but also in using the keys on the underside of the instrument. Many players tend to wedge the flute between the thumb and the flexor surface of the proximal phalanx of the left index finger. Although some players adjust to this position, many have problems arising from the tension this creates in the hand. In addition, the radical deviation that accompanies this hand position makes the reach to the keys by the ring and small fingers much more difficult, especially if

> the flute is not fitted with an offset G key, or if these fingers are disproportionately short, as is not infrequently the case. (p.57)

There were few other books with specific flute advice written in the early nineties, though Norris is an exception. *The Musician's Survival Manual – A Guide to Preventing and Treating Injuries in Instrumentalists* includes a short chapter specifically to the *Problems of Flutists*. Norris (1993, p.77) states that "there are numerous joint, muscle, and nerve problems that occur in flutists." Norris discusses medical conditions affecting flutists, and ergonomic flutes and adaptive devices such as thumb and finger rests. While anatomical information is basic, Norris discusses posture, treatment options, and predisposing factors to injury. Several other authors from the late nineties through to 2005 wrote books outlining musician injuries, medical conditions, and relevant applied anatomy, and rehabilitative exercises, though with little flute-specific information, such as Weiss (1996) and Andrews (2005).

The concept of encouraging musicians to think of themselves as athletes was introduced extensively in *The Athletic Musician: A Guide to Playing Without Pain* (Paull & Harrison, 1997). The principle of muscular imbalance is explained, as well as how stretching and strengthening may assist in avoiding injury. A chapter is devoted to ergonomics, with specific advice on seating and standing positions, lifting techniques, environmental factors, practice habits and mental imagery. There are some references to flute playing, including photos of various playing positions, and ergonomic flute modifications. The authors concur with many other performing arts medical specialists that "the scientific knowledge to successfully prevent and treat the vast majority of playing related injuries already exists." (p.5)

During the transition from the 20th to the 21st century, a number of comprehensive books on playing-related medical conditions appeared, clearly intended as general

guides, with only a small amount of flute-specific information. An example of this is Winspur & Wynn Parry (1998) who describe the flute as "somewhat of a devil for musculoskeletal problems" (p.14). *The Musician's Hand - A Clinical Guide* is written with a general musician reader in mind, and some basic issues to do with flute hold and ergonomic flute design are presented. The text sheds light on many medical conditions affecting the musician's hand, such as tendinitis, dystonia, and nerve compression syndrome (including carpal tunnel syndrome). Written from the clinician's perspective, it includes surgical and other treatment options, as well as causes of conditions and preventative strategies. Similarly, *Medical Problems of the Instrumentalist Musician* (Tubiana & Amadio, 2000) is a comprehensive publication, with chapters on functional anatomy, biomechanics, hand control, neurophysiology, epidemiology, clinical approaches, overuse syndrome, medical problems and treatments, posture, rehabilitation, stage fright, ergonomics and prevention.

In *Fit as a Fiddle - The Musician's Guide to Playing Healthy*, Dawson (2008) discusses body structure and function, medical conditions including carpal tunnel syndrome, arthritis and tendinitis, as well as overuse syndrome, treatment alternatives and rehabilitation. There are a few references to flute playing, as well as some general information on positioning issues for wind instrumentalists, and instrument modifications.

One of the most comprehensive reference books to appear in the performing arts medicine literature in recent times is *The Biology of Musical Performance and Performance-Related Injury* (Watson, 2009). Watson, who lectures in anatomy and neuroscience, and studied flute in his youth, discusses a range of medical problems affecting musicians, including musculoskeletal conditions. Conditions include thoracic outlet syndrome, ulnar and median nerve entrapment (including carpal tunnel syndrome), entrapments of the small nerves in the fingers (p.85) and focal dystonia

(p.269). Posture is addressed in depth, with several references to the flute playing position. Watson states:

> Among the woodwinds, the flute is particularly problematical for posture. There are numerous hand and wrist problems associated with this instrument…but playing posture may, in addition, cause problems in the shoulder region. In order to allow the right arm sufficient freedom to move, either the trunk or the neck (or both) must be rotated to enable the mouth to lie parallel with the lip plate. Any tendency to allow the trunk or neck to slump forward simply compounds the problems and should be avoided. This not only put unnecessary strain on the back but also interferes with breathing. (Watson 2009, p.31)

Watson also discusses performance-related stress and anxiety, as well as prevention strategies, practice habits, and instrument ergonomics including suggestions for flute specific modifications such as Bo Peps, curved head joints and changing foot joints.

A unique publication, especially in its presentation and accessible style, is *The Musician's Body – A Maintenance Manual for Peak Performance* (Llobet & Odam, 2007). It gives thorough explanations as to why muscles fatigue, suggestions for practice methods, risk factors for injury, as well as preventative and management strategies. The advice is holistic, covering a wide range of topics including relevant functional anatomy, posture, practice methods, and other aspects which may influence posture including psychological and environmental conditions. Chapter 4, entitled *Musicians, Instruments and the Workplace – Adjusting the Task to Suit your Body*, includes one page of flute-specific advice (p.48). The issue of balancing the flute is briefly discussed, with suggestions for improving finger and hand positioning. Modifications and adaptations such as flute rests, key extensions, as well as vertical, angled, swan neck, and curved head joints are also recommended (pp.54-55). Performing anxiety is addressed extensively in Chapter 6 *Mind and Music - Further Psychological Aspects* (pp.79–89).

These general guides are high quality publications, with an excellent overview of a range of health issues and medical conditions affecting musicians. The guides address

risk factors for injury, ergonomics, and strategies for prevention. However, for flutists searching for flute-specific advice on positioning, pedagogy, posture or technique, there is little to be found in this literature. One author to recently bridge the gap between the flute literature and the performing arts medicine literature is Fain (2009) who has broken significant ground in *An Application of the Principles of Anatomy, Physiology, and Neurology to the Balancing and Playing of the Flute.* This is a valuable contribution to both the flute and performing arts medicine literature. Fain is a qualified physical therapist and professional flutist so can expertly explain the functional anatomy of flute playing. In addition to musculoskeletal characteristics of playing, Fain discusses the anatomy and physiology involved in respiration. The author includes an entire chapter on the mechanisms of breathing (Chapter 10), highlighting the function, as well as the demands on particular muscles of respiration which also impact directly on playing posture (pp.268-295).

Fain included interviews with high profile players about the types of flutes they played, holding position (classic alignment, Modified Rockstro, or Rockstro position) and the strategies they used to prevent, or manage playing-related injuries.

It is interesting to note that Fain does not condone the Rockstro position, which is taught as an alternative method of aligning and balancing the flute, particularly in the USA. She states that "the right arm must be raised slightly higher or the flute drooped to accommodate the greater flexion of the wrist. This awkward angle not only causes excess stress on the finger flexors, it sets up a bad kinetic change that reaches all the way to the spine." (pp.242-243) The Rockstro position is advocated as an alternative method to be considered by flutists (Nyfenger, 1986, pp.45-46). A limitation of Fain's study was not including important demographic data such as age and gender in her survey of 181 flutists.

2.6.2 Rehabilitative Exercises for Musicians

A number of books from the music health literature feature a range of stretches, strengthening, and other rehabilitative exercises for musicians (for example, Horvath, 2009; Lieberman, 1991; Llobet, 2007). However, there are also a small number of books and DVDs exclusively devoted to exercise programs. One of the earliest examples of this is a DVD called *Musicians Exercise Program - Therapeutic Exercise for Musicians* demonstrating practical exercises for musicians that can be done on tour, without exercise equipment. These body weight exercises are derived from Tai Chi and dance movements, and include both stretching and strengthening exercises (Norris, 1990).

Ginette Hamel is a Canadian physiotherapist who has worked with dancers and musicians for many years. Volume 2 of the DVD *Stability with mobility - Exercise program to promote freedom of movement for musicians* (Hamel, 2008) includes a series of exercises which can be used by musicians to release tension, improve flexibility, stability, strength and posture, as well as prevent injury. The exercises require basic equipment such as small balls, fit (Swiss) balls, towels, therabands (resistive elastic bands), and foam rollers (noodles). These resources serve as very good general reference books and DVDs outlining many of the contributors to playing-related pain, but flute specific information is limited.

2.7 Prevention and Management of Playing-Related Musculoskeletal Disorders

Many authors concur that playing-related musculoskeletal disorders are often preventable. This section outlines the risk factors for injury, preventative strategies, as well as treatment and management options that are presented in the performing arts medicine literature.

Foxman & Burgel (2006) state that prevention needs to be "initiated at the beginning of music education" stressing the importance of an ergonomically sound set up of the musician and their instrument (p.310). The importance of early diagnosis, treatment and rehabilitation, as well as education about prevention strategies is also discussed (p.311). The clinical results of a study of musician injuries is described, but this study does not include flutists. Spaulding (1988) concurs that education plays a crucial role in prevention, stating "information and support should be afforded to teachers and parents, who play a critically important role in the growth and development of musicians during their learning years" (p.135). These types of risk factors and strategies for management are consistently stated among performing arts medicine authors, yet are not found in the flute literature. The specific application to flute playing of typical risk factors for injury and strategies for management will be discussed in Chapter 6, but a summary of these appears in Table 2 (risk factors) and Table 3 (treatment and management).

Table 2: Risk Factors

Risk Factors for Musculoskeletal Conditions	Author/s
Environmental Issues, Lifestyle, Stress and Anxiety • Inadequate physical fitness/muscle tone/conditioning • Room temperature/lighting/noise • Poor diet/nutrition • Alcohol/tobacco/drug/substance abuse • Dehydration • Psychological problems/poor coping mechanisms • Income-related factors (seasonal employment, contracts)	Ackermann, 2010 Brandfonbrener, 1991a Foxman & Burgel, 2006 Lederman, 2003 Llobet & Odam, 2007 LoBuono, 2001 Norris, 1993 Potter & Jones, 1995
Poor/awkward posture • In playing musical instruments • In other musical activities • Playing-related asymmetries **Faulty Technique, Load and Practice Habits** • Modifying too many issues at once • Teaching/early education • Excessive repetition or force • Inadequate warm-up/rest/breaks • Excessive, or sudden change of activity • New repertoire/change of teacher or instrument, • Excess hours of exposure • Unusual work hours	Ackermann, 2010 Brandfonbrener, 1991a Dawson, 2006, 2008 Foxman & Burgel, 2006 Lederman, 2003 Llobet & Odam, 2007 LoBuono, 2001 Norris, 1993 Potter & Jones, 1995
General health, physical characteristics and instrument ergonomics • Concurrent illness/Pre-existing medical condition • Genetic conditions (e.g. hypermobility) • Issues with vision (near-sightedness etc) • Age/gender/height/thumb length/neck length • Configuration of teeth • Pressure of instrument at body contact points • Physical mismatches between musician and instrument (size/weight/shape)	Brandfonbrener, 1991a Dawson, 2006, 2008 Foxman & Burgel, 2006 Lederman, 2003 Llobet & Odam, 2007 LoBuono, 2001 Norris, 1993 Potter & Jones, 1995

Table 3: Treatment and Management Strategies

Treatment and Management Strategies	Author/Year
• Improve fitness/conditioning (generally low resistance/high frequency strength exercises) • Corrective exercise/rehabilitation Specific suggestions by Ackermann 2010: • General exercise working a wide range of muscles such as Body Balance, Stretch and Flexibility, Pilates, Yoga. Exercise should focus on abdominals, shoulder stabilisers, and spinal postural muscles. Build up exercise gradually • Don't workout just prior to playing	Ackermann, 2010 Brandfonbrener, 1991a Dawson, 2006, 2008 LoBuono, 2001 Foxman, 2006 Llobet & Odam, 2007 Lederman, 2003 Norris, 1993 Potter & Jones, 1995
Re-assess technique and practice habits such as: • Modify technique/instrument • Appropriate choice of repertoire/teacher • Gradual increase in playing activity levels • Limit repetition • Practice mentally • Get sufficient rest/breaks/move around • Improve ergonomic set-up/posture in musical and non-musical activities (e.g. computing)	Brandfonbrener, 1991a Dawson, 2006, 2008 Foxman, 2006 Lederman, 2003 Llobet & Odam, 2007 LoBuono, 2001 Norris, 1993 Potter & Jones, 1995
Improve Lifestyle/Environment • Avoid smoking, drugs, substances, excess alcohol • Proper nutrition and rest • Modify environment (lighting, noise, smoke) • Treat performance anxiety • Reduce stress • Body awareness (Alexander Technique, Feldenkrais, Yoga, Tai Chi)	Brandfonbrener, 1991a Dawson, 2006, 2008 Foxman, 2006 Lederman, 2003 Llobet & Odam, 2007 LoBuono, 2001 Norris, 1993 Potter & Jones, 1995
Medical and other interventions • Medication to reduce inflammation/pain • Splinting, injection, surgery, thermotherapy (ice/heat) • Electrodiagnosis (Electromyography/EMG/Biofeedback)	Dawson, 2006, 2008 Foxman, 2006 Lederman, 2003 LoBuono, 2001 Llobet & Odam, 2007 Norris, 1993 Potter & Jones, 1995

2.7.1 Books Written from the Musician's Perspective

Much of the literature on musician injuries was written by physicians and other health professionals. However, several publications have also been written by professional musicians, focusing on positioning, practice techniques, as well as many contributing issues addressed in earlier literature, such as performance anxiety and stress. One of the earliest examples is *You Are Your Instrument: The Definitive Musician's Guide to Practice and Performance* (Lieberman, 1991). The author is a violinist and singer who addresses the issue of muscular imbalances associated with playing instruments, providing advice on breathing, awareness, performance issues including performance anxiety, as well as a set of rehabilitative exercises, which are intended to assist in injury prevention. Lieberman presents an holistic picture of the contributors to overuse syndrome, and musculoskeletal disorders, including stress, anxiety, training, posture, lifestyle and environmental factors. The concept of muscle balance is explained, and photos of stretches and strengthening exercises are provided. There are several anatomical diagrams, accompanied by explanations of how certain playing-related postural tendencies occur.

A more recent example is *Playing Less Hurt: An Injury Prevention Guide for Musicians*. Horvath (2009) addresses contributing factors and types of injuries, medical conditions, instrument modifications, and stretching and strengthening exercises. She shares her own story of managing playing-related pain, discusses practice routines, and ergonomic set-ups to support her arguments. Horvath's key focus is on prevention strategies, and this is one of a few available books on the subject of musician health written by a professional musician. Another by Klickstein (2009) a professional musician and educator, presents an holistic approach to music making in *The Musician's Way – A Guide to Practice, Performance, and Wellness*, devoting a significant amount of the book to managing performance anxiety, and injury prevention.

While there is little flute-specific information, there are detailed discussions on playing-related medical conditions, causes of injury and how to prevent them from occurring.

2.8 Aetiology, Incidence and Types of Flute Playing-Related Conditions

A relatively small number of surveys specifically on the musculoskeletal problems and other health concerns of flute playing populations have been undertaken and will be discussed in Chapter 4 of this thesis. The most important surveys are outlined in Table 4.

Table 4: Surveys of Flute Playing Populations

Surveys of Flute Playing Populations		
Author	**Name of Study**	**Number of Participants**
Fain, 2009	Survey on the Physical Aspects of Playing the Flute 2009	n=181
Fortune, 2007	Research Study Assessing The Relationship Between Music Performance Anxiety and Muscle Tension in Flute Players	n=20
Matejka, 2009	Ursache, Analyse und Prävention von Erkrankungen im Bewegungsapparat bei Flötisten im Alter zwischen 15 und 18 Jahren Translation (Lonsdale): Cause, Analyse and Prevention of Musculoskeletal Disorders in Flutists Aged Between 15 and 18 years)	n=21 (n=11 flutists & n=10 symmetrically played wind instruments)
Norris, 1996	National Flute Association Survey 1991	n=420
Spence, 2001	University of North Texas-Musician Health Survey (1998)	n=329
Spence, 2001	Flute Health Survey distributed at the 1999 National Flute Association Annual Meeting	n=40
Thompson, 2008	The Biomechanics of Flute Performance 2008	n=30

2.8.1 Studies on Flutists Using Electromyography (EMG)

Very few studies have used electromyography to analyse muscular responses during flute playing. A study was undertaken by Fortune (2007) at the University of Sydney assessing electromyographic activity of the left upper trapezius during a screened and audited performance of two challenging orchestral flute excerpts. The results of this study were included as part of a Masters thesis on the relationships between performance-related musculoskeletal disorders and muscle tension, anxiety, musical task complexity and musical ability. This study focused on only one muscle, the left upper trapezius (p.85) whereas the new study described in Chapter 5 investigates several different muscle groups involved in flute playing.

2.8.2 General Musician Surveys on Playing-Related Musculoskeletal Conditions

A number of other surveys have shown that playing-related musculoskeletal conditions are common, however, many have either a small sample of flutists, or the flutist data is grouped with other wind players. Australian doctor, Hunter Fry, was among the earliest researchers to focus on playing-related "overuse" injuries. His report *Prevalence of Overuse (Injury) Syndrome in Australian Music Schools* (Fry, 1987) indicates three major factors leading to overuse are genetics, playing technique, and intensity multiplied by the duration of practice. His prevention strategies included education of teachers and students on "overuse syndrome", "safe and sensible practice habits", and to eliminate the "muscular activity used to hold up heavy instruments" (pp.39-40). The study included 276 woodwind players from Australian music schools, but there is no flute-specific data available in the findings. A later study (Fry, 1988) included 48 flute players, of which 11 were treated for "overuse syndrome" (p.573). Apart from general demographic data, such age, gender and playing experience, there is little other

information to help determine what factors may have played a role in their injuries (such as practice habits, posture, lifestyle and other factors.)

Roach, Martinez, & Anderson (1994) found that students who played musical instruments were at a greater risk of upper body joint pain than the general student population (p.130). The study involved 249 students, 90 of whom were instrumentalists, but none played flute. Chan et al. (1999) investigated the prevalence of musculoskeletal problems among professional orchestral musicians in Hong Kong. However, due to a very small sample of woodwind playing respondents (n=3), it was not possible to comment on instrument-specific injuries (p.46). Similarly, a study of performance-related medical problems among 97 musicians in 4 youth orchestras only included 1 flute player (Britsch, 2005, p.44). Guptill, Zaza, & Paul (2000) reported that 83.8% of college music student woodwind players at a large Midwestern American university had experienced playing-related injuries. Flutists were included in the study, but there are no statistics reporting specifically on flute playing-related injuries (p.87).

Similarly, no flute-specific data is detailed in a survey of 815 classical orchestral musicians in the UK and Germany (Harper, 2002). The survey addressed musculoskeletal and other medical problems, as well as lifestyle factors, stress, concerns about environmental and working conditions and treatment or therapies (pp.84–86). Heming (2004) reported that 70% of 59 surveyed musicians had suffered a playing-related injury, with one-third of those unable to play for a period of time. A total of 8 flutists were among this group, half of which had suffered from an injury. Beyond this statistic, there is no flute-specific data in the report.

2.8.3 Types of Flute Playing-Related Musculoskeletal Disorders

Fishbein, et al. (1988) surveyed 95 professional flute and piccolo players in *Medical problems among ICSOM musicians: Overview of a National Survey* in the USA. The

survey questions related to both musculoskeletal and "all the other medical problems", including stage fright, as well as lifestyle factors and treatments sought (p.2). While specific numbers of flute participants are available, statistics in this report relate to the overall group of respondents. Of the total group, 76% of ICSOM musicians "reported at least one medical problem that was severe in terms of its effect on performance", with "stage fright" being the "most prevalent medical problem". Additionally, "the neck and back were the most frequently mentioned locations for musculoskeletal problems" (p.8). Similarly, in a study of predictors of pain and other musculoskeletal symptoms among Sydney professional musicians, Davies & Mangion (2002) analysed their survey data in two groups: "players of orchestral stringed instruments and players of all other instruments" (p.158).

In a study of performance-related injuries of 314 student musicians age 18 and younger from 1985 to 2002, 33 flutists were examined at a speciality clinic (Burkholder, 2004). Injury sites were reported as shoulder/scapula (2); elbow (2); forearm (9); wrist (9); hand/fingers (19); thumb (5); head/eyes/ears/nose/throat (3) and neck/back (2). Burkholder stated that "flutists had trouble with the left hand and wrist, which must support the flute in a strongly dorsi flexed position while fast fine motor movements are executed by the fingers". This study also concluded "young age does not appear to be a protective factor against injury".

Nemoto & Arino (2007) undertook a health check survey of 235 wind players from Japanese military bands, including 20 flutists. Of those, 16 had experienced playing-related medical problems, and 13 had experienced symptoms such as a stiff neck, wrist pain, or jaw pain (p.67). The study focused on hand and upper extremity problems, but little flute-specific data was reported, though they found that "the frequency of problems was highest among oboe, clarinet and flute players." (p.69) Nemoto found

that players of flute, oboe and clarinet reported more hand and upper extremities problems than players of other wind and brass instruments in military bands. Nemoto concluded, "physicians, musicians, music teachers, and band administrators should all be more conscious of the potential for musicians to develop a wide array of physical problems directly related to the repeated use of their musical instruments".

Significantly, Nyman, Wiktorin, Mulder, & Johansson (2007) found that musicians playing in an elevated arm position experienced a higher prevalence of neck-shoulder pain than those working in a more neutral position (p.370). The study (n=235) included 10 flutists and while this is a small sample, the results are consistent with other surveys which show that neck and shoulder pain is common among this population.

Apart from playing-related discomfort, pain and tension, flutists suffer from debilitating musculoskeletal conditions such as focal dystonia (Altenmüller, Wiesendanger, & Kesselring, 2006, p.267; Brandfonbrener, 1995), entrapment of the small nerves in the fingers (Watson, 2009, p.85), flutist's neuropathy (Dawson, 1997, p.107) and tenosynovitis (Dawson, 1997, p.110). Other non playing-related conditions which make flute playing more painful are degenerative tendinitis (Dawson, 2008, p.76), de Quervain's syndrome or tenosynovitis (Dawson, 2007, p.109; Watson, 2009, p.78), and osteoarthritis (Dawson, 2008, pp.72-73).

2.9 Other Relevant Studies

As discussed, there are very few examples of flute-specific studies on the topic of health, injuries, or medical conditions in the literature. However, one recent study does focus on the topic of flute-playing posture. Dib & Sturmey (2007) describe a postural training program for "typically developing girls aged 8 to 9 years" in *The effects of verbal instruction, modelling, rehearsal, and feedback on correct posture during flute playing*. The training program involved using "applied behaviour analysis" to teach

"correct posture", defined as: "1) placing both feet flat on the floor, 2) keeping back and neck straight, and 3) holding the flute parallel to the floor." (p.383) There is no anatomical basis given to the reader for the reasons the authors consider this position to be the "correct" posture. The authors do not suggest any other important criteria for "correct posture", such as the positioning of the shoulders, chin, hands, elbows. For example, it is possible for the back and neck to be "straight", while still lifting the shoulders, or jutting the chin forwards. By contrast, Brandfonbrener (1991b, p.38) states:

> Many teachers and performers are firmly grounded in the belief that there is a "right" way and a "wrong" way to perform – a kind of pedagogical imperative. Indeed there are some approaches to performance on instruments or the voice that seem to enable most musicians to function optimally, but until people are cloned, there will always be exceptions to the application of any methodology."

It is unclear from Dib and Sturmey's report whether the students played on straight or curved flutes, and there is no mention of their physical size. The major weakness in this paper is the description of "correct posture", which as reported in the new survey results in Chapter 4 of this thesis, has different interpretations for each flutist. Additionally, Dib & Sturmey (2007, p.383) states "the fact that musicians often develop physical problems because of their posture while playing suggests that there is not enough focus on teaching new students the correct posture for instrument play". While early education is considered to be vital in preventing injuries, it is not the sole contributing factor. The authors have not acknowledged, for example, that some flutists in this age group, may not be physically big, or strong enough to be playing full length, straight flutes. Spaulding (1988) advises against assuming that "bad technique" is the only way to prevent injuries occurring and stresses that "the potential development of disorders seldom can be attributed to a single factor" (p.137).

2.10 Conclusion

The literature review shows that there are few studies specifically focusing on flute playing-related musculoskeletal disorders and their contributing factors. General studies of musicians tend to group the flutes together with other woodwind instruments, despite the flute position being very different to the clarinet, oboe, bassoon and saxophone which are held closer to the midline of the body. The few studies undertaken on flutists exclusively, or which specifically mention flutists, indicate that they suffer typically from neck, middle/upper back, shoulder, and hand/wrist pain. In the traditional flute literature, very few authors mention the possibility for injury, and there is conflicting information about "correct" holding position, alignment and posture.

The performing arts medicine literature offers general advice on a range of medical conditions, treatments options, and prevention strategies. There is very little flute-specific information and it is often restricted to a short discussion on flute modifications, offset G mechanisms, flute balance points and curved head joints. It is necessary to bring together the very valuable information contained in the performing arts medicine literature with the expertise of a musician who is both a flute performer and educator.

There are still vast gaps of knowledge which this thesis is addressing, including a discussion on ergonomic flutes and devices, as well as ergonomic principles applicable to teaching and playing situations. The traditional flute literature has a wealth of information about the history of flute construction, and performing traditions, including the pre-dominance of male flutists until well into the twentieth century. Recent studies show that women who play asymmetrical instruments may be at a greater risk of injury in certain musculoskeletal sites, such as the neck, back and shoulder. A greater understanding of historical perspectives will shed light on the reasons behind designing the flute to be played asymmetrically with a long stretch to the keys. Chapter 3 includes

some insight into the driving factors behind the need to construct the modern flute in this form.

3. HISTORICAL PERSPECTIVES: AN OVERVIEW OF FLUTE CONSTRUCTION

The flute is one of the earliest known musical instruments, and a multitude of different types have been used in many of the world's cultures (Powell, 2002, p.1). Recent discoveries in Europe indicate that early western flutes existed up to 35,000 years ago, and were made of materials such as vulture bone and mammoth ivory. One bone flute found in Hohle Fels, Southern Germany in 2008 has five finger holes, and would have originally been about 34 centimetres long (Conard et al, 2009). Since ancient times, the western flute underwent many transformations, until the introduction of the modern flute in the mid-nineteenth century. Although the demographic of flutists has changed dramatically since that time, irrespective of physical size or background, most modern flutists play concert flutes that are of a similar length.

This chapter will provide a brief overview of flute construction and highlight the musical, and technical reasons behind designing the modern concert flute in its current size, as a transverse instrument, rather than a vertically held one. Ergonomic developments by contemporary flute makers addressing the injury concerns in the flute playing community will also be discussed.

3.1 Middle Ages and Renaissance

Unfortunately, there are no remaining examples of flutes from medieval times, and what is known about these instruments is derived from descriptions in ancient poetry and other literature, as well as depictions in art works (Powell, 2002, p.7). The wooden transverse flutes (held across the body, not vertically) of the Middle Ages and the renaissance were made in one piece, with holes bored into the tubing. The flutes of the middle ages ("Zwerchpfeiff") had 6 finger holes, were just under 61 centimetres (2 feet)

in length, and were played together with drums for military purposes (Toff, 1996, p.42). By the Renaissance period, differently sized flutes were used mainly to accompany singers, taking on the name of each of the vocal lines, for example: Discantus (descant), Altus (alto), Tenor and Bassus (bass). The length of the flute and the diameter of its tubing determined its pitch range, meaning that a shorter, narrower tube produced higher pitches than a flute with a longer, wider tube. From the year 1400, flutes were also used in instrumental chamber music, taking on a more soloistic role (Toff, 1979, pp.11-12).

3.2 Baroque

In the Baroque period, the recorder ("flauto") was commonly used in ensembles, as well as in instrumental sonatas and concertos. As a greater range of notes, dynamics, expression and tonal projection was desired in ensembles, the recorder was gradually replaced by the more powerful transverse or "German" flute (Toff, 1996, pp.42-43; 1979, p.15). Around 1660, French maker Hotteterre redesigned the flute, by adding a D sharp key over a seventh finger hole. These flutes were constructed in three pieces, and the D sharp key extended the chromatic possibilities to a two octave plus range (D1 - D3), though notes above that were "forced" (Toff, 1996, pp.43-44). However, depending on which court or theatre a performer worked in, the pitch varied anywhere from A=390 to A=410, and flute makers had to construct instruments to suit. "Each maker developed a personal concept of tone and intonation and devised original technical means of achieving his ideas." (Powell, 2002, p.74).

As a way of making the instrument more flexible in terms of intonation, by around 1720 flutes were made in four sections, with up to seven interchangeable "upper middle sections" made of different lengths. This enabled flutists to adjust the intonation or pitch, according to the particular keys they were playing in at the time (Powell, 2002

p.80; Toff, 1996, p.45). Toff (p.44) states that by 1722, attempts had already been made to extend the flute's range down to C1 (middle C).

3.3 Classical/Early Romantic

By the middle of the 18th century, flutes were constructed with more chromatic keys, to be able to play music in a greater range of keys. Around 1760, three London-based makers, Pietro Florio, Caleb Gedney, and Richard Potter, added G sharp, B flat, and F keys to the one-keyed flute, which eliminated the need for many cross (complex) fingerings. High notes like F3 became more stable in tone and intonation. Later Florio, Gedney and Potter also lengthened the flute by two inches and created a new C-foot joint, with two added holes bored into the tubing. Another maker, Dr J.H Ribock added a closed key in the left hand for C2, and German maker Johann Georg Tromlitz added a 2nd F natural key which made progressions from F to D or D sharp more fluent. By the early 19th century, 4-, 6- and 8-keyed flutes with their new note range of D1 - G3 were commonly played (Toff, 1996, pp.46-47).

3.4 The Industrial Revolution, Romantic Era, and the Inventor of the Modern Flute

During the industrial revolution, there were significant mechanical improvements in flute making, such as Claude Laurent's 1806 glass flute with silver tenons, sockets, lengthened springs, and re-designed key mountings (Toff, 1996, p.49). English maker, Frederick Nolan then introduced "open-standing keys, either a single lever or a linked pair, whose touchpieces were rings that surrounded the finger holes". This device enabled one finger to close one key, while a connected key was open (Toff, 1996, p.49).

On hearing the renowned English flutist Charles Nicholson performing in 1831, professional flutist and maker Theobald Boehm was convinced that part of the reason for his impressively powerful tone was a flute with enlarged finger holes. Boehm had

already been experimenting since 1828 with flute modifications such as “tuning slides, hardened gold springs, and the mounting of keys on screwed-in pillars” and “longitudinal rod-axles to connect keys” (Toff, 1996, p.50). Thereafter, he re-designed the entire mechanical system, ensuring the finger holes were as large as possible, and placed not only in keeping with acoustical principles, but were also comfortable for the fingers (Boehm, 1964, p.59; Toff, 1996, p.52).

Boehm’s flute was introduced to the public from the end of 1832, at concerts in Munich, Paris and London, though the local flute community at the time was reluctant to learn new fingerings. By 1837, the French flutist Paul Camus, endorsed the Boehm flute, and with further modifications by French maker Auguste Buffet, as well as flutists Victor Coche, and Vincent Dorus, the flute gained popularity. An example of their changes was the moving of all of Boehm’s axles to the inner side of the flute, rather than both sides (Toff, 1996, p.50).

During 1846 and 1847, Boehm studied acoustics at the University of Munich and realized that a cylindrical tube should replace the conical bore, to create the optimal tone, and he also re-designed the size and shape of the embouchure hole in the head joint. These changes required further adjustments to the key work, and after experimenting with new materials, he preferred the sound of a silver tube to the earlier wooden flutes. Thus, the modern concert flute became based on Boehm’s resulting 1847 model, a technological breakthrough in design which addressed many of the inadequacies of earlier flutes, such as poor projection, inconsistent intonation and a multiplicity of fingering systems. (Bate, 1969, pp.115-133; Toff, 1979, pp. 44-79; 1996, pp.50-54)

There has only been one major fingering system alteration prior to the twentieth century, by Giulio Briccialdi in 1850, who introduced the thumb lever, enabling the playing of B natural and B flat with the left hand thumb (Toff, 1996, p.56). By 1860,

Boehm's model was the favoured instrument at the Paris Conservatoire, due to the influence of Dorus who was the flute professor at the time. Louis Lot was the official supplier of flutes to the Conservatoire, their metal flutes becoming more popular than their wooden instruments from 1870 onwards (Giannini, p.172). Some additional changes to the system were introduced in the twentieth century, such as the B-foot gizmo key, C sharp trill key, split E mechanism, lower G insert, and C sharp and D sharp rollers (Moratz, 2010, pp.48-49). However, the basic mechanism and size of the instrument is still based on Boehm's model.

In reviewing the history of flute construction up until the mid-nineteenth century, it is evident that tonal projection, intonation, and expansion of the flute's technical range were the main factors that lead to the instrument's current dimensions. However, Boehm's success in placing the finger holes in both acoustically accurate positions, as well as comfortable ones for the player, indicates that he may also be considered one of the earliest ergonomic flute makers. He stated that "the practicability of my system of fingering has long demonstrated itself not only in its use by artists, but also by beginning students who learn to play the scales and trills in all keys in much shorter time than was possible on the old flute." (Boehm, 1964, p.62)

While possibly not an intention of the maker, Boehm's design may well have made the flute easier to play for female flutists, who were traditionally not considered suitable candidates for learning the instrument. The modern flute is played today by both men and women, but this was not always the case.

3.5 Demographics and Gender Considerations

Flute makers and performers throughout most of western flute making history were male. Teaching traditions were designed by men, for men. Rockstro (1967) provides a list of instruction books and methods, all written by men, published between 1730 and

1827 (p.305). Many of the key flute methods, instruction books and studies were written by flutists such as Francois Devienne, Charles Delusse, Benoit Berbiguier Joseph-Henri Altes, Paul Taffanel, Philippe Gaubert, and Marcel Moyse (Powell, pp.210-223). These books are still in use by flutists today. Rockstro (pp.550-645) lists many other eminent flutists from 1640 - 1868, all men, such as Louis Hotteterre, Jean Baptiste Loeillet, Pierre Buffardin, Johann Joachim Quantz, Michel Blavet, Johann Tromlitz, Jean Tulou, Jules Demersseman, Anton Fuerstenau, Louis Drouet, Friedrich Kuhlau, Kaspar Kummer, Charles Nicholson, Theobald Boehm, Heinrich Soussmann, Paul Calmus, Vincent Dorus, Giulio Briccialdi, and Robert Pratten. Rockstro does mention some good female musicians, but their instruments were not flute, but piano (p.605) and guitar (p.646).

Bowers (1987, p.6) states that around the middle of the seventeenth century, while women played in public concerts on flute, they "did not provide women with any of the more routine employment opportunities from which men benefited; none of the extant lists of personnel indicates that women were hired to play in the orchestras that accompanied at nearly all of the concerts." Similarly, Powell (2002, p.110) states that "In England as in the rest of Europe, the flute was almost exclusively the province of men. Women performed on fashionable ladies' instruments such as the harpsichord, piano or English guitar in the early 1760s, and later on the harp. Performing in public on male instruments, as Marianne Davies did on the flute at this time, was a highly radical act". Toff (1996, p.244) explains that the flute, even amongst amateur players was used for social reasons, not just musical:

> Social changes also affected amateur musicians. The middle class, with its rising economic and social status, sought to imitate the eighteenth century gentry in manners as well as wealth. And so the flute continued in the nineteenth century to be the favored gentleman's instrument; only the gentleman had changed. In Manchester, England, for instance, this trend was epitomized by the establishment, in 1774, of the Gentlemen's Concerts, an organization comprising twenty-six flutists.

> Just as young ladies considered mastery of the piano a necessary social grace, flutists - mostly men - used their instrument as a social tool.

Even by the early twentieth century, the flute was considered an instrument best suited for men to play. Fitzgibbon (1913) provides illustrations of "famous flautists of the past", among them an all male group: Tulou, Berbiguier, Kuhlau, Briccialdi, Rockstro, Demersseman, Nicholson, Dorus, Drouet, and Boehm. Fitzgibbon (1913, p.220) stated:

> The flute is the only wind instrument which has to any appreciable extent been adopted by women…Yet the instrument is extremely well suited for ladies. The attitude when playing is graceful and healthy, affording ample opportunity for the display of a beautiful arm; it is a gentle instrument, requiring but little physical exertion.

In his treatise, first written in 1890, with a 2nd edition in 1928, Rockstro (1967, pp.410-411) states:

> The consummate ease and elegance of the correct position of the flute-player will compare favourably with that of any other instrumentalist. It is partly owing to this gracefulness of attitude that the flute is so peculiarly well adapted for ladies, amongst whom I hope to see it even more popular than it is at present.

Considering the prevalence of playing-related musculoskeletal disorders in the flute community, holding a unilateral position against gravity, for extended durations, it is difficult to conceive that flute playing requires "little physical exertion". In 1922, Dayton Miller declared that the flute had "always been a favourite instrument with gentlemen performers...more than ever before, the gentleman's instrument". Miller considered, however, that "Boehm's technical improvements made the flute "pre-eminently suited for use as a lady's instrument" (Boehm, 1964, p.xxvii-xxviii).

Apart from other cultural and social expectations of women, there may also have been physical difficulties in playing the old system flutes. Women generally have smaller hands than men and when comparing the placement of finger holes of pre-Boehm flutes and the modern day flute, it is clear that there was a much greater stretch of the fingers

to reach the holes for the early flutists. This stretch may therefore have been difficult for females in the Baroque, Classical and Romantic periods.

Figure 1: Comparison of Pre-Boehm and Modern Flute Mechanisms

A change came about from 1925 in the USA, where women's symphony orchestras began to be established. Neuls-Bates (1986, p.350) explains that "since the all-male symphony orchestras continued to exclude them, women sought employment and professional experience by establishing their own orchestras, with full complements of eighty of more players, which specialized in the performance of strictly symphonic repertory." Almost thirty women's orchestras flourished in the United States from the 1920s to the 1940s, with a major change for female musicians occurring with the commencement of war:

> …for the war effort of the 1940s drastically altered the employment pattern. It depleted the ranks of men and thereby made possible the entrance of female players of all instruments into the major symphony orchestras, as well as the orchestras in opera, radio and the movie and recording industries, from which they had formerly been excluded. (Neuls-Bates, p.363)

Even until mid-twentieth century, few women held professional chairs in orchestras. Powell (2002, p.281) wrote:

> Three decades ago, though girls were taking up the flute in unprecedented numbers, women flutists who held prominent positions in orchestras or as soloists were few: Doriot Anthony Dwyer (principal flutist of the Boston Symphony as early as 1952), Lois Schaefer, Patricia Lynden, Susan Milan, Paula Robison, and Carol Wincenc were among the best known. In a count made in January 2001, 429 women held posts as flutists or piccoloists in 998 orchestras in 35 countries, as compared with 569 men.

3.6 Gender and Playing-Related Musculoskeletal Disorders

Brandfonbrener (2000, p.175) states that there is an increased incidence of playing-related medical problems among female musicians and Fishbein (1988, p.5) reported that "compared to males, female musicians were more likely to report at least one medical problem (89% vs. 78%) and at least one severe problem (84% vs. 72%)". There have been few flute-specific surveys reporting on playing-related injuries, and of those Fain (2009) omitted gender data, and others included between 85% and 95% of female respondents, therefore an overwhelming majority (Fortune, 2007; Spence, 2001; Thompson, 2008). Norris (1996, p.77) states that the "total number of flutists (students, amateurs, professional performers and teachers) worldwide is not known, but one major manufacturer estimates the number in the hundreds of thousands, mostly young, mostly female. The occurrence of injuries in this group has not been previously studied in depth." Other studies have also reported higher rates of injuries in female musicians (such as Abreu-Ramos & Micheo, 2007; Roach, et al., 1994; Zaza, 1992). In a study by Engquist, Orbaek, & Jakobsson (2004), no gender differences were observed, however, wind players were grouped together, without any specific mention of flute-specific statistics.

The survey described in chapter 4 will draw attention to specific flute playing issues which may affect women more significantly. Gender issues within historical flute performance practice will be examined and bring to the fore a topic which is only

briefly addressed in the literature, especially with respect to the physical considerations of playing.

3.7 Gender and Type of Instrument Played

Although there exists some data on who plays the flute and therefore some evidence of gender-specific differences, the amount of epidemiological data is relatively small when it comes to understanding the factors that contribute to flutist health. For example, there is little to no research comparing the muscular responses of male versus female, or larger versus smaller framed flutists to varying playing loads (e.g. technically difficult repertoire, or playing over extended durations). However, a study of musculoskeletal pain in student instrumentalists compared to a general student population by (Roach, et al., 1994) found that female musicians "were 1.9 times more likely than men to report upper-body joint pain in general" and "were 3.6 times more likely to report upper-back pain and 2.8 times more likely to report shoulder pain than were the men" surveyed. They compared this with women in the general student population (non-musicians) who "were 70% less likely to report shoulder pain than were the men". Of particular interest is that 78% of the violinists in the study were women and 88% of the percussionists were men (p.128). This is relevant because the "women who played the violin had 23 times the odds of upper-body joint pain and 14 times the odds of shoulder pain than did the men who played the violin." While there were no flutists in the study, the playing position of the violin is, like the flute, held against gravity, asymmetrically, whereas percussion playing is generally highly dynamic, using a greater range of movement, and more symmetrical.

Significantly, Nyman, et al., (2007, p.375) found that:

> Orchestra musicians working in an elevated arm position (e.g. violinists, violists, flutists, and trumpet players) had a higher prevalence of neck-shoulder pain than those working in a more neutral position, even with an exposure of <2 hours of active playing time per workday. The duration of active playing time per workday did not affect the prevalence of neck-shoulder pain among the subjects playing in a more neutral arm position.

In other words, gender may become an issue when playing particular instruments and this is not necessarily able to be determined when flutists are grouped together with other woodwinds in the studies. Of potential significance to flutists, is that the instrumentalists in Roach (1994) who were not currently suffering from upper-body pain spent "an average of 9 hours a week in some type of physical activity" (p.130). They also concluded that the "lesser upper-body mass of women as compared with men" may be influencing the higher rate of pain in female violinists, and that this could, therefore, be managed and prevented by appropriate physical training programmes to improve strength and endurance in the upper body." (p.130)

Wahlström, Edling & Fjellman-Wiklund (2009) found that female music teachers who play in asymmetric postures "reported significantly more symptoms in the neck, shoulders, and upper back than male teachers". There were 3 flutists included in the asymmetric playing position group (n=22). In the same study, teachers who played with an asymmetric posture "had significantly more musculoskeletal disorders than music teachers with a symmetric playing posture. (p.113)

These outcomes may have significant implications for future research, flute construction and flute pedagogy, gender specific advice, suitability and sizing of instruments at various stages of playing, practice routines, and the importance of physical conditioning in preventing playing-related musculoskeletal disorders. Currently there are no differences in the flute education and training of male and female flutists, and studies comparing male and female pain data is limited. A recommendation of this research would be to investigate potential differences in the rate of musculoskeletal disorders

among male and female flutists, and whether physical training programs may decrease the prevalence of injuries.

In the traditional flute literature, there seems to be little mention of concerns with playing-related pain. Perhaps this may be partly to do with the natural upper body strength of men and pain not being a significant issue, especially when the more comfortable Boehm flute was introduced. However, there were also some inherently ergonomically sound practices in the education of young boys in late nineteenth century France that are worth noting.

3.8 Changes in Early Flute Education

Much of the standard teaching of flute technique, tone, articulation and phrasing in modern times is based around the methods written by the great flute masters at the Paris Conservatoire, who represent a style of playing lasting almost a century and known as the French School of Flute Playing (1860 - 1950). All of the famous teachers and performers from this period were male flutists, including the founder of the 'French School' Paul Taffanel, and a long line of successors at the Paris Conservatoire including Adolphe Hennebains, Philippe Gaubert, Marcel Moyse, and Rene Le Roy (Dorgeuille, 1986, p.23). It was common at the end of the nineteenth century in France for young boys to commence their musical training on either tin whistle or fife, before progressing to the flute. As a boy, one of Taffanel's most famous students, George Barrère, gave tin whistle lessons to his friends at school (Toff, 2005, pp.7-8). Barrère stated:

> At recess, all the boys neglected marbles for lessons from George Barrère on the tin whistle. The toy shops of Epernon could not supply these vehicles for virtuosity fast enough. This was between the years 1886 and 1888 when I was between ten and twelve years of age. (Allison, L.M, in Dorgeuille 1986, p.80)

The Paris Conservatoire was a "military musical academy" at the time of the French Revolution (Powell, p.210). Francois Devienne, for example, taught music, "to the

children of the new republic's soldiers" (Powell, p.210). The French government established mandatory batallions for primary school age boys in 1881 (Toff, 2005, p.8) Barrère took up the fife in 1888 and joined the "Bataillons Scholaires":

> These gave military training to the boys and furnished them with uniforms, bugles, drums and fifes. Of course I entered the fife corps. The teacher was a flute pupil of the Paris Conservatoire and was most encouraging to the youthful Georges Barrère. (Allison, L.M, in Dorgeuille, p.80)

As a result of his improvements on fife, his teacher encouraged him to play a silver Boehm flute, later joining the Paris Conservatoire flute class at age 14 (Toff, 2005, pp.8-9). Another of Taffanel's famous students, Georges Laurent, commenced his training in a military band:

> The French Government renders military service compulsory and therefore every French boy knows that his country will demand his services in some capacity for a least a period of two years. In view of the musical traditions in his family, it is not surprising that Georges should have been attracted to the music section of the army. So with all the sagacity of a small boy, he decided that he would play flute in the Military Band...This first instrument was of wood and had seven keys. (Kennarie, B., in Dorgeuille, p.97)

Similarly, Louis Fleury, another renowned student of Taffanel, commenced learning on a small flute, in this case, the piccolo. He states:

> Later, when I was twelve years of age, a piccolo was bought for me and I had for an instructor a barber. I made rapid progress and thereupon a Boehm-system flute was purchased for me, then an amateur flutist, a pharmacist, directed my footsteps towards the serious art of flute-playing. (Fleury, L., in Dorgeuille, p.93)

In modern times, young flute students typically commence learning on a standard concert flute, without an initial period of playing on a smaller instrument, such as a fife or piccolo. Perhaps this method of learning was partially brought about by the introduction of school music programs in the USA, before the First World War (Toff, 1996, p.3). Toff states that at this time "An immediate effect of this burgeoning flutist

population was the development of the student flute, an instrument inexpensive enough to be accessible and durable enough to withstand amateur handling" (pp.3-4).

An introductory period on a fife, or piccolo would have enabled boys in the late nineteenth century to learn musical fundamentals on small flutes, while maintaining good posture, before progressing to standard instruments. This is an example of sound ergonomics, in that it matches the physical characteristics of the player with the correct size of instrument, to avoid unnecessary loading. Ergonomics in flute making has become very important in recent times, not just for beginners, but experienced players as well. Some of these will be briefly discussed here, and examined more thoroughly in Chapter 6.

3.9 The Importance of Ergonomics in 20th and 21st Century Flute Making

Some modern flute makers now design flutes to increase comfort and stability during playing, while still staying true to Boehm's key system. Ergonomic options across the range of flutes, from the standard model, down to alto and bass flutes will be discussed in the next section.

3.9.1 Ergonomic Flutes and Modifications

The Drelinger Headjoint Company has introduced the *UpRite Head Joint* which results in the player achieving a more symmetrical playing position, with both arms held centrally, in front of the body. Similarly, Dutch maker Maarten Visser from the FluteLab company, has designed a *Swan Neck* and *Vertical Head Joint*, which are designed to assist players achieve a more comfortable position. With the greater demand for extended ranges, Dutch maker Eva Kingma, has created a family of low flutes, with ergonomic benefits, such as comfortable hand positions, reduced weight, an upright bass flute, and an adjustable resting stand.

A wide range of flutes suitable for beginners have also been introduced to the market, including curved head joints, D-foot flutes, the *Yamaha Fife* (a small, plastic flute with finger holes and no keys), as well as the Azumi *Waveline* flute, with a twist in the tube that shortens the length of the flute. There are also several instrument modifications such as finger rests, thumb rests, and key extensions, which are inexpensive and can be attached to the standard flute. These and other ergonomic alternatives will be discussed in more detail in Chapter 6.

Despite the efforts of a number of contemporary flute makers to produce ergonomic flutes and devices, a review of the flute literature indicates that apart from acknowledging the challenges of the flute-playing position, there is little information about contributing factors to playing-related musculoskeletal disorders. There are also few flute-specific suggestions on how to prevent and manage any resulting discomfort, pain or injuries. Chapter 4 describes a new, large-scale study, which through both extensive quantitative and qualitative responses, substantially increases the current knowledge of flute playing-related disorders.

4. INTERNATIONAL SURVEY ON INJURY PREVENTION AND MANAGEMENT FOR FLUTISTS

Due to limited data on the specific musculoskeletal disorders of flutists, and a paucity of data from outside of the USA, a new study was needed to more definitively establish the extent of flute-associated musculoskeletal disorders internationally. Spence (2001) reported "there are many medical problems facing the flute playing community" and that "further investigation and observations of this population is necessary" (p.99). Despite this recommendation, the current survey is, as far as can be determined, the only large-scale study of musculoskeletal problems facing flutists since that time. Previous surveys have provided little information about the possible relationships between the lifestyle habits of flutists including their fitness and general health, and current rates of injury.

This chapter focuses on the 2007 survey. It was designed to fill gaps in existing knowledge, contextualize it within previous relevant surveys, and demonstrate how this survey furthers our understanding of flute playing-related musculoskeletal disorders. For completeness and to aid clarity, the chapter is structured in order to present the significant findings together with a discussion of the findings. All of the online survey questions are located in Appendix B. More detailed data is located in Appendix C. Representative qualitative data is reported within the chapter but more detailed qualitative data is located in Appendix C.

4.1 Methods

Using online survey templates on http://www.surveymonkey.com, survey questions addressed a range of issues previously not fully addressed including flute education,

history of playing injuries, preventative and management strategies, lifestyle factors and teaching methods. It comprised seven sections:

1) *About the Research*

This section was to inform potential participants about the purpose of the survey, which was to establish the injury concerns of flute players and teachers of all backgrounds, as well as their knowledge and awareness of playing-related injury prevention and management. Participation in the anonymous survey was invited, and a brief background to the study was given. It was explained that completion of the survey deemed that the participant gave consent to the research.

2) About You

Demographic details such as age, gender, country of residence as well as playing level, musical qualifications and background were discussed in this section. For the purpose of safeguarding anonymity, subjects were not required to identify their exact age, therefore statistics such as mean age are not provided. There were also questions about the early flute education, flutes played, the emphasis teachers placed on posture or positioning, as well as participation in educational activities such as flute conventions, masterclasses, workshops, and online flute forums.

3) Lifestyle, General Health and Fitness

Participants were asked about their body weight, general health and fitness, levels of happiness, participation in aerobic activity and resistance training, and lifestyle factors such as smoking and consumption of alcohol. They discussed aspects of their medical history which may cause or impact on playing-related discomfort or pain, as well as their experience with visual problems and headaches. Participants were asked to describe postural tendencies in playing and answer questions about their experiences with playing-related discomfort or pain.

4) Management and Prevention of Playing-Related Discomfort/Pain/Injury

In this section subjects discussed their practice schedules, regularity of breaks, medications (if any), practitioner treatments and strategies used to prevent or manage playing-related discomfort, tension or pain. Participants were asked about their opinions on training in injury prevention and management.

5) Playing-Related Discomfort/Pain

If relevant, participants were asked to describe any playing-related pain symptoms (such as aching/stiffness, burning, radiating, sharp pain, or tingling, numbness) in specific musculoskeletal sites. They also provided information about factors that felt made their condition better or worse.

6) Questions for Flute Teachers

Flute teachers were asked about their teaching background, what training they felt gave them a better understanding of flute playing-related injury prevention and management, and strategies they recommended to students to prevent or manage injuries. They were also asked to give a definition of what they believed to be the essential aspects of good flute playing posture or positioning.

7) Further Comments and Contact Details

While the survey was anonymous, respondents had the option of leaving their contact details and further comments if they desired. Identifying comments have been removed from the data set, including in qualitative responses.

4.2 Recruitment, Ethics and Data Management

The survey was promoted through flute networks, which included popular international online flute discussion groups such as FLUTE (http://www.larrykrantz.com), Galway Chat and Flutenet, via a link created in the survey program. The link was also emailed to representatives of flute societies, university music faculties, and teachers, who were

invited to pass the link onto their members, colleagues and students. Some also included the link on their websites, including Flutewise (http://www.flutewise.com); Karen Lonsdale (http://www.karenlonsdale.com), the Flute Network (http://www.flutenet.com/) and the Flute Society of New South Wales (http://www.flutesocietynsw.org.au/). The survey drew responses from 421 respondents, and 408 of those were able to be included. The 13 responses that were not included in the final results were excluded because either no questions were answered, or so few questions answered, that there was no comparative data, beyond basic demographic information. All flutists were invited to participate in the online survey, with age categories ranging from 11 and under, to 71 and over, though there were no responses from those aged 11 or under. Flutists and teachers from all backgrounds participated in the study, including students, amateurs and professionals, representing different styles of music. The Griffith University Human Research Ethics Committee granted ethical approval and approval statements for the survey have been included in Appendix A.

The participant demographic data will be presented, before discussing the major survey outcomes related to prevalence of musculoskeletal problems, posture, health, fitness and lifestyle, medical history, and teaching practices. Based on the findings, recommendations for flute teaching and performance will be made. The results and discussion will be presented separately under pertinent survey topic headings.

Data were first collected on the Survey Monkey website, then entered onto SPSS. A survey report utilizing descriptive statistics follows. Investigations of the relationship between pain and other variables such as gender and age have been analyzed using the Pearson Chi-Square, (or Fisher's Exact Test, if the assumptions were not met). Apart from such associations, an in-depth statistical analysis will not be attempted beyond the reporting of response frequencies (as totals and/or percentages).

The current survey provides extensive feedback from respondents on a wide variety of topics pertaining to flute playing-related discomfort, pain and injuries. The respondents provided detailed responses about their views on playing posture, previous injuries and medical conditions, practice habits, lifestyle, education and training, as well as teaching methods. All of the previous flute survey reports provide quantitative data, but either no or few qualitative responses. The opportunity for flute teachers to provide extensive feedback on a variety of issues pertaining to injury prevention and management had also not been provided in previous studies. The current survey responses will provide the reader with valuable insight into teaching practices, training, and how teachers advise their students on prevention and management strategies.[3]

The results and discussion will be presented synchronously for ease of comprehension. Appendix C contains additional results tables that are not included within the main body of this chapter. A very large number of comments were provided by respondents and in every case, assist in presenting a much clearer picture of the attitudes and feelings of flute players and teachers. Representative examples of these comments have been included in this report, and compared with both the flute and performing arts medicine literature.

4.3 Results

4.3.1 Demographics - Age, Gender, Country of Residence

Since the survey was related to personal health issues, there were only two mandatory questions in the survey. To ensure a high rate of participation, each respondent was required to indicate which age range they belonged to, rather than their specific age, as

[3] In many questions participants were given the opportunity to clarify or add to their responses in comment boxes. Any obvious spelling, grammatical and typographical errors have been corrected for ease of reading.

well as their gender. The choice not to request an exact age was to ensure respondents felt safe and comfortable in sharing information about their personal experiences with playing-related pain. A combination of information such as exact age, gender, country of residence, as well as performing and teaching status together could have easily identified certain high profile performers. Performers have previously suffered injury in silence for fear that admitting to pain would negatively impact on their employment as a musician (Dawson, 2008, p.7). Providing an age range rather than an exact age was one way of ensuring that such performers and teachers felt secure in sharing their honest views.

Participants in the survey represented a wide cross section of the flute playing community, in terms of age, education, playing experience and musical background. A wide range of ages was represented, with the largest group of respondents in the 12 - 18 years category (91/408 or 22.3%). The other groups were 19 - 25 years (72/408 or 17.6%), 26 - 30 years (23/408 or 5.6%), 31 - 40 years (59/408 or 14.5%), 41 - 50 years (82/408 or 20.1%), 51 - 60 years (60/408 or 14.7%), 61 - 70 years (16/408 or 3.9%), 71 years and over (5/408 or 1.2%).

The younger age categories were designed to correspond approximately with primary school and middle school (11 years and under), high school (12 - 18 years), and university or college (19 - 25). This was to ascertain whether there might be a particular younger age when playing-related discomfort or pain becomes a problem. This topic will be discussed later in the chapter when examining the group of flutists who were suffering from playing-related discomfort or pain at the time of the survey. There were no respondents aged 11 or under, though there was no restriction on their participation. A full breakdown of the ages of participants is included in Appendix C, Table 36.

The majority of respondents (334/408 or 81.9%) were female. (Appendix C, Table 37) This result is consistent with earlier flute surveys such as Spence (2001) who compared the University of North Texas survey (284/329 or 88% female), with the Flute Health Survey in 1999 (34/40 or 85% female). Similarly, 17/20 or 85.0% of participants in Fortune's 2007 study were female, and 27/30 or 90.0% of participants in Thompson's 2008 study were female. This shows clearly how the demographic of flutists has changed very dramatically since the Boehm flute was initially introduced in the mid-nineteenth century, up until the early decades of the twentieth century.

The majority of respondents resided in Australia (147/406 or 36%), and the USA (160/406 or 39.2%), followed by the UK/Bermuda (35/406 or 8.6%), Canada (19/406 or 4.7%), and New Zealand (18/406 or 4.4%). There were a small number of respondents from other continents, including Africa, Asia, Europe, and South America. The survey was only written and disseminated in the English language, due to financial and time constraints. Previous flute surveys have been undertaken primarily in the USA (Fain, 2009; Norris, 1996; Spence, 2001; Thompson, 2008), though there are some smaller surveys from Australia (Fortune, 2007) and Austria (Matejka, 2009). The high rate of participation from Australian and American residents was likely due to the ease of dissemination of the survey link in those countries via popular online flute forums and email lists. Appendix C, Table 38 shows the countries of residence of all participants.

4.3.2 Playing Experience, Performing Activities and Music Qualifications

The level of playing experience ranged from flutists who had been playing less than 5 years (44/408 or 10.8%), to an even split between those playing for 6 - 20 years (180/408 or 44.2%), and more than 20 years (183/408 or 44.9%). Only 1 participant had played flute for less than a year. Apart from first year beginner players, there was a good representation of flutists of all other levels of playing. (Appendix C, Table 39).

There is little information available from previous surveys about the playing background of participants except in the smaller studies such as Fortune (2007) and Thompson (2008).

The majority of respondents (364/404 or 90.1%) considered flute to be their main instrument, and the remainder played other instruments as their major, such as piano, clarinet, oboe, and saxophone. Flute is an important doubling instrument for reed players in styles such as jazz and musical theatre, hence the inclusion of this question in the survey. (Appendix C, Table 40).

Of the total group, 91/408 or 22.3% described themselves as a professional performer, 92/408 or 22.5% as a semi-professional, and 95/408 or 23.3% as adult amateur performers. Flute educators were well-represented, with private studio teachers (158/408 or 38.7%), multi-instrumental teachers (55/408 or 13.5%), and university professors or teachers (36/408 or 8.8%). Of the total group, 72/408 or 17.6% were school students (primary or high school), 54/408 or 13.2% were undergraduates in music degrees, and 31/408 or 7.6% were post-graduate music students. A number of respondents (62/408 or 15.2%) were flute teachers in schools.

It was likely that there was cross representation in the groups, as many performers, whether professional, amateur or students, are also flute teachers.[4] The "other" category included jobs such as classroom teacher, flute sales representative, composer, band director or conductor, church musician, retired player, flute event organizer, and flute repairer. The total group, therefore, represented a very wide cross section of the flute community. (Appendix C, Table 41)

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[4] In many countries, there are no industry requirements or laws which prevent musicians from teaching, especially in private studio settings.

Respondents were involved in a wide range of performing activities, with the largest representation playing in orchestras (235/400 or 58.8%), as theatre pit musicians (143/400 or 35.8%), in flute choirs (165/400 or 41.3%), concert or symphonic bands (166/400 or 41.5%), flute recitals (215/400 or 53.8%), chamber music (186/400 or 46.5%), gigs such as weddings, functions, restaurants (135/400 or 33.8%) and as church musicians (118/400 or 29.5%). The results suggest that the respondents as a whole were a very active group of performers, whether orchestral, solo or in ensembles. Flutists in the "other" category were in early music, military or fife and drum groups, on maternity leave, former players, hobby musicians (playing for leisure), a flute technician, or just playing in flute lessons. Earlier surveys of flute populations did not indicate what flute playing activities participants were involved with, so this information is unique to the current study. (See Appendix C, Table 42)

Almost half of the participants (195/387 or 50.4%) possessed a formal music qualification or Associate/Licentiate/Fellowship performance diplomas from examining bodies such as the Australian Music Examinations Board (AMEB) and Trinity College. A formal music qualification included any university degree or diploma in which music was either a major or minor study. This included music education and teaching degrees or diplomas. Associate, Licentiate and Fellowship diplomas are awarded after successfully performing a full-length recital program of professional standard repertoire. Therefore, flutists attaining these qualifications have reached an advanced level of playing, while not necessarily possessing the depth of theoretical knowledge or performing experience of a university music student or graduate.

Of the group who did not possess a formal qualification, many were working towards grade levels such as those examinations offered by the Australian Music Examinations Board or Trinity College, or they had partially completed a music degree. As many

respondents had completed more than one qualification, the highest only was used for comparative purposes (see Appendix C, Table 43). The educational background of flutists was not reported in detail in previous surveys of flute populations.

4.3.3 Level of Involvement in the Flute Community

Over half of the respondents (214/373 or 57.4%) were members of at least one flute society, guild or club in Australia, Finland, the USA, Brazil, France, New Zealand, South Africa, The Netherlands, or the UK (See Appendix C, Table 44). Half of the respondents (181/356 or 50.1%) were subscribers to flute or woodwind magazines (or newsletters) such as *Flute Focus*, *Flute Network*, *Flutist Quarterly*, *Flute Talk*, *Pan*, *Flutewise*, *Traverso*, *Traversieres*, or the *Woodwind Quarterly*. Magazines specified in the "other" category of responses were *Fluit*, *Huilisti*, *GBFA Gazette*, *Winds (BASBWE)*, Australian flute society newsletters such as *Victorian Flute Guild Magazine* and the Queensland Flute Guild's *Keynotes*. This category also included lapsed subscribers. (Appendix C, Table 45) This question was asked to determine the level of general interest in flute playing in this sample. As well over half of the respondents were current subscribers to flute journals of some type, this showed that there were a large number of dedicated flute players in the sample.

Around half of the respondents (169/345 or 49.0%) were a member of online discussion groups such as *FLUTE* (www.larrykrantz.com), *Flute Chat* (Galway), *Flutenet*, *Flutemakers*, *NFA Forum*, *piccoloist.com*, *Flutist*, *Tuttiflutti* (Yahoo), *8notes*, *Fletowisko.prv.pl Forum*, *Flutewise* Blog, *Earlyflute*, *FluteSmith*, *fluteland.com*, *Andover Educators* (Body Mapping), *Cindy Broz's List* and *flute-ensemble*. (Appendix C, Table 46)

Almost half of the participants (192/391 or 49.0%) attended a flute convention, fair, festival, workshop or masterclass at least every 2 years, with a further 23.3% (91/391)

attending less often than that. Just over a quarter (108/391 or 27.6%) said they never attended those flute events. Just under a quarter of respondents (76/326 or 23.3%) said they never attend other music workshops (Appendix C, Table 47). Respondents noted the following workshops in the "other" category: Flutewise, school workshops and band programs, local events, Keith Underwood classes, band clinics, Wildacres Flute Retreat, folk festivals, choral festivals, conferences, Alexander Technique, Body Mapping, Feldenkrais, and college music society.

The questions about participants' level of involvement in the flute community were to assist in developing a more detailed profile of the respondent, than those which appeared in earlier surveys. Many flutists, for example, while not professional musicians, or music students, are still very actively involved in the flute community, performance and educational activities. A limitation in many previous surveys on musician health has been the focus on particular demographics, especially students, professional players, and other elite musicians.

4.3.4 Early Education

Respondents were asked to comment on the flute teacher who taught them in the first twelve months of lessons. This question was asked to ascertain whether there may be any correlation between a flutist's early teaching and current rates of discomfort or pain. The number of respondents who studied in their first year of tuition with a specialist flute teacher (180/406 or 44.3%) was slightly more than those who commenced their flute studies with a multi-instrumental teacher whose main instrument was not flute (154/406 or 37.9%). While this percentage may seem high, in the countries that were best represented in the survey (Australia and USA), it is common to commence learning the flute within school band programs. Often a multi-instrumental teacher or band

director teaches a range of instruments, if not all the instrument in the band. That teacher may have had minimal tuition themselves on the flute.

A further 14.0% (57/406) studied with a multi-instrumental teacher whose main instrument was flute. A small number of participants (23 or 5.7%) had been self-taught.[5] In other words, 237/406 or 58.4% of respondents had lessons as a beginner with either a specialist flute teacher, or a multi-instrumental teacher whose main instrument was flute. Some respondents had lessons with both band teachers and specialist teachers, so the total percentages add up to greater than 100%. The "other" category consisted of teachers who were a parent, university student, high school student, adult education teacher, or another instrumentalist (e.g. pianist). (Appendix C, Table 48)

Over half of the total group (224/406 or 55.2%) learnt flute in private lessons during the first 12 months of tuition, and 131/406 or 32.3% learnt in a group with only flute players (no other instrumentalists). Within the "other" category were family members, other instrument lessons, books and internet sources, as well as adult education classes. This statistic describes the style of early lessons well, where many students do not commence lessons on a one-to-one basis, but as part of a group. While the social aspect of group lessons may be an advantage, some possible disadvantages may include a student been matched with other students who learn at a different pace, and the attention of the teacher being necessarily divided between however many students take part in the lessons. Appendix C, Table 49 shows the breakdown of the types of early instruction received by participants. The early education of flutists was not reported in earlier surveys.

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[5] Flute tuition by multi-instrumental teachers or band conductors whose main instrument is not flute, is particularly common in school band programs in many states of the United States of America, and in several Australian states.

4.3.5 Emphasis on Posture by Flute Teachers

Respondents expressed concern about the lack of emphasis that their teachers placed on posture during their studies.

Table 5 shows that flutists were more likely to have received "much emphasis" on posture by either their first private flute teachers (106/343 or 30.9%) or university flute professors (107/217 or 49.3%) than band program teachers (41/220 or 18.6%). These figures are all highlighted in bold on Table 5. This is a concerning statistic, bearing in mind that band teachers are working with school-age children, including beginners.

Table 5: Emphasis on Posture by First Private, Band and University Flute Teachers

Answer Options	None	Hardly any	Some	Much	Response Count
Private Teacher 1	13.1% (45)	21.6% (74)	34.4% (118)	**30.9% (106)**	343
Band Program Teacher 1	25.4% (56)	30.0% (66)	26.0% (57)	**18.6% (41)**	220
University Flute Professor 1	6.9% (15)	17.5% (38)	26.3% (57)	**49.3% (107)**	217

Playing habits, whether good or bad, are formed in the earliest stages of learning. Band programs often commence when flutists are between 9 and 11 years of age, and several authors including Debost (2002), Moratz (2010), and Wye (1987 & 2000) emphasize the importance of establishing good posture and playing position at this early stage of development. These results indicate that greater emphasis is needed in the teaching of posture generally, but that this area is particularly weak among band program teachers. These statistics are supported by respondent comments, a selection of which appear in Table 6.

Table 6: Lack of Emphasis on Posture in Lessons

Lack of Emphasis By Flute Teachers on Posture
1. My marching band teacher didn't teach "good" posture or playing position. It was emphasized that the flute should be parallel to the ground to create the right militaristic "look" for band competitions.
2. Most of my postural information I picked up or worked out myself
4. The band teacher (my first teacher) told us to think of the flute like a "seesaw" with the left 1st finger as the fulcrum. We were told to push the flute into our chins hard. We were taught to "hold the flute up" but nothing about holding it correctly. I had no private lessons until university, when the professor encouraged me to put my flute more "in front" of me instead of pulling it back so far to the right, as I'd been taught to do in marching band.
11. The posture instruction was mainly about hand and arm position, and virtually nothing about how one should stand or sit for long periods without incurring injury.
14. I received a lot of incorrect information about "posture" and set up on the flute for many years. It wasn't until I started doing work with the Alexander Technique that I gained some insight in to how the body actually functions and how it's constructed.
24. Information imparted was lacking any underlying science or integrity.
31. My second private teacher taught the importance of posture/hand positions - but taught me incorrectly, based on very rigid rules that did more harm than good!
42. My teacher in the early years did not have time in the lesson to focus on posture. It was only looked at seriously at year 11 level when I had solo lessons with a private teacher
44. Posture wasn't discussed much, until I started to have some back pain. And then it was discussed a bit, but not very much.
49. Not until I was at AMusA standard, after over 10 years, did I receive more proper instruction as to posture.
54. Posture and playing position were not addressed in any way until I developed tendinitis during my first year of university instruction.
56. My first flute teacher was a clarinet major, so she did not focus on good posture, as did my band programme teachers.

It is concerning that some flutists don't receive advice on posture until playing-related disorders occur. The flute literature provides very inconsistent advice on posture, with very few, if any anatomical justifications for suggesting particular playing positions. It is evident from the comments that some flute teachers are providing students with inconsistent and sometimes incorrect advice on posture. However, some flutists were very satisfied with the advice they received, as indicated in Table 7.

Table 7: Respondents Satisfied with the Emphasis on Posture in Lessons

Respondents Satisfied with the Emphasis Teachers Placed on Posture
7. Proper hand position and posture were always stressed, even when I was just starting out. I remember my teacher talking specifically about problems I might have in the future if I wasn't careful about how I held the flute.
10. My posture was always looked at from lesson 1, although I did undertake improvements when I attended university - straightened a curved back and hand positions.
12. Now that I have reached university level playing, my flute professor has placed great emphasis on keeping the flute held high - something so simple that can deteriorate in my own practice time when I start to get tired or lazy. This I feel is so important, especially at this level, because bad practice habits breed bad performance habits - and I wish there was more of an emphasis on it when I first started out (especially now that I start to get neck cramps from my head leaning slightly more down to the right when I play).
27. It took many years to fully realise the effect of posture on the music. I have had 4 teachers. The 4th and current teacher has had the major effect upon me. I am no longer lacking good advice on this matter.
34. All my flute teachers back in Argentina felt very strongly about a good posture and were very strict. We don't have band programme there so that doesn't apply.
36. As soon as I switched teachers they changed my posture completely and now my body doesn't feel the stress that it used to have.
37. I have played with several community bands over the last 10 years and had a number of different conductors. The conductors/band programme teachers involved in the adult starters' band program placed quite some emphasis on correct posture.
46. Trudy Lile and Mary O'Brien have put a lot of emphasis on my posture and hand positions...and it has paid off
47. My university flute teacher 2 has been a big help. Has made a major difference to my pain problems!
52. Private teacher 3 occurred AFTER my University studies, and by far placed the most emphasis on posture and playing position.

4.3.6 Type of Flutes Played

The majority of respondents played on a concert flute with a sterling silver head joint and body (237/392 or 60.5%), or with a sterling silver head joint and silver plated body (67/392 or 17.1%). Other professional, or advanced flutes that were represented included gold flutes (20/392 or 5.1%), aurumite - a fusion of silver and gold (11/392 or 2.8%), and a gold head joint with silver body (5/392 or 1.3%). A small group of

respondents played on a fully silver plated flute (25/392 or 6.38%), which is typically used by either beginner players, less experienced amateurs, or sometimes woodwind doublers whose main instrument is not flute. This result suggests that most respondents in the survey were at least intermediate standard of playing, or above, and a minority were less experienced players, or beginners.

Fain's survey (2009) included a similar percentage of flutists playing on solid silver head joints (66.1%), though a considerably higher percentage of flutists playing on gold head joints (25.1%). Most respondents in Fain's study played on 0.16mm wall flutes (sterling silver body), in other words, were likely to be quite advanced, or professional level players.

Predictably (as there were no participants age 11 or under) almost all respondents (390/394 or 99%) played on a concert flute with a straight head. Curved head joints were used mainly by alto flute players (40/95 or 42.1%) or bass flute players (34/37 or 91.9%). (Appendix C, Table 50)

Offset G mechanism concert flute players were more common (256/381 or 67.2%), with the remainder playing inline instruments (125/381 or 32.8%). (Table 8) Fain's study (2009) included only a slight majority of offset G mechanism players (54.4%). An inline mechanism requires a slightly longer stretch of the left arm to the G key than an offset model. Debost (p.19) recommends the offset G model for "young hands" for this reason.

Table 8: Type of Mechanism (Offset or Inline)

Offset/Inline G Mechanism			
Answer Options	**Offset**	**Inline**	**Response Count**
Concert Flute	67.2% (256)	32.8% (125)	381
Alto Flute	79.5% (70)	20.5% (18)	88
Bass Flute	94.3% (33)	5.7% (2)	35
Contrabass Flute	66.7% (2)	33.3% (1)	3
Piccolo	51.0% (101)	49.0% (97)	198
Baroque Flute	20.0% (3)	80.0% (12)	15

Similar to Fain (2009) the majority of flutists (259/387 or 66.9%) played a flute with a B-foot joint, as indicated in Table 9.

Table 9: Type of Foot Joint (C or B)

Foot Joint				
Answer Options	**C Foot**	**B Foot**	**Not applicable**	**Response Count**
Concert Flute	33.1% (128)	66.9% (259)	0.0% (0)	387
Alto Flute	86.7% (78)	7.8% (7)	5.6% (5)	90
Bass Flute	75.0% (27)	19.4% (7)	5.6% (2)	36
Contrabass Flute	33.3% (1)	33.3% (1)	33.3% (1)	3

Again, similar to Fain (2009), most respondents (314/387 or 81.1%) played on open hole (French style) flutes, which is consistent with the industry convention for intermediate, advanced and professional flutists (Moratz, 2010, p.39). (Table 10)

Table 10: Type of Mechanism (Open or Closed Hole)

Open/Closed Hole			
Answer Options	**Open**	**Closed**	**Response Count**
Concert Flute	81.1% (314)	18.9% (73)	387
Alto Flute	3.4% (3)	96.6% (85)	88
Bass Flute	10.8% (4)	89.2% (33)	37
Contrabass Flute	0.0% (0)	100.0% (2)	2

4.3.7 Lifestyle, General Health, Fitness, and Medical History

Almost half of the respondents (191/387 or 49.4%) described themselves as being within normal weight range, with only 5.2% (20/387) of the group describing themselves as quite underweight or quite overweight. (Appendix C, Table 51) The majority of respondents (274/385 or 71.2%) considered their general health to be good or excellent, with only 31/385 or 8.1% reporting their general health to be poor or fair. (Appendix C, Table 52)

The majority of respondents (63.4% or 244/385) described themselves as either happy or very happy (Appendix C, Table 53). Only 3.9% (15/385) described themselves as either very unhappy or unhappy.

Over half of the group (207/385 or 53.8%) participated in aerobic activities such as walking, running, cycling, or swimming at least three times per week, on average. A further 110/385 or 28.6% participated in aerobic activity one to two times weekly, on average. Only 69/385 or 18.0% of the total group participated in aerobic activity less often than once per week, or not at all. (Appendix C, Table 54) This result was similar to Fortune (2007, p.91) where 99.0% of subjects (19/20) exercised at least once per week. Fain (2009, p.30) also found that most respondents "felt they were in good or average shape". Just over half of the group (187/365 or 51.2%) participated in strength or resistance training, such as using free weights, machine weights, body weight, or resistance bands, at least once or twice per week.

Activities that respondents specified in the "other" category included yoga, Pilates, tai chi, stretching, various types of dancing, gardening, racquet sports, outdoor sports, and skating. It was clear from the responses that many participants used the "other" category to describe their aerobic or strength training activities, already counted in the aerobic or strength training answers.

Smoking was not an area of concern with this sample. Most respondents were non-smokers (356/386 or 92.2%), with only 3.4% (13/386) describing themselves as regular or heavy smokers. No respondents described themselves as heavy drinkers of alcohol, and less than a fifth (67/388 or 17.3%) described themselves as regular drinkers. Therefore, the majority of respondents (321/388 or 82.7%) rarely or never drank alcohol, or were social/occasional drinkers. (Appendix C, Table 55)

Common medical conditions that respondents had experienced that affected their flute playing at some time were anxiety (52/324 or 16.0%), carpal tunnel syndrome (28/324 or 8.6%), depression (58/324 or 17.9%), hypermobility (30/324 or 9.3%), tendinitis (52/324 or 16.0%), scoliosis (27/324 or 8.3%) and temporomandibular joint syndrome (37/324 or 11.4%). Other conditions that affected the flute playing of respondents were fractured or dislocated bones (jaw, fingers, wrist, elbow, shoulder, tailbone), ganglion, rotator cuff injury, shoulder impingement, ulnar neuropathy/nerve entrapment, raynaud's syndrome, mitrovalve prolapse, asthma, joint replacements, Scheuermann's Disease, Lyme Disease, pinched nerve, whiplash, frozen shoulder, polymyalgia rheumatica, osteopenia, peripheral neuropathy, parathyroid adenoma, cancer, allergies and food sensitivities, migraine, slipped discs, trigger thumb, anaemic RSI, aortic stenosis, paresthesia, tennis elbow, heart problems, and hernia. Appendix C, Table 56 shows the medical conditions that flutists in the study had been diagnosed with at some time.

Due to an omission in the survey question, the duration of sitting and standing during the day could not be reported accurately. However, respondents were asked to describe symptoms experienced when sitting or standing for extended periods and these included tension, aching, discomfort and pain in neck, back (upper and lower), shoulder, hips; sciatica; tired, aching or a heavy feeling in the legs; discomfort or pain in heels, ankles, calves, feet and gluteals; numb fingers; fatigue, weakness, cramps and dizziness.

4.3.8 Questions About Vision, Lighting and Headaches

Problems with vision did not appear to be factor for most respondents, with only 36/384 or 9.4% reporting that the eyes were regularly or very often strained or uncomfortable during playing. Most respondents (333/381 or 87.4%) either never or rarely suffered from frontal headaches during playing. Similarly 329/383 or 86.0% either never or rarely suffered from frontal headaches after playing. Less than 7.0% (26/384) of respondents suffered regularly or very often from migraines.

About half of the total group (192/381 or 50.4%) said that they never or rarely practised or performed in conditions of low to moderate light levels. Only 8.7% (33/381) or respondents practised or performed regularly or often in such conditions. Overall, vision problems, headaches, and lighting conditions did not appear to be an issue in this sample. (Appendix C, Table 57) Poor environmental conditions, including inadequate lighting, are cited in the literature as being a contributing factor to playing-related musculoskeletal problem, but most respondents were not affected by such issues.

4.3.9 Playing Positions

Almost half of the respondents (163/378 or 43.1%) reported that they had a tendency towards gripping the flute too tightly either in normal situations, or after becoming fatigued. Gripping or using excessive tension is discouraged in both the flute and performing arts medicine literature. Other tendencies towards poor playing positions included slumping in a chair (100/378 or 26.5%), standing with one hip pushed to the side (96/378 or 25.4%), raising the shoulders (89/378 or 23.5%), shoulders rolled forwards or inwards (85/378 or 22.5%), the neck falling to the side (87/378 or 23.0%), or pressing the flute too hard against the chin (83/378 or 22.0%). (Appendix C, Table 58)

In addition to other suggestions given on the survey list, respondents reported tendencies towards particular playing positions such as angling the flute too low, lying

down, sitting cross-legged, leaning to the right, locking knees, leaning against a wall, bending at the wrist, dropping the head, uneven distribution of weight on feet/legs, chin pointing upwards, left index finger pressing too hard against flute, and twisting the hands.

4.4 History of Playing-Related Discomfort or Pain

The rate of musculoskeletal symptoms of playing-related discomfort or pain was similar to previous surveys undertaken. Half of the respondents (192/386 or 49.7%) had experienced flute playing-related discomfort or pain that was severe enough to distract them while performing (at some time). Over a quarter of the total respondents (99/384 or 25.8%) reported that they had taken an extended period of time off flute playing because of flute playing-related discomfort or pain. Exactly half of the respondents (191/382 or 50.0%) stated that the level of discomfort, pain, or tension experienced tended to dictate the length of their practice sessions. (Appendix C, Table 59)

Over a quarter of the total respondents (105/386 or 27.2%) stated that they had made specific changes to their flute playing position on the recommendation of a medical or health practitioner, for the purpose of avoiding injuries. Dawson (2008, pp.24-25) explains how important the role of music teachers is in avoiding physical problems, by ensuring that students are given good advice on posture from the earliest lessons. He also stresses the importance of a good ergonomic set-up, including an appropriate choice of instrument to match the size of the player (p.25). If these and other ergonomic practices could be implemented by all flute teachers, then perhaps the necessity for some players to learn about positioning from medical and health practitioners could be reduced.

Over a quarter of the total group (103/386 or 26.7%) were suffering from flute playing-related discomfort or pain at the time of completing the survey. Almost one fifth of the

total group (76/384 or 19.8%) had suffered from hypermobility of the fingers, wrists, or elbows, a known contributor to musculoskeletal conditions. (Appendix C, Table 59) Qualitative analysis of the comments provided in this question also backed up these findings and showed, for example, that some flutists are learning about injury prevention and management strategies from medical and health practitioners, or advanced teachers, instead of during their initial flute education and training. Respondents were asked if they felt that during their flute studies they received sufficient information or advice on injury prevention and management and 70.8% of respondents (269/380) reported that they didn't. This is clearly an area in which the flute community saw a need, but which was not being met. Comments indicated that this was of grave concern to some members of the flute community, and needs to be addressed. (Table 11)

Table 11: Concerns - Lack of Training in Injury Prevention and Management

Concerns About the Lack of Training in Injury Prevention and Management
2. I received no instruction/advice from flute teachers about injury or posture except where/how to place my right thumb and where/how to rest my flute on what part of my left hand... I was lucky enough to figure a lot of the rest of it out.
3. My first years of study did NOT include information about musicians' health. I began to experience pain while a doctoral student but was fortunate to study with Alexa Still, who urged me to see a doctor and start physical therapy. I have learned a great deal about injury prevention as a result of my own pain. It would have been helpful, of course, to learn this information MUCH sooner, as a child beginning the flute! I now make sure to talk to my beginners about good hand position, frequent breaks, stretching, etc.
15. Injury prevention advice is given to myself and fellow students only when posture begins to suffer e.g. hunched forward whilst playing. When I informed my teacher of my painful clicking wrist I was told to take a Nurofen.
30. I feel I got very good instruction about Injury Prevention & Management but it came very late in life. A lot of it now is keeping the pain level down & not injuring further.
31. When dealing with ulnar neuropathy, I was not able to play (or do much of anything) for nearly a year. With a lot of physical therapy, I was able to regain full ability.

Concerns About the Lack of Training in Injury Prevention and Management
38. In a sense I consulted myself. (GPs are notorious self-diagnosticians and slow to seek help from others!). I became aware of occasional discomfort when practicing a lot, while studying music full-time). This almost always happened if I tried to sight-read too fast, and I developed pain, probably in my left hand dorsal extensor tendon sheaths, (i.e. over the back of the left hand, but not in the fore-arm). I rested and began analysing the sources of tension, but not as thoroughly then as I have in the past year. Fortunately I never developed any injury.
39. I was given no instruction on proper mechanics of the hands and arms while playing. I was only told to learn to hold the instrument at a true horizontal angle.
40. I had pain in my wrists as a university student and was told to get splints. Other than that I didn't have any information on injury prevention or management. After that first year, I stopped playing the flute and changed my major (not because of the pain).
41. I ended up wearing a plaster and medicated for over 6 months due to tendinitis and sciatic problems, for practising to many hours straight with no rest at all - 5 or 6 hours standing non-stop and practising even when feeling tired or arms/wrists/shoulders would hurt.
44. The doctors told me to give up flute or just live with the pain of RSI. Went to acupuncture and it worked. The conservatorium was not supportive of musicians with RSI and no information was given about it.
60. Due to lack of injury prevention and posture techniques when I first started learning was the reason for the pain I have been suffering the past few years. But now with my current teacher, we are reversing this as we believe the pain is coming from incorrect technique (holding the flute) and some small postures when holding the flute also. So I have hardly any pain at all now**.**
65. ...There are certain injuries that are standard amongst flutists - jaw, left hand pinched nerve, right thumb pain, pinky issues -usually right hand - and perhaps these can be addressed prior. Best advice ever given me was by a physical therapist who worked to balance the stronger muscles made that way by lots of flute playing - with the weaker muscles - made stronger by elastic bands and other resistance, and stretching exercises. I now show my students stretching exercises given to me by this physical therapist who literally saved me. Also - I try to teach avoidance of repetition - using one's brain to practice as much, if not more, than physical practice. I hope this might help!
66. My flute teachers did not have any information for me regarding injury as none of them suffered flute related injuries themselves. We were lucky enough to have a physiotherapist on campus (VCA) who helped me significantly.
68. I have made specific changes based on information from Alexander Technique, which is not officially a health care profession.

Consistent with some of the comments discussed earlier in the chapter on how much emphasis flute teachers place on posture, these comments suggest that flute teachers are not providing students with sound advice on how to avoid musculoskeletal problems. There is concern that advice is only forthcoming after a problem occurs, and even then,

some flutists receive the information from sources other than teachers, such as physiotherapists (physical therapists). This is consistent with Fain (2009, p.29) who found that a very small percentage of respondents (7.5%) "had ever taken a course on health issues for musicians."

4.5 Practice Habits

Respondents were asked how much they typically played flute, whether in practice, rehearsal, teaching, or performance. It was recognised that daily schedules may vary dramatically, so respondents were given a comment box to clarify their answers if they desired. The largest group within the total (98/376 or 26.1%) typically played flute up to 2 hours per day, with an additional 80/376 or 21.3% playing up to 1 hour per day. In other words, almost half of the total group played flute for less than 2 hours per day. Around a third of the group (119/376 or 31.6%) played for over 3 hours per day. Only 12/376 or 3.2% typically played for more than 6 hours per day. (Appendix C, Table 60) Responses indicated that flutists did have extremely variable routines. Appendix C, Table 61 includes representative comments, offering an insight into the great variability of practice routines. Respondents indicated that they play flute not only during personal practice, rehearsals, or performances, but also during teaching, which results in extended hours of playing on certain days. Indeed, the length and frequency of practice is often somewhat determined by other music commitments, such as rehearsals, and teaching schedules.

The majority of respondents (250/375 or 66.7%) typically played flute at least 5 days per week, with 126/375 (33.6%) playing daily. Just over a quarter of the total group (104/375 or 27.8%) played up to 4 days per week. (Appendix C, Table 62)

4.5.1 Practice Breaks

Over half of the total group of respondents (200 or 378 or 52.9%) reported they take breaks whenever they need to. Only 42/378 or 11.1% stated that they rarely or never take breaks (Table 12). Of the group who rarely or never take breaks, 17/42 or 40.5% were under the age of 25, 8/42 or 19.0% were professional players, 8/42 or 19.0% were school students and 12/42 or 28.6% were adult amateur players. Most of this group of respondents (40/42 or 95.3%) had played flute for at least 6 years. Of concern is that 5/42 or 12.0% of the group who rarely or never take breaks played typically for at least 5 hours per day. Spence (2001, p.100) reported that 42.1% of participants practised until they felt fatigued. As studies have consistently shown a concerning rate of musculoskeletal disorders in the flute community, the simple strategy of taking more frequent breaks, could be one method of addressing these problems.

Table 12: Frequency of Practice Breaks

Which of the following best describes how often you take practice breaks?		
Answer Options	**Response Percent**	**Response Count**
At least every 15 minutes	6.3%	24
At least every 30 minutes	12.4%	47
At least every hour	13.8%	52
Whenever I need to	52.9%	200
Rarely/Never take breaks	11.1%	42
Not applicable	3.4%	13
Comments welcome		35
answered question		378
skipped question		30

Horvath (2009, p.198) emphasizes the importance of using practice time wisely, and cautions musicians not to become so involved in the music, that they lose awareness of how long they have been playing. Llobet (2007, p.90) advises taking a practice break every half hour and to cease playing as soon as possible if pain occurs. Llobet suggests doing gentle stretches rather than playing through pain, and to see a performing arts

specialist if the pain does not subside, or recurs when next playing (p.90). Comments from participants highlighted some of the issues mentioned by both Horvath and Llobet, which included becoming so involved in the music that practice breaks are missed (Table 13). Those who did take practice breaks commented on their ability to focus better, use time more efficiently, and avoid pain.

Table 13: Comments about Taking Breaks

Respondent Comments About Taking Breaks
3. When recovering from injuries I was practicing in very small increments, and until the past month only 25 minutes with a 5-minute break. Now I am up to two 45 minutes practice sessions each day, with longer breaks.
9. Sometimes it is less often - I never used to take breaks. I would practice for 2-3 hours without stopping at all except to get some water real quick.
13. After 20-30 minutes, my left hand goes numb and I have to break until the feeling comes back. After 1 hour or more orchestral, my neck begins to ache.
14. It depends on what you call a break. I pause frequently to let my head clear (either light-headed or headache), do flute-related exercises, etc. Sometimes I take 5-minute naps & sometimes I do housework for about 15 minutes.
24. I monitor my levels of tension - gripping the keys; pressing too hard against chin etc. Stopping, regularly to shake the hands or move the head around is very useful.
25. During individual practice, I am able to rest more, during rehearsal I play up to 2 hours with no rest.
27. I used to play for 3 hours at a time. I've learned that frequent breaks not only help my health but also help me to focus better. I now learn more repertoire in much less practice time as a result of my frequent breaks.
30. I *should* take them often - every 15 minutes. I know this. But, I get involved - and it's hard to stop. A definite weakness, and I'm not taking my own advice.
33. Most of my playing is currently in rehearsals so normal practice routines are a small part of total playing time.
35. I find that taking breaks whenever I need to helps with concentration and leads to less pain

4.5.2 Alleviation of Pain and Practitioners Consulted

Almost half of the total group of respondents (177/364 or 48.6%) had never used any type of medication to alleviate flute playing-related pain, tension or injury, whereas 168/364 or 46.2% had used over the counter painkillers. Approximately one fifth of the total group (71/364 or 19.5%) had used non-steroidal anti-inflammatory medications

such as Voltaren, Naproxen or COX-2 inhibitors for playing related pain, tension or injury. Only a small percentage had used oral steroids (10/364 or 2.7%), steroid injections (20/364 or 5.5%), muscle relaxant drugs (15/364 or 4.1%), or anaesthetic injections (5/364 or 1.4%) to treat playing-related symptoms. Other types of medications included in participant responses ("other") included anti-anxiety, anti-panic and anti-depressant medications, narcotic analgesics, beta blockers, arthritis cream, as well as naturopathic or herbal treatments. (Appendix C, Table 63)

While 43.5% (157/361) had not consulted any of the listed practitioners about playing-related discomfort or pain, the remaining flutists most commonly consulted with massage therapists (92/361 or 25.5%), physiotherapists (91/361 or 25.2%), and medical doctors, including specialists (88/361 or 24.4%). Almost a fifth (65/361 or 18.0%) had consulted with a chiropractor. (Appendix C, Table 64) While a much smaller study, Fortune (2007, p.94) also reported that flutists consulted commonly with massage therapists, physiotherapists, and chiropractors, though they were less likely to consult a medical practitioner. Fain (2009, p.29) also reported that 49.7% of respondents have "consulted with a health care professional about something related to their body and flute playing".

Among the practitioners not listed but mentioned by respondents in the "other" section were myofascial therapist, hypnotherapist, hand specialist, rolfing practitioner, biokineticist, reflexologist, cranal sacral therapy, Chinese massage therapist and sports medicine practitioner, teachers of Alexander Technique, Feldenkrais, Pilates, Body Mapping, and Yoga. (Appendix C, Table 64)

Respondents reported five key strategies were most beneficial in preventing or managing playing-related discomfort or pain. These included massage (168/366 or 45.9%), stretching (166/366 or 45.4%), general exercise and fitness (132/366 or 36.1%),

Alexander Technique (96/366 or 26.2%) and heat pack (96/366 or 26.2%). Almost a fifth of the respondents (70/366 or 19.1%) found strength training (including bodyweight, therabands, weights and so on) beneficial. It is important to note that each of these strategies is also recommended in the performing arts medicine literature. Fortune (2007, p.94) also reported that flutists found that stretching (30%), rest (25%), Alexander Technique (20%) and massage (10%) to be the most effective strategies for treating flute playing-related musculoskeletal disorders.

Other suggestions included by participants in the "other" section were: rolfing, medication, taping or bracing, flute modifications (key extensions, cushioning pads, Bo Pep, Thumbport), dispokinesiotherapy, splints, ice, heat, natural therapies and creams (e.g. arthritis, carpal tunnel, cayenne, arnica), cranal sacral therapy, reflexology, and Chinese sports medicine. (Appendix C, Table 65)

4.5.3 Interest in Further Information and Training

Support for further training in injury prevention and management was strong, with most respondents (293/374 or 78.3%) agreeing that a knowledge of basic anatomy is useful in the prevention and management of flute playing injuries. Fain (2009, p.9) concurs:

> 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.

An overwhelming majority (343/377 or 91.0%) believed that all flute teachers should receive training in injury prevention and management. Similarly, most respondents

(337/375 or 89.9%) agreed that all flute players should receive training in injury prevention and management. (Appendix C, Table 66)

The majority of respondents showed an interest in further information and training on the topic of injury prevention and management, particularly website materials (296/375 or 78.9%), and workshops or lectures (226/375 or 60.3%). (Appendix C, Table 67)

4.5.4 Pain Descriptors

Respondents were asked if they had ever experienced discomfort or pain in any part of the body (fingers/hands, arms, elbows, wrists, neck, shoulders, chest, middle/upper back, lower back, jaw) and to describe it as either aching/stiffness, burning, radiating, sharp pain, or numbness, swelling, or tingling. Up until this question in the survey, a total of 378 flutists had answered the previous questions. The "skipped question" counts above relate to the total number of respondents who commenced the survey. Therefore, the figure of 378 flutists is being used as the total group at this point for the following statistics. The most common types of pain among the total group of respondents (378) are shown in Table 14.

Complete breakdowns of all types of pain and musculoskeletal sites are included in Appendix C: Aching (Table 68), Burning (Table 69), Radiating (Table 70), Sharp (Table 71) and Swelling, Numbness, Tingling (Table 72). It is interesting to note that in Fortune's study (2007, p.90) "pain" and "tingling" were the most commonly reported symptoms.

Table 14: Most Common Types of Pain

Type of Pain	Body Site	Count/Percentage
Aching/stiffness	Fingers/hands	210/378 (55.55%)
	Arms	123/378 (32.53%)
	Wrists	95/378 (25.13%)
	Neck	142/378 (37.56%)
	Middle/Upper Back	119/378 (31.48%)
	Shoulders	159/378 (42.06%)
	Lower Back	116/378 (30.68%)
	Jaw	88/378 (23.28%)
Tingling	Fingers/hands	125/378 (33.07%)

4.5.5 Factors Which Worsen or Improve the Condition

Contributing factors that were most likely to make conditions worse were reported as tiredness/fatigue (177/325 or 54.5%), not taking sufficient breaks (151/325 or 46.5%), stress/worry (135/325 or 41.5%), poor posture in non flute playing activities, including computing (129/325 or 39.7%), not stretching (117/325 or 36.0%), playing in cold rooms/spaces (98/325 or 30.2%), lack of exercise/fitness (92/325 or 28.3%) neck falling to the side (85/325 or 26.2%), shoulders rolling forwards (82/325 or 25.2%) and performance anxiety (80/325 or 24.6%). (Appendix C, Table 73)

The majority of respondents who stay free of discomfort or pain at least some of the time (204/313 or 65.2%) attributed "good or improved playing position in general" to staying free of discomfort or pain. They also attributed the following factors to staying free of discomfort pain: rest (158/313 or 50.5%); freedom of movement while playing (124/313 or 39.6%); the ability to relax or deal with stress (121/313 or 38.7%); being fit or exercising (119/313 or 38.0%); feeling happy/satisfied/positive/confident (102/313 or

32.6%); good posture in non flute playing activities (99/313 or 31.6%) and having good teaching (96/313 or 30.7%). (Appendix C, Table 74)

These responses are consistent with the performing arts medicine literature which indicates that typical risk factors for playing-related injury include tiredness or fatigue, not taking sufficient breaks, stress, worry, anxiety, performing anxiety, poor posture in playing and non-playing activities, and a lack of conditioning. A full list of risk factors may be found in Table 2 (Chapter 2).

4.6 Questions for Flute Teachers

A total of 213 flute teachers answered questions about their teaching background, activities and training. They were also asked about recommendations given to students for the specific purpose of avoiding or managing injury. Not all teachers answered all questions, so percentages apply to the count who responded, with missing values shown for each question.

Almost a third of those who responded taught between 1 and 5 students per week (66/213 or 31.0%) and only 12/213 or 5.6% taught 41 students or more per week. A further group was on a teaching break or on leave at the time of answering the survey (37/213 or 17.4%). This may explain why there were fewer responses to the remaining questions to teachers. Almost half the group taught between 6 and 40 students per week (98/213 or 46.0%). (Appendix C, Table 75)

Most teachers surveyed gave individual or private lessons (196/203 or 96.6%), while 71/203 or 35.0% taught group lessons with flute players only. Almost one tenth of the teachers identified themselves as a lecturer or professor (19/203 or 9.4%). One fifth of the teachers said they were also a masterclass or workshop presenter (41/203 or 20.2%). A quarter of the teachers worked as conductors as well (51/203 or 25.1%). (Appendix

C, Table 76) Almost a third of the teachers had taught for less than 5 years (64/205 or 31.2%), and almost half (89/205 or 43.4%) had taught for over 15 years. (Appendix C, Table 77)

Most of the group taught primary students (170/201 or 84.6%) and high school students (170/201 or 84.6%). Almost two thirds of the teachers taught adult amateurs (121/60.2%). Almost a third of the teachers taught university music undergraduates (62/201 or 30.8%), while a smaller group taught postgraduate music students (22/201 or 10.9%). A small group also taught semi-professionals or professional players (25/201 or 12.4%). These statistics show that many experienced teachers responded to this section of the survey. Many respondents fell into more than one category. The "other" category included retired teachers, and beginners not yet at school (Appendix C, Table 78).

Over half of the teachers (115/207 or 55.6%) had never undertaken any training that they felt gave them a better understanding about injury prevention and management for flutists. (Table 15) Of those who had undertaken training (92/207 or 44.4%), 67 commented on events that were of value to them and Alexander Technique, Body Mapping and Feldenkrais were mentioned often, as shown in Table 16.

Table 15: Training Undertaken in Injury Prevention and Management

Have you ever undertaken any training (i.e. workshops/lectures), that you feel gave you a better understanding about Injury Prevention and Management for Flute Players? Please outline if you wish.		
Answer Options	Response Percent	Response Count
Yes	44.4%	92
No	55.6%	115
The following workshops/programs/events were of great value:		67
answered question		207
skipped question		201

Table 16: Training That Flute Teachers Found Beneficial

Training in Injury Prevention and Management That Flute Teachers Found Beneficial	Number of mentions
Alexander Technique (Amy Likar and Ann La Berge mentioned)	32
Andover Training or Body Mapping (Amy Likar, Lea Pearson and Sydney Flute Festival)	22
NFA Convention Health Sessions, flute society workshops, conferences (Health Promotion in Schools of Music Conference)	11
Lessons or workshops with various teachers (William Bennett, Virginia Taylor, Karen Lonsdale, Sydney Flute Academy, Dr Andrea Cheeseman, Gary Schocker, Thomas Nyfenger, Dr Bernhard Riebl, Gerda Alexander, Tatjana Orloff, flute tutor at New Zealand Secondary Schools Orchestra sectional).	11
Feldenkrais	8
Physiotherapy training/advice from physiotherapist, or hand therapist (Philip Chamagne mentioned)	5
Exercise programs (pilates, yoga, dance, stretching, gym)	5
Performance Anxiety Management	2
Personal training qualification, consulting with medical professional, Suzuki Method training, university courses, anatomy/physiology, own injury experience.	1 each

Alexander Technique is cited in the literature as an effective method of improving body alignment, releasing physical and mental tension, as well as increasing awareness (Blanchard, 2007, pp.119, 142; Lieberman, 1991, pp.129-130) Body Mapping is based upon the principles of the Alexander Technique (Conable, 2000, p.5; Pearson, 2006, p.xv). Respondents frequently mentioned Alexander Technique as being beneficial in terms of prevention pain, but also as an educational tool. Interestingly, few respondents mentioned that they had received training in injury prevention and management in university music schools, or conservatories. Some music schools do offer Alexander Technique courses to students, however, apart from this, flutists appeared to be receiving information on injury prevention and management at flute festivals and workshops, though allied health and medical practitioners, exercise programs, and other courses.

Teachers were asked about recommendations to students for the specific purpose of avoiding or managing injury, with the most common being to change playing position (184/198 or 92.9%), take regular breaks (126/198 or 63.6%), change seating position in band/orchestra (117/198 or 59.1%), service flute (111/198 or 56.1%), stretch (108/198 or 54.5%) or use an offset G Key (95/198 or 48.0%). (Appendix C, Table 79). Other recommendations included ergonomic flutes and modifications, alternate or change instrument, Rockstro or Modified Rockstro grip, consult with health and medical professionals (e.g. podiatrist, natural therapist, speech pathologist, counsellor, psychologist, trigger point therapist), body awareness (Body Mapping, Alexander Technique), teach good playing position, relaxation activities (e.g. reading, yoga, spa, meditation, tai chi), use fit ball and learn anatomy.

4.6.1 Definition of Good Posture or Positioning

Performing arts medical experts cite playing position or poor posture as an important contributor to playing-related injuries. Yet, in the flute literature, there is inconsistency in terms of defining precisely what is good posture or positioning. Several authors seem to agree that "poor posture" constitutes habits such as slumping, leg crossing, slouching (Hill 1995, p.4), leaning forwards, jutting neck forwards, and hanging the right arm over the back of a chair (Soldan & Mellersh, 1993, pp.23-25; Westphal, 1962, p.18). Hill alludes to the possibility of injury, but only states "you must not slouch" (p.4), or that certain positions are "awkward and unnatural" (p.4). He doesn't explain specifically why these positions may be undesirable. Westphal discourages such poor postures because of its effect on breathing, tone and technical progress (p.18).

Soldan (pp.23-25) gives a list of postural "don'ts", in order to prevent breathing, tone, intonation and technical problems. Soldan (p.25) discourages hanging the arms over the back of a chair, because "the playing muscles in your arm will be affected and the

whole position of the body will be wrong". There are no anatomical grounds given for making this assertion, or any further explanations as to the physical consequences or sitting in this position.

Authors concur that the end of the flute should be held to the front of the body, not directly to the side, as seen in a typical marching band position (Hill, 1995, p.2; Poor, 1983, p.11; Wye, 1988, pp.12-13). In the current survey, teachers were asked to describe in their own words what they believed to be the essential aspects of good flute playing position, and 150 responses were obtained. In the following section, several aspects of posture, as suggested in the flute literature will be discussed and compared with the survey responses.

Flute teachers surveyed used a number of more general terms to describe good posture, such as: "natural" (42 occurrences); "relaxed" or "relaxation" (93 occurrences); "free of tension" or "without tension" (26 occurrences); "straight" back/trunk/spine (39 occurrences), and "natural" (42 occurrences). "Balance", or "balancing" (i.e., the flute or head, for example) was used 43 times in the 150 responses. (Putnik, 1970), p.7 states that the "prime consideration in holding the flute is to support it in the most natural and comfortable position compatible with finger freedom, steady support, and freedom to breathe properly." Hill (1995, p.2) writes that the "flute should be comfortable", and 13 survey respondents also described good posture in this way. Some examples are shown in Table 17.

Table 17: Teachers' Descriptions of Good Posture

Teachers' Descriptions of Good Posture
18. Relaxed and comfortable with as natural a body position as is possible with the flute.
56. I think its extremely important to be ALWAYS searching what's (sic) most comfortable...
63. Relaxed, comfortable & supportive
135. Playing the flute should be as comfortable and natural as speaking

Llobet (2007) presents a modified opinion, that "feeling comfortable does not necessarily mean that your posture is the best one for you" and that the "most effective posture is individual to you and will be achieved when you can balance your body weight well". These authors advise the musician to "avoid subjecting your body to undue effort and stress, risking injury that could threaten your ability to perform." (p.33) They outline three basic principles to describe good posture: verticality, stability and muscle/joint balance. Llobet (2007) stresses the importance of the need for joints to "work as efficiently as possible" to aim for balance and symmetry, as well as even distribution of weight through the soles of the feet (p.34). Musicians are cautioned that if "joints are placed in extreme positions, tension is placed on the ligaments and this increases the rubbing of tendons passing through the area. It is therefore very important that your joints, especially those in the upper extremities (principally the fingers, wrists and elbows), maintain an intermediate position and stay as relaxed as possible." (Llobet, p.36) Moratz (2010) offers similar advice in *Flute for Dummies*:

> Human bodies are built more or less symmetrically, so playing a side-blown instrument like the flute can feel awkward, unwieldy, and have to stay relaxed and work to the best of your ability to preserve integrity of your body alignment and overall balance while at the same time managing to hold a three - pound piece of metal to one side for long stretches of playing. (p.99)

4.6.2 Wrist Position

Flute teachers offered varying suggestions for what they believed to be good wrist positions (Table 18):

Table 18: Teachers' Descriptions of Good Wrist Position

Flute Teachers' Descriptions of Good Wrist Position
17. As much as possible, all parts of the body should be in their most natural position - that is, avoid bending anything that wouldn't relax in a bent manner, such as wrists.
33. Keep wrists in neutral position is the most important
53. An erect stance, with the head and shoulders centered over the hips, relaxed arms, straight wrists (as much as possible), curved fingers, and a relaxed, light touch on the key cups.
146. Left fingers should be curved - if that means bending that wrist, so be it.

Bending at the wrist is considered ergonomically unsound by international experts in Workplace Health and Safety (Armstrong, 2000, p.72; Dul and Weerdmeester, 2008, p.25). Yet, the flute literature is often inconsistent with advice on wrist position. Toff (1996, p.125) for example, suggests that the left "wrist should be squarely under the flute, at a right angle to the instrument", providing illustrations where the wrists are clearly bent. Similarly, Floyd (1998, p.18) advocates that the left wrist should be "curved underneath" the flute to assist in balancing the instrument. Floyd suggests that the weight of the flute should be placed on the wrists and right thumb, to remove any load on the fingers (p.19).

Soldan & Mellersh (1993, p.26) state that the "wrists must be slightly bent at an angle to the arms (players vary in the amount of wrist-bending; in this book we illustrate quite a steep angle." Similarly, Putnik (1970, p.7) advises that the "left wrist should be somewhat bent and under the flute, while the right wrist is almost straight."

Hill (1995, p.2), on the other hand, concurs with ergonomists that by holding the wrists in an “angular” position, there is “a very high risk of incurring severe muscular problems”. A more recent publication (Moratz, 2010, p.124) encourages flutists to adopt as “neutral a position as possible”, and not to bend more than necessary. Moratz states, “If you’re making a sharp angle between your hands and wrists, you’re setting yourself up for undue tension, discomfort, and possibly even overuse injury”. Moratz recommends using a *Thumbport* device if necessary to keep the wrist in neutral position.

Pearson (2006, p.58) more specifically draws attention to the potential physical problems that could occur as a result of bending at the wrist while playing: “in flute playing we often shorten across the wrist, compressing the bones together, reducing circulation, and pinching nerves...To give the carpal tunnel the most space, avoid over-straightening or excessively bending the wrist, especially the left hand”. Fain (2009, p.219) concurs that the best position for the wrist is a neutral one. She expresses her concern about the Rockstro or Modified Rockstro position because it requires the wrist to be in either a neutral or zero degree position, or flexed, which do not "place the hand in an ideal set-up to accomplish the finely-controlled repetitive action required of flutists" (p.220).

4.6.3 Position of the Head

Of 150 responses to the question of what flute teachers considered good posture, there were 68 references to head position. There were 30 occurrences of the word “neck” in the total responses to the same question. While 3 respondents used “neutral” to describe the desired position of the spine or general position of the body, 34/150 or 22.7% of responses mention an “upright”, “straight”, “erect”, or “natural” position for the head and neck, indicating a preference for a neutral position (rather than a tilted head).

Responses indicate the many different expressions used by flutists which may align with the principle of neutrality, as described in the health science and performing arts medical literature. Table 19 shows comments from teachers about the position they felt was appropriate for the head, and these are grouped according to similarity of response.

Authors suggest various positions for the head / neck while playing flute. Hill (1995, p.2) advises that the head "may be slightly tilted, so that the flute is sloping slightly towards the floor". Toff (1996, p.124) states that the head should be held straight, with the lips parallel to the floor, though agrees that many prefer the downwards tilt of the head. Mather (1989, p.4) recommends that the head should be "level and in balance" and explains that a head tilt, while holding arms low, is taxing for the neck and shoulder muscles. Winspur & Winn Parry (1998, p.15) state that "the flute is held below the level of the shoulder to avoid tension in the shoulders and neck and the left forearm from the strain of holding the instrument horizontally. However, this means that the hand has to be tilted down to the right and in turn can strain the right neck muscles."

Soldan & Mellersh (1993, p.51) advise: "keep your head and neck erect to avoid constrictions in the throat and allow the maximum resonance". They state that "most players hold the flute at an angle dipping slightly downwards rather than horizontal, parallel to the floor: This dipping angle stops the arms from getting tired, and keeps the shoulders low and relaxed (best for good breathing). With the flute up, horizontal, you may find your arms and shoulders begin to ache, tensions develop, breathing is less effective, so your tone suffers." (p.18)

In the current survey, a respondent commented: "Neck and back straight, not hunched forward." However, in the next sentence seems to contradict that: "Head rotated to left and tilted slightly to the right to allow lips to be parallel to a downward sloping flute." (Response 49)

Table 19: Teachers' Description of Good Positioning for the Head[6]

Flute Teachers' Descriptions of Good Positioning for the Head
1, 2. Keep head up and not jutting forward or to the side. The head balanced in its natural position. **10.** Keeping the head going up and the whole body following **47.** Neck floating upwards and relaxed, balanced with no jutting or tucking **59, 72, 76.** Head/aligned with spine or balanced head over spine (resist sticking head forward into the flute) **100.** Aligned spine, right through body to properly balanced head on spine...Neck balanced and straight on spine (no jutting forward, sideways, etc.)
13. Neck, shoulders and torso - straight and facing forwards. **84.** Feet apart and balanced look straight ahead - head not up or down **89.** Straight neck - therefore not leaning shoulder to the right with flute on downward angle. **109.** Neck and face towards front - the flute comes to you - don't go to the flute!!
15. Neck with natural curve, head up and turned slightly to the left
18. Let head sit naturally/comfortably on your neck **23.** Head balanced on neck, not leaning up or back **41.** Head not tilted to either side, facing straight ahead **68, 73, 78 and 104**. Head erect or head up **70, 92, 99, 140 and 144.** Head/neck straight, not tilted/neck and head up **122.** Keep head from leaning forwards
28. Erect posture with good alignment head to seat/toe **49.** Neck and back straight, not hunched forward. Head rotated to left and tilted slightly to the right to allow lips to be parallel to a downward sloping flute. **53.** An erect stance, with the head and shoulders centered over the hips **54.** Body erect, head high and straight **66.** The general body posture should be upright as if suspended by the top of the head **88.** I feel that your body should be straight as is your head but your chin be tucked in slightly.

[6] Responses not in numerical order, but grouped according to similar views.

A head tilt (lateral flexion of the neck) to the right was recommended by 3 respondents. Another 15 respondents suggested that the head should be turned (neck rotation) or slightly turned to the left. Two respondents suggested a “correct”, or “good” position for the head, without specifying exactly what that is, as in the following examples: “Very careful management of correct hand, shoulder, body and head position” (Response 21) and “with a good head position” (Response 90)

Overall there didn’t seem to be agreement on the positioning of the head, either in the survey responses, or the flute literature.

4.6.4 Position of the Elbows

Respondents in the current survey suggested a great variety of positions for the elbows. (Table 20) Some felt the elbows should be held away from the body, and some felt they should be "down". Other flutists gave very specific indications for the positioning of the elbow such as "slightly less than 90 degrees from the flute" (Response 34) and "left elbow aligned with left foot" (Response 68). Another respondent felt that the elbows should both be held at an "even height" (Response 70). Even within a small group of teachers, there were quite different concepts of where the elbows should be positioned during flute playing.

The flute literature includes similar inconsistencies about elbow positioning, though to some extent these can be explained by whether the writer advocates a ‘classic flute alignment’, or the Rockstro position. Hill (p.4) recommends a classic alignment, and suggests that the left elbow should be held close to the body, and the right elbow a little further away from the body. Poor (1983, p.9), an advocate of the Rockstro Position, concurs that the left elbow should not be held up away from the body causing the flute to roll back towards the player, but proposes that the right arm “should be held almost horizontally, which allows the knuckles to be on a level with the flute” (p.10). Poor

also suggests a "slight downward curve to the right wrist in order to achieve the most natural feeling" (p.10). Toff (1996, p.124) recommends that both elbows be held about six inches from the body.

Table 20: Teachers' Description of Good Position of the Elbows

Teachers' Descriptions of Good Positioning of the Elbows
6. Keep the elbows away from the body
15. "...elbows not raised too much"
20. "no resting elbow on hip"
23. "elbow down"
31. "elbows slightly away from body"
34. "The right elbow shouldn't swing out behind the body but should be slightly less than 90 degrees from the flute."
35."...the elbows/arms in whatever position causes the least contraction or tension of them."
68. "left elbow aligned with left foot"
70. "Elbows at even height when playing."
72. "Lifting elbows slightly away from sides, so that weight of arms is not constricting lung inflation."

4.6.5 Marching Band Position

One area in which authors unanimously agree is that the marching band position is not a good or healthy one. In the marching band position, the flute is held absolutely parallel to the floor, with the foot joint end of the flute pulled back towards the body, to be in line with the shoulders. As such, the left shoulder must rotate inwards excessively, and the right shoulder must externally rotate, excessively. Wye (1988, p.12) states that the marching band position "creates some of the worst problems encountered in flute playing, such as a bleating vibrato, a tight throat (and therefore, blowing problems), poor articulation, not to mention backache, arm ache and neck ache, and, in consequence, for your audience, earache." Moratz (2010, p.310) is equally critical of the marching band position, stating:

> Often, people who spent a little too much time in their school marching band gravitate towards the perfectly-parallel option, sticking their elbows way out away from their torsos - but even though it looks great to have a sea of uniformly straight flutes on the football field, it's fundamentally unsound from a playing perspective, and your band director is just going to have to deal with it.

4.6.6. Definition of Posture in the Health Science Literature

The health science literature tends to define posture in terms of the position of the joints of the body, muscle balance or imbalance, neutral position or skeletal alignment, as well as efficiency of movement, which minimises the load on the joints. Pheasant (1991, p.107) suggests, "A good working posture is one which can be sustained with a minimum of static muscular effort - and in which it is possible to perform the task at hand more effectively and with least muscular effort. In general, a varied working posture is better than a fixed working posture, but a working posture which is static and relaxed is better than one which is static and tense." Similarly Laughlin (1995, p.168) states: "Ideal posture is that shape the body adopts as its 'minimum-energy configuration'- the shape that requires the minimum amount of energy to support." St. George (1989, p.37) states that "ideal posture occurs when all body parts are balanced and in alignment with each other", and that "muscles should work minimally if alignment is good". Kendall et al (1993, p.71), define ideal alignment as one which "involves a minimal amount of stress and strain, and is conducive to maximal efficiency of the body". They assert that the head should be "erect in a well-balanced position that minimizes stress on the neck musculature". Few of the survey respondents used words such as "neutral" (6 occurrences), "alignment" or "aligned" (11 occurrences); and the position or role of the "joint" or "joints" only occurred 9 times in 150 responses. This is perhaps explained by the fact that keeping the joints in neutral position while playing flute is not entirely achievable, especially when some of the examples given for poor posture are raised arms, and turned head.

Dul (2008, p.5), states that the "joints ought to be kept as much as possible in neutral position", where "the muscles and ligaments that span the joints are stretched to the least possible extent and are thus subject to less stress". He suggests keeping the work, or in a flutist's situation, the flute, close to the body (p.6), avoiding excessive reach of the arms (p.19), and to avoid work above the shoulder (p.28). However, for the head to be held in neutral position, the right arm must be held away from the body to reach the right hand keys, which requires the hands to be held above or near shoulder level.

4.6.7 Teachers' Concerns About Band Seating

Flute teachers were very concerned about positioning and posture in band settings. Their comments highlight some of the challenges facing flute teachers, which included resistance from parents to take advice on appropriate instruments, lack of interest from conductors, a lack of space in rehearsal venues to enable correct positioning, and lack of interest from fellow musicians in bands to adjust seating. (Tables 21 and 22) These responses are consistent with Wye (1987, p.9) who states:

> During a player's performing life, he has to cope with uncomfortable chairs, orchestral seating positions, chamber music placement, concert platform positions, the stress of trying-to-get-it-right and many other factors. All these can encourage a less productive posture and, even for professional performers, may need re-adjustment from time to time.

Considerable attention needs to be given to ensemble seating, as flutists are currently required to play in postures which place an unnecessary load on their bodies. Band directors, schools and community ensembles need to be aware of the risk factors involved in sitting in poor playing positions and create ergonomically sound playing conditions to prevent musculoskeletal issues from occurring. It is concerning that flute teachers need to make changes to seating in flute sections when band directors and community ensembles should be ensuring adequate room for the flutists as part of a standard set-up procedure. An important recommendation of this study is for band

directors, conductors, flute teachers, and students to ensure that the seating arrangements chosen for flutists is optimal for their health and well-being.

Table 21: Posture in Bands and Ensembles

The following questions require a 'Yes', 'No', or 'Not applicable' answer:				
Answer Options	**Yes**	**No**	**Not applicable**	**Response Count**
1. Have you ever attended a school or community band/ensemble rehearsal and observed flute players sitting too close together, which resulted in them sitting in poor playing postures? (I.e. spines twisted, necks falling to the side, arms on backs of chairs etc)?	95.2% (200)	3.3% (7)	1.4% (3)	210
2. Have you ever asked a conductor to change the seating position to improve the playing posture of flute players?	60.8% (127)	35.9% (75)	3.3% (7)	209
3. Have you ever asked the flute players concerned to change their seating position to improve playing posture?	84.3% (177)	14.3% (30)	1.4% (3)	210
4. Have you ever recommended that a student should play on a different instrument (i.e. curved head joint) to prevent later injuries, but the student/parent/school was either unwilling or financially unable to make the change?	27.4% (57)	58.7% (122)	13.9% (29)	208
Further comments welcome:				16
			answered question	210
			skipped question	198

Table 22: Concerns - Posture and Seating Arrangements in Bands and Ensembles

Teachers' Concerns About Seating in Bands and Ensemble
1. I did encounter a Hong Kong Chinese parent who was clearly very, very concerned with appearances and image and conforming. Outright refused to consider buying a curved head joint for her very small 10 year old, saying all the while that it was the daughter who didn't want it. Yet in the lesson the daughter was eager to try a curved head joint that I had borrowed and delighted in how easy it made things for her and how her sound improved. This was a very sad experience for me.
5. I make the flute ensemble stand to solve postural issues - particularly for breathing. I have had young students use curved head joints. I had to ask one young child to not continue because she was double jointed and too weak and her left thumb couldn't hold up even a flute with a curved head.
6. Most conductors/band directors are not open to suggestion in my experience. Many of them would be pleased if most of the flute players left because it hurt to play! They do need the lessons in physiology and position as much as flute teachers/other instrumental teachers.
7. Flutists should learn to not be embarrassed by playing a special head joint, or assuming a position that helps them to play with an injury. School music directors should encourage students to have good position by placing chairs and stands for good posture, correcting students who slouch or hang an arm over the back of the chair, and most of all not force flute player to hold their instruments incorrectly - just for looks.
8. Sitting postures in bands and orchestras is mostly very poor, even in professional ensembles. There is rarely enough space for chairs to be pushed back allowing players to sit right at the front. Also, lateral space is often not enough to allow for the correct rotation of the body to the right. I have sometimes advised small children to use a curved head joint to avoid neck tension and poor finger positions caused by the uncomfortable stretch to reach the keys.
9. Usually the chairs are badly designed to sit upright in
10. All my students use curved head joints if they are not big enough for full size flutes. I have some to loan out.
11. Band directors do NOT understand that flutists NEED MORE ROOM between chairs. I have to explain this often. I urge them to have no more than two students sharing a stand, and preferably to give each student her/his own stand and music.
12. I have frequently discussed with my students the importance of having enough room in the section. However, it is not possible to always spread out further. So, I have coached them on how to turn chairs and adjust stand positions to free up room for proper posture as well.
13. Crowded band rooms and lots of flutists in any one ensemble encourage poor playing position (typically, head titled to the right, right elbow "resting" on back of chair). Solution: angle chairs so that flutists are angled with their left shoulder towards the podium and the flute pointed farther backwards.
14. I'm forever complaining in community bands about the seating being too close together. Nothing is ever done about it and I think everyone regards me as a crank. I've also spoken to individual band members with particularly poor posture and mostly it goes in one ear and out the other.

4.7 Comparison of Respondents in Discomfort or Pain with Those Who Were Not

Over a quarter of the total group (103/386 or 26.7%) of the total group reported that they were experiencing pain at the time of participating in the survey. It was hypothesized that the group currently in discomfort or pain would follow the typical injury patterns of flutists as reported in previous surveys. It was also thought they would exhibit risk factors, such as age, gender, joint laxity, incorrect or inefficient technique, postural flaws, lack of conditioning, practice intensity/workloads, not compensating for asymmetric work, psychological factors, instrument ergonomics, overall health, poor environment, as described in the performing arts medical literature (Brandfonbrener, 1991; Lederman, 2003, p.550; Llobet & Odam 2007, pp.24-29).

It was expected that playing-related pain, discomfort or injuries would occur in flutists from a wide range of backgrounds, and playing experience and the results demonstrated injury patterns that were very consistent with previous surveys and performing arts medical research. It was predicted that those who had not learnt from specialist flute teachers in the first 12 months would be more likely to be currently in pain. The current survey found that participants who were "currently suffering from flute playing-related discomfort or pain", were slightly more likely to have been students of specialist teachers, than non-specialists in their first year of learning flute.

In this section, a profile will be presented of each group of players, that is, those that were suffering from flute playing-related discomfort or pain at the time of participating in the survey, and those who were not. Demographics, playing background, instrument types, health aspects will all be discussed in terms of their influence or otherwise on the incidence of playing-related discomfort or pain

4.7.1 Age

A significant number (25/103 or 24.3%) of respondents in the group currently in pain were aged 19 – 25 years. This is a time when many students are at university, in undergraduate and postgraduate programs, and therefore playing at high intensity for extended periods. At this time of life, many orchestral players in particular are also competing at major local, national and even international music competitions, taking their first professional orchestral auditions, and playing in youth orchestras. Many players of this age are also working with professional orchestras, either as freelance players ("casual or sub") or have already won a full-time position. For many elite young musicians, this can be a particularly intense and stressful period of playing, because of having to learn vast amounts of new repertoire, and deal with the performance anxiety associated with preparing for orchestral auditions, university level recital examinations and competitions.

4.7.2 Early Tuition and Length of Time Playing

Typically flutists start learning flute around 8 to 11 years of age, or in school years 3 to 5 (Blanchard, 2007, p.185), including in school band programs in the United States of America (Colwell & Hewitt, 2009, pp.56-57), and Australia (Morrisroe, Barnden, Tucker, Cook, & Eustice, 1988; Zamora & Morrisroe, 1990, pp.1-50), where the majority of the respondents resided. Beginners in the United Kingdom also commence instrumental tuition around the 4th grade in school (Mixon, 2007, p.3). In the United States of America, the teaching of wind instruments in groups or classes "led to a spectacular growth of bands in the public schools by the 1930s" (Kohut, 1996, p.193).

Despite hypothesizing that students who learnt from specialist teachers in the first year of flute tuition may be at less risk of later playing-related discomfort, pain or injuries, they were in fact slightly more likely to be currently in discomfort or pain (48/102 or

47.1%) than those who had learnt from multi-instrumental teachers whose main instrument was not flute (39/102 or 38.2%). Similarly, whether a flutist had learnt as a beginner in private or group lessons did not appear to be a factor in reports of current flute playing-related discomfort or pain. These statistics however, need to be viewed with caution, because playing-related injuries are often developed over extended periods of playing, such as many hours per week, over the course of musical life or career (Dawson, 2008, p.31) Flutists indicated that their band teachers for example, placed little emphasis on posture and positioning. The statistics on early tuition need to be interpreted with these considerations in mind.

The group currently in discomfort or pain was much more likely to have been playing flute for at least 11 years (82/103 or 79.6%).

The rate of injury in those who had been playing up to 10 years was significantly lower, than the more experienced players (21/103 or 20.4%). If 11 years of playing time is added to a typical beginner age (8 – 11 years of age), this would place many flutists in the most 'at risk' group identified in this survey (i.e., 19 - 25 years of age). High rates of playing-related discomfort and pain were also noted in respondents who had been playing for more than 20 years (55/103 or 53.4%). In other words, the greater the length of time playing, the greater the rate of playing-related discomfort, or pain. This is consistent with the literature which discusses the cumulative effects of playing-related injuries (Dawson, 2008, p.31).

Previous flute specific surveys did not report on the relationship of length of time playing with prevalence of playing-related discomfort, pain or injuries.

4.7.3 Type of Player

Those suffering from playing-related discomfort or pain included private flute teachers (52/103 or 50.5%), professional performers (33/103 or 32.0%), and semi-professional performers (27/103 or 26.2%). Intense playing load combined with increased playing time lends is a risk factor for playing-related musculoskeletal problems (Dawson, 2008, p.34; Llobet, 2007, pp.2-3). Therefore, those most likely to be currently suffering from discomfort or pain were those involved most in performing careers. Those who were least likely to be suffering currently from playing-related discomfort or pain were primary or high school students (12/103 or 11.7%).

4.7.4 Music Qualifications

The group of respondents not suffering from playing-related discomfort or pain at the time of the survey were much more likely to have no formal music qualifications (30/103 or 29.1%), than the group that was in discomfort or pain. Those suffering from playing-related discomfort or pain at the time of the survey, were significantly more likely to possess music performance degrees, such as Bachelor of Music, Master of Music, Doctor of Musical Arts degrees. (Table 23) This is consistent with the findings discussed previously, that those in performing careers were most likely to be suffering from playing-related discomfort or pain.

Table 23: Music Qualifications and Playing-Related Pain

Currently Suffering From Discomfort or Pain			
	Yes	**No**	**p-Value**
Formal Music Qualification (185)	61 (33.0%)	124 (67.0%)	0.007
No Formal Music Qualifications (201)	42 (21.0%)	159 (79.0%)	

Flutists who are studying towards a music degree, or other performance qualifications such as Associate, Licentiate and Fellowship diplomas are often working under intense playing loads, and practicing for extended periods of time. Those working towards music qualifications are likely to be preparing a large amount of difficult repertoire, for exams, recitals, and professional concerts, with strict deadlines. Many private teachers also play flute for extended periods of time per day, as they demonstrate repertoire for students, and they may also work as either professional or semi-professional performers.

Again, this result is consistent with the performing arts medicine literature which reports that playing intensity and load (Llobet, p.3) and overuse (Dawson, 2008, p.31) are important contributing factors to playing-related injury.

4.7.5. Gender

It is interesting that Roach (1994) found that "the likelihood of pain at a specific site varied depending on the instrument played" (p.125). Roach reported that female instrumentalists "were 1.9 times more likely than men to report upper-body joint pain in general. They were 3.6 times more likely to report upper-back pain and 2.8 times more likely to report shoulder pain than were the men". (p.127) Unfortunately Roach's study did not include flutists, therefore cannot be compared directly with the current survey. However, Edling (2009) also reported that female music teachers playing in asymmetrical positions such as violin and flute, reported a significantly higher prevalence of symptoms in the neck, shoulder, and upper back" than males (p.117). These results certainly suggest that further research into playing-related injuries comparing male and female flutists is warranted. This is also an important recommendation arising from the results of this survey and this will become more evident through the following statistical analysis.

In the current study, gender was not a significant factor across the total sample of those who were currently suffering from discomfort or pain. (Table 24)

Table 24: Gender and Current Playing-Related Discomfort or Pain

Are You Currently Suffering From Playing-Related Discomfort or Pain?				
		Yes	**No**	**p-Value**
Gender	**Male (67)**	15 (22.39%)	52 (77.61%)	NS
	Female (319)	88 (27.59%)	231 (72.41%)	

(Significance p <0.05; NS, non-significant)

However, gender was a significant factor when comparing the various types of pain in particular musculoskeletal sites. For example, women were significantly more affected by aching pain than males in the arms (110/317 or 34.70%), neck (123/283 or 43.46%), shoulder (141/318 or 44.34%) and middle/upper back (105/316 or 33.23%). Table 25 shows a comparison of "aching" pain in males and females, for various body sites, which is consistent with these studies.

Other types of pain females suffered significantly more from than males were "burning" pain in the arms, radiating, numbness and tingling pain into the fingers, as well as sharp pain into the wrists and neck. (Table 26)

Table 25: Gender and Aching Pain

Are You Currently Suffering From Discomfort or Pain?					
	Male		**Female**		**p-Value**
	Yes	**No**	**Yes**	**No**	
Aching Fingers (371)	29/63 (46.03%)	34/63 (53.97%)	181/308 (58.77%)	127/308 (41.23%)	NS
Aching Arms (384)	13/67 (19.40%)	54/67 (80.60%)	110/317 (34.70%)	207/317 (65.30%)	0.015
Aching Elbows (382)	6/68 (8.82%)	62/68 (91.18%)	35/314 (11.15%)	279/314 (88.85%)	NS
Aching Wrist (350)	12/66 (18.18%)	54/66 (81.82%)	83/284 (29.23%)	201/284 (70.77%)	NS
Aching Neck (349)	19/66 (28.79%)	47/66 (71.21%)	123/283 (43.46%)	160/283 (56.54%)	0.029
Aching Shoulder (385)	18/67 (26.87%)	49/67 (73.13%)	141/318 (44.34%)	177/318 (44.66%)	0.008
Aching Chest (381)	2/67 (2.99%)	65/67 (97.01%)	10/314 (3.18%)	304/314 (96.82%)	NS
Aching Middle/ Upper Back (383)	14/67 20.90%	53/67 79.10%	105/316 33.23%	211/316 66.77%	0.048
Aching Lower Back (383)	17/68 25%	51/68 75%	99/315 31.43%	216/315 68.57%	NS
Aching Jaw (384)	13/68 19.12%	55/68 80.88%	75/316 23.73%	241/316 76.27%	NS

(Significance p <0.05; NS, non-significant)

Table 26: Gender and Other Types of Pain

Are You Currently Suffering From Discomfort or Pain?					
	Male		**Female**		**p-Value**
	Yes	**No**	**Yes**	**No**	
Burning Arms (386)	0/68 (0%)	68/68 (100%)	22/318 (6.92%)	296/318 (93.08%)	0.019
Radiating into Fingers (386)	0/68 (0%)	68/68 (100%)	31/318 (9.75%)	287/318 (90.25%)	0.007
Sharp Pain into Wrist (352)	1/67 (1.49%)	66/67 (98.51%)	30/285 (10.53%)	255/285 (89.47%)	0.019
Sharp Pain Neck (351)	0/67 (0%)	67/67 (100%)	26/284 (9.15%)	258/284 (90.85%)	0.007
Numbness Fingers (386)	7/68 (10.29%)	61/68 (89.71%)	68/318 (21.38%)	250/318 (78.62%)	0.036
Tingling Fingers (385)	15/68 (22.06%)	53/68 (77.94%)	110/317 (34.70%)	207/317 (65.30%)	0.043

(Significance p <0.05; NS, non-significant)

4.7.6 Type of Flute Mechanism and Pain

B-foot joints were used more commonly among respondents than C-foot joints. Flutes with B-foot joints are slightly longer, and therefore also a little heavier than an equivalent C-foot model, which may cause some players concern. However, this concern was not supported in the results of this survey, as there was no significant difference between the type of foot joint used, at least in the group of players who were currently suffering from discomfort or pain (Table 27). The length of the foot joint may be a consideration with small, or young flutists, but this cannot be determined through the results of this survey.

Table 27: Type of Foot Joint and Pain

Currently Suffering From Playing-Related Discomfort or Pain			
	Yes	**No**	**p-Value**
C-Foot (121)	35 (28.93%)	86 (71.07%)	NS
B-Foot (249)	65 (26.10%)	184 (73.90%)	

(Significance p <0.05; NS, non-significant)

Significantly more respondents played on an offset-G key style of flute (256 or 62.75%) than on an inline-G key model (125 or 30.64%).

Fain's study (2009) showed a slight majority of respondents played offset-G flutes (54.4%) compared to 45.6% of online players. Fain stated "the responses to questions concerning pain and other problems showed no major differences whether the flute was inline or offset" (Fain, 2009, p.24) This was not the case in the current study, which shows that there was a greater percentage of offset-G players who were suffering from flute playing-related discomfort or pain at the time of participating in the survey. (Table 28)

Table 28: Flute Mechanism (Offset or Inline) and Pain

Currently Suffering From Discomfort or Pain			
	Yes	**No**	**p-Value**
Offset (244)	75 (30.74%)	169 (69.26%)	0.027
Inline (121)	24 (19.83%)	97 (80.17%)	

(Significance p <0.05; NS, non-significant)

Since the majority of players in both surveys opted to play an offset-G mechanism, this statistic may seem surprising, but through closer observation of each group, it is clear that other contributing factors may be significant in the statistic. For example, 64%

(80/125) of the 'inline' group had been playing for more than 20 years, compared with 39.1% (100/256) of the 'offset' players. A greater percentage of undergraduate music students played 'offset' (17.6% or 45/256), than 'inline' mechanisms (4.8% or 6/125).

The 'inline players' were less likely to be orchestral players (65/124 or 52.4%), compared with the 'offset' players (158/251 or 62.9%). The 'inline' group was not as well represented by players under 30 years of age or under (29.6%), as the 'offset' group (130/256 or 50.9%). Therefore, age, intensity, type and length of playing time, may well be more important factors in determining current rates of discomfort and injury than the type of mechanism played on. This data cannot be compared directly with Fain's report, as demographic data was not collected in that study.

The choice of whether one plays an inline or offset mechanism is a personal one. This choice may depend on the physical attributes of a player, including hand size and arm length. Further studies comparing muscular responses of flutists of differing heights and hand sizes playing offset or inline mechanisms would need to be undertaken to verify these findings.

4.7.7 Type of Flute Played: Open Hole or Closed Hole, C or B Foot Joint

There was no significant difference between open hole and closed hole players in the group currently suffering from discomfort or pain. (Table 29) Generally, 'open hole' flutes are purchased by intermediate through to professional level players, the vast majority of respondents in the current survey (300/369). While many would advocate a closed hole flute for beginner players, Debost (p.37) states:

> It is hard to understand why students are supposed to learn on instruments that encourage bad habits, such as covered-key flutes. By the time they graduate to the French system they have developed bad hand positions that are terribly frustrating to change. More makers should offer cheap French-model flutes (with open keys) so that more people can start with reasonable finger placement.

Table 29: Flute Mechanism (Open or Closed Hole) and Pain

Currently Suffering From Discomfort or Pain			
	Yes	**No**	**p-Value**
Open Hole (300)	84 (28.00%)	216 (72.00%)	NS
Closed Hole (69)	16 (23.19%)	53 (76.81%)	

(Significance p <0.05; NS, non-significant)

Similar to Fain's study, the majority of flutists in the current survey played on flutes with a B-foot joint (in other words, a flute which is slightly longer than a C-foot joint because of the addition of the extra low B key). Some flutists may be concerned that use of a B-foot joint, which increases the length of the flute because of the additional B key, may be a risk factor for injury. However, this concern was not reflected in the survey results where those with and without current discomfort or pain reported equally on the use of this device.

4.7.8 Health and Posture

Those players not suffering from discomfort or pain at the time of the survey were less likely to be overweight (107/282 or 37.9%) that those in pain (49/103 or 47.6%), however weight was not a significant factor when comparing these two groups.

Whether a flutist was involved in weekly aerobics activities such as walking, running, cycling and swimming was not a significant factor in current discomfort or pain. Of those who were in pain, only 20/103 or 19.4% were not involved in aerobic activity at least once or twice per week. This was a similar result to the group who were not currently suffering from discomfort or pain (49/280 or 17.5%).

Those not suffering from discomfort or pain were only slightly more likely to do strength or resistance training at least once per week (141/267 or 53.1%) than those in

discomfort or pain (45/96 or 47.0%). Whether a flutist did strength or resistance training at least once a week or not was not a significant factor in terms of whether they were in pain or not. Resistance training includes a range of variables, such as the number of repetitions, and the level of resistance. This statistic relied upon self-reporting of activity, so to gain a better understanding of the benefits of strength or resistance training for flutists, more controlled scientific testing would be necessary.

A quarter to almost half of those reporting pain at the time of the survey group tended towards certain poor playing postures, such as gripping the flute too tightly (49/100 or 49.0%), neck falling to the side (31/100 or 31%), shoulders rolled forwards (31/100 or 31%) and shoulders raised (28/100 or 28%).

The consumption of alcohol was not a significant factor in this group. Similarly whether flutists were a smoker or not was not significant, though the sample of non-smokers was very low.

4.7.9 Practice Habits

The average length of time spent in daily practice did not appear to be a predictor of playing-related musculoskeletal pain, as those currently in discomfort or pain, and those not were practising for similar lengths of time. However, the group not currently in pain was more likely to take practice breaks whenever they needed to, as distinct from those in pain, who took breaks at least every hour.

4.8 Limitations and Evidence of Support for the Research

4.8.1 Demographics

There were no responses from flutists aged 11 or under, though it was possible for people of this age group to participate in the study. The survey was lengthy, and some

questions may have been too difficult for young students to answer. At this age, children may not necessarily have a good understanding of basic aspects of flute playing, including types of mechanisms (for example foot joint differences, open hole/closed hole or offset G keys).

4.8.2 Recruitment of Participants

Recruitment was primarily undertaken online, through email lists and web site notices. No hard copy reports were disseminated which may have discouraged some flutists without much online or computing experience. While email notifications were sent to major music schools at universities, it is possible that the Survey Monkey link was caught up in spam filters, or that school secretaries didn't pass them onto the relevant staff or to flute students.

Despite encouraging all flutists to take part by advising "We are interested in hearing from ALL flute players, whether they have had injury concerns, or not", the title of the survey may still have tended to attract those interested in the subject of injury prevention, or those who had been previously injured. However, this is likely to have been offset somewhat by the anonymity aspect of the online format.

4.8.3 Online Format

The online format may have discouraged less computer literature flutists to take part in the survey. Additionally, there were numerous surveys in which there were not a complete set of responses and this may have been caused by either computer failures, or a loss of internet connection. Occasionally the use of drop down boxes caused errors. For example, a respondent gave their location as Brisbane in the contact details, but accidentally clicked on Azerbaijan instead of Australia as the country they lived in. Obvious errors such as this one were edited in the online survey.

4.8.4 Compulsory Questions

Respondents were only required to answer two compulsory questions (age and gender), the remainder of the survey being voluntary. The benefit of this was to encourage flutists to answer as many questions as possible. A limitation with this was that some questions may have been inadvertently not answered, as the Surveymonkey.com program did not show a warning if a question had been skipped (apart from the first two questions.)

4.8.5 Language and Terminology

The survey was only presented in the English language, so there were few responses from countries where English is not spoken as a main language. The survey was also promoted only on websites and email lists written in the English language. From the outset, differences in terminology were considered and the survey questions were designed to be understood by flutists in many lands. However, there was some confusion over certain wording in the final survey. One notable example of this was "school", which in Australia refers only to primary and high school, but in the United States of America, refers also to university. Nevertheless, answers to other questions, revealed whether a student was in high school or university (such as age, and several questions about educational background.)

4.8.6 Support for the Research

Participants were invited to leave further comments at the conclusion of the survey, which resulted in 69 responses. Participants showed very clear support for the research, and indicated that they felt it was timely and necessary (Appendix C, Table 80). Participants showed an interest in the findings of this research (Appendix C, Table 81), as well as in further information and training in the area of injury prevention and

management (Appendix C, Table 82). Some responses have been truncated for the sake of brevity.

4.9 Summary of the Findings

This study sought to establish the injury concerns of flute players and teachers of all backgrounds, as well as their knowledge of playing-related injury prevention and management. The study involved a broader demographic than in previous surveys, in that there was representation from many countries, playing and educational backgrounds, and musical performance activities. The most important findings from this survey will be summarized briefly in this section.

There is a lack of emphasis on posture and positioning in flute lessons, particularly by band program teachers. There is not only a concern about the lack of training available in injury prevention and management, but also a desire to take part in such educational programs. Flutists reported not learning about posture and positioning until playing-related injuries occurred and in some cases, are receiving advice on how to improve their playing position from practitioners such as physiotherapists, as well as through awareness programs such as Alexander Technique and Body Mapping.

While the flutists in this sample generally considered themselves to be fairly healthy and active, playing-related discomfort, pain and injury was still a significant problem, with 49.7% of respondents having experienced flute playing-related discomfort or pain that was severe enough to distract while performing. Over a quarter of the respondents (25.8%) had taken an extended period of time off playing because of pain and 26.7% were suffering from playing-related discomfort or pain at the time of the survey. Over half of the respondents (56.5%) had typically consulted with physiotherapists, massage therapists, chiropractors and medical doctors about their condition.

Flutists indicated that the most effective strategies for prevention or managing playing related-discomfort or pain were massage, stretching, general exercise and fitness, Alexander Technique, heat packs, and strength training. They attributed tiredness and fatigue, not taking sufficient breaks, stress/worry, poor posture in playing and non-playing activities, not stretching, playing in cold rooms and a lack of exercise and fitness to making their condition worse. Flutists attributed rest, freedom of movement while playing, the ability to relax or deal with stress, being fit, feeling happy, good teaching, and good posture to staying free of discomfort or pain.

Flutists suffer typically from aching types of pain, particularly in the fingers and hands, arms, wrists, neck, middle/upper back, shoulders, lower back and jaw, as well as tingling in the fingers and hands. While gender was not a significant issue in the total group currently suffering from discomfort or pain, it was significant when considering specific types of pain and musculoskeletal sites. For example, women were significantly more likely to suffer from the following types of pain: aching arms, neck, shoulder, middle and upper back, burning in the arms, radiating pain, numbness and tingling into the fingers, as well as sharp pain in the wrist and neck.

Flutists possessing formal music qualifications were significantly more likely to be suffering from playing-related discomfort or pain than those who were not. This result is likely to be due to a higher intensity of playing among those players, than those not holding a formal music qualification

The findings of this major survey are consistent with earlier studies of the playing-related musculoskeletal disorders of flutists. The results have helped to characterize the problems more clearly than previous surveys, through a greater insight into the playing and teaching lives of the broader flute community. They have also given a deeper understanding of the ways that flutists approach preventing and managing these problems.

5. FINDING A FUNCTIONALLY EFFICIENT FLUTE PLAYING POSITION: A DESCRIPTIVE STUDY USING ELECTROMYOGRAPHY

5.1 Introduction: Understanding the Effects of Flute Playing

> Through the generations, in attempting to help students, teachers have developed a mass of exercises without any investigation into the anatomic correctness of the movements involved…our profession lacks a body of knowledge, of researched, tested, and proven material such as exists in many other fields of learning.
>
> Ours is a hearsay tradition carried through the generations by word of mouth from teacher to student. Scientific study in our profession has been minimal, and even that little bit has all too frequently been overlooked.
>
> The treatment of injuries to musicians is becoming better understood, and the incidence of successful treatment is increasing. However, if after medical treatment a symptom persists, one must look to the technique of the player for answers. (Taubman, 1988)

Taubman's words are still applicable today, 27 years after her address on musicians' injuries at the inaugural Biology of Music Making Conference in 1984. There have been few scientific studies with flutist participants and several of those which have been undertaken have focussed primarily on breathing such as Cossette, Monaco, Aliverti, & Macklem (2008); Cossette, Sliwinski, & Macklem (2000), or vibrato (Gärtner, 1981). Another study by Koppejan, Snijders, Kooiman, & Van Bemmel (2006) used biomechanical analysis to design a right hand thumb support in order to prevent musculoskeletal injuries in flutists. More recently, Fortune (2007) used EMG readings to establish links between left upper trapezius muscle tension and music performance anxiety. Another study by Thompson (2008) used bi-lateral anthropometric measurements, upper-extremity performance tests and descriptive data to conclude that strength, flexibility, pain spots and exposure are risk factors for flute playing-related pain.

The survey in Chapter 4 clearly demonstrates that flutists differ in their interpretation of what good playing position or posture is. Poor playing position is known to be a contributor to playing-related musculoskeletal disorders, and flutists typically suffer from these in areas such as the middle back, upper back, shoulders, neck, wrist, hand, and fingers. Despite this, while a scientific approach is necessary in evaluating muscular activity during flute playing, few have been undertaken. To gain an increased understanding of the effects of flute playing on the body's anatomical structures, a number of methods is available, one such being electromyography (EMG).

5.1.1 Electromyography (EMG)

Electromyography (EMG) is "the recording of electrical changes occurring in muscles during contraction" (Karpovich & Sinning, 1971, p.14). Analysis of muscle activity is made possible by way of either surface, needle or fine-wire electrodes, which detect electrical signals of varying duration, frequency and amplitude during contraction (Dondelinger, 2010, p.129). It has been used extensively in health science and sports medicine as a medical diagnostic tool, and in the analysis of movement in sports and other activities, such as examining the mechanics of abdominal wall contraction (Brown & McGill, 2010), examining the effect of wrist orthoses on EMG activity in the upper limb (Ferrigno, Cliquet, Magna, & Filho, 2009), investigating neuromuscular disease in children (Pitt, 2010), and the analysis of shoulder joint muscles when performing a chest press (Trebs, Brandenburg, & Pitney, 2010).

Electromyography or EMG Biofeedback has also been utilized as a tool for measuring muscular activity in musicians. There are a number of examples of EMG studies on musicians, including brass players (Iltis & Givens, 2005; Lammers, 1983), string players (Ackermann, et al., 2002; Berque & Gray, 2002; Fjellman-Wiklund, Grip, Karlsson, & Sundelin, 2003; Philipson, Sorbye, Larsson, & Kaladjev, 1990), pianists

(Montes, 1993; Riley, 2010; Yoshie, Kudo, & Ohtsuki, 2008), and singers (Watson, Hoit, Lansing, & Hixon, 1989). However, there are only a small number of EMG studies that have specifically involved flutists, such as Cossette, et al., (2000) *Respiratory parameters during professional flute playing* and Fortune (2007) *Performance related musculoskeletal disorders in university flute students and relationships with muscle tension, music performance anxiety, musical task complexity and musical ability*. Due to a paucity of scientific research on the muscular activity involved in flute positioning, a new study was required.

5.2 Hypothesis

This EMG study will investigate upper body muscular activity in flute playing. Victor Popov, Specialist Physiotherapist from Queensland Sports Medicine Centre has treated elite sports people and professional musicians including flutists and suggested the following hypothesis for this electromyography study:

> There will be some abnormality or excessive activation of Pectoralis, Scalene, Upper Trapezius and a decreased activation of Rhomboids, and Mid/Lower Trapezius. In other words, there will be: "Over activation of the elevators and protractors of the scapula and a lack of activation of the retractors and depressors. (Popov, 2007, personal communication)

Non-invasive, surface electromyography (EMG) was used to collect information on muscle activity during flute playing. This technique is an accepted method for determining the activation sequence and amount of muscle activity used in a range of different research including functional assessment, biomechanical assessment and rehabilitation.

Due to a limitation on the number of EMG channels able to be accessed simultaneously, the following major upper body muscles involved in flute playing were prioritized for study: sternocleidomastoid, pectoralis, anterior and posterior deltoid, middle trapezius

(which would include overflow from rhomboid activity), upper trapezius, wrist flexors and extensors. Due to limited EMG channels and the sensitive nature of the skin surrounding the area, the scalenes were not studied. The EMG responses of each of the selected muscle groups, was compared visually with video footage of each of the players obtained simultaneously, to understand the similarities and differences in their technical approaches and postural tendencies. The video footage was paired with EMG outputs by using a visual time point signal on the video screen. The observational information obtained using this method was used to better describe the physical characteristics of the playing position, and to suggest ways to make the playing more efficient. This method of synchronously analyzing the EMG data and player movements provides useful mixed quantitative and qualitative information for devising methods for more detailed biomechanical analysis of flute playing in future studies.

5.3 EMG Procedure and Equipment

To reduce skin resistance, the EMG technique requires cleaning of the participant's skin overlying the muscle to be assessed and specifically underlying the position on which the disposable surface EMG electrodes are placed. Cleaning is by initial swabbing with an alcohol wipe and light surface abrasion with a proprietary agent to reduce skin impedance and aid in detection of the EMG signal. (Figure 2) Two self-adhesive electrodes are positioned directly on pre-determined locations, in the middle of the muscle belly where accessible superficially. (Figure 3) A third (ground) electrode is placed at a site distant to the muscle of interest. There should be no pain associated with this technique. (Figure 4)

Figure 2: Cleaning the Skin

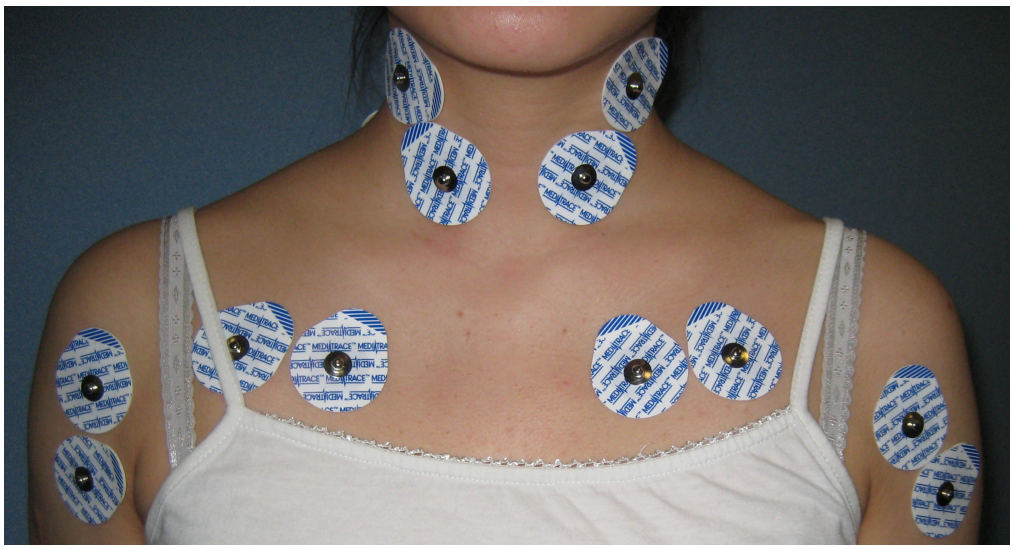

Figure 3: Self-adhesive Disposable Electrodes are Applied to the Clean Skin

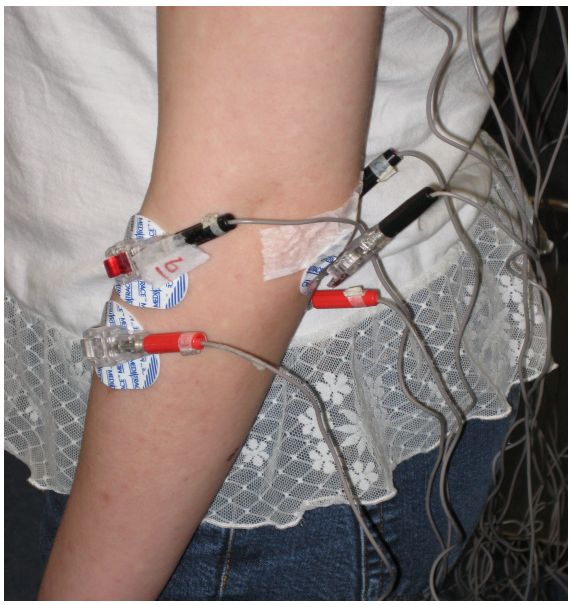

Figure 4: Electrodes Positioned in the Middle of the Muscle Belly

The electrode leads connect to an EMG device (Figure 5), so the electrical signal from the muscles can be converted into a digital signal for the electronic database.

Figure 5: EMG Device

The electrodes are interfaced to a computer using EMG software (MP100 System; BioPac Systems Inc, California). Each muscle group is represented by an individual coloured line, as shown in Figure 6.

Figure 6: Screen Capture of a Sample EMG Readout for Each Muscle Group

The EMG study was filmed to assist in the analysis of data so that musical considerations may be directly compared with physical responses (Figure 7).

Figure 7: Full EMG Set-Up

5.4 Method

Establishing positions functionally appropriate for flutist outcomes of EMG analysis were used to provide quantitative information to assess muscle activity and understand possible causes of symptoms reported in surveys. The EMG data was obtained from a

professional flutist and a university undergraduate music student. The data was compared directly with the maximum voluntary contractions (MVCs)[7] of each player analyzed, in order to gain information about the relative percentage activity in each muscle group during playing. Percentage outputs of EMG gave some indication of the amount of work required by muscle groups for playing two pieces of varying complexity. (Or, in other words, how much activity different muscles are performing, relative to their maximum capacity). This data will provide a baseline against which to assess any later research which compares different body positions, or flutist experience.

The EMG studies gathered primary data, showing the muscular responses to varying loads, such as technically easy versus technically complex passages, as well as those requiring sustained airflows, and repertoire for difficult breathing. The EMG study was filmed to assist in the analysis of data so that musical considerations may be directly compared with physical responses. These outcomes were used to clarify possible causes of playing-related discomfort, pain or injuries and symptoms reported in the current survey, as well as previous studies. The EMG data was analyzed by Dr Peter Mills, Dr Liisa Laakso and Karen Lonsdale. Drs Mills and Laakso provided details of muscle electrical activity (muscle involvement) during the performances.

5.4.1 Choice of Musical Excerpts

The repertoire selection was chosen from the tertiary student's current university exam preparation repertoire, which are both standard works in the traditional flute literature. As the student was already suffering from some playing-related discomfort, it was not advisable to increase her physical load for this study by choosing unfamiliar repertoire.

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[7] "The maximal voluntary force that an individual can exert with a muscle, or group of muscles." (Enoka & Fuglevand, 1993, p.215)

The professional had already performed both of these pieces on previous occasions. For this reason, neither player had any undue or increased technical load in the lead up to the EMG study. The compositions chosen were approximately 2 minutes in duration.

***Sonata in A minor "Arpeggione"* by Schubert, Movement 1**
(Bar 10 to the first note of bar 53)

The opening of the first movement of the *Arpeggione Sonata* by Schubert required each player to play fairly slow, sustained melodies in the low register, requiring a controlled airflow. Good breath control is the major challenge of this piece, and there are no major technical challenges in terms of fingering for an advanced flutist. The excerpt duration was approximately 1 minute 50 seconds. (Figure 8)

***Concertino* for Flute and Piano by Chaminade**
(Bar 3 to the bar first note of bar 31)

The excerpt chosen required slow, sustained melodies and a controlled output of high volume airflow as well as some virtuosic, fast scalic runs (no particularly awkward fingerings). The key centre is D major, and all of the figures in this section are well within the capabilities of an advanced flutist. This excerpt requires a wide dynamic range, from 'p' to 'ff', including several crescendi and diminuendi, and encompasses almost the entire pitch range of the flute. In addition to the fast finger work, the main challenge is to achieve a full volume that would be likely to carry across the *fortissimo* sound of an orchestra, band, or concert piano. The excerpt duration was approximately 2 minutes. (Figure 9) Each excerpt was played twice by each flutist. They both gave a complete performance of Schubert, then Chaminade to study the left and right sides of the pectoralis, sternocleidomastoid, anterior and posterior deltoid. Then each gave a complete performance of both pieces to study the left and right wrist flexors and extensors.

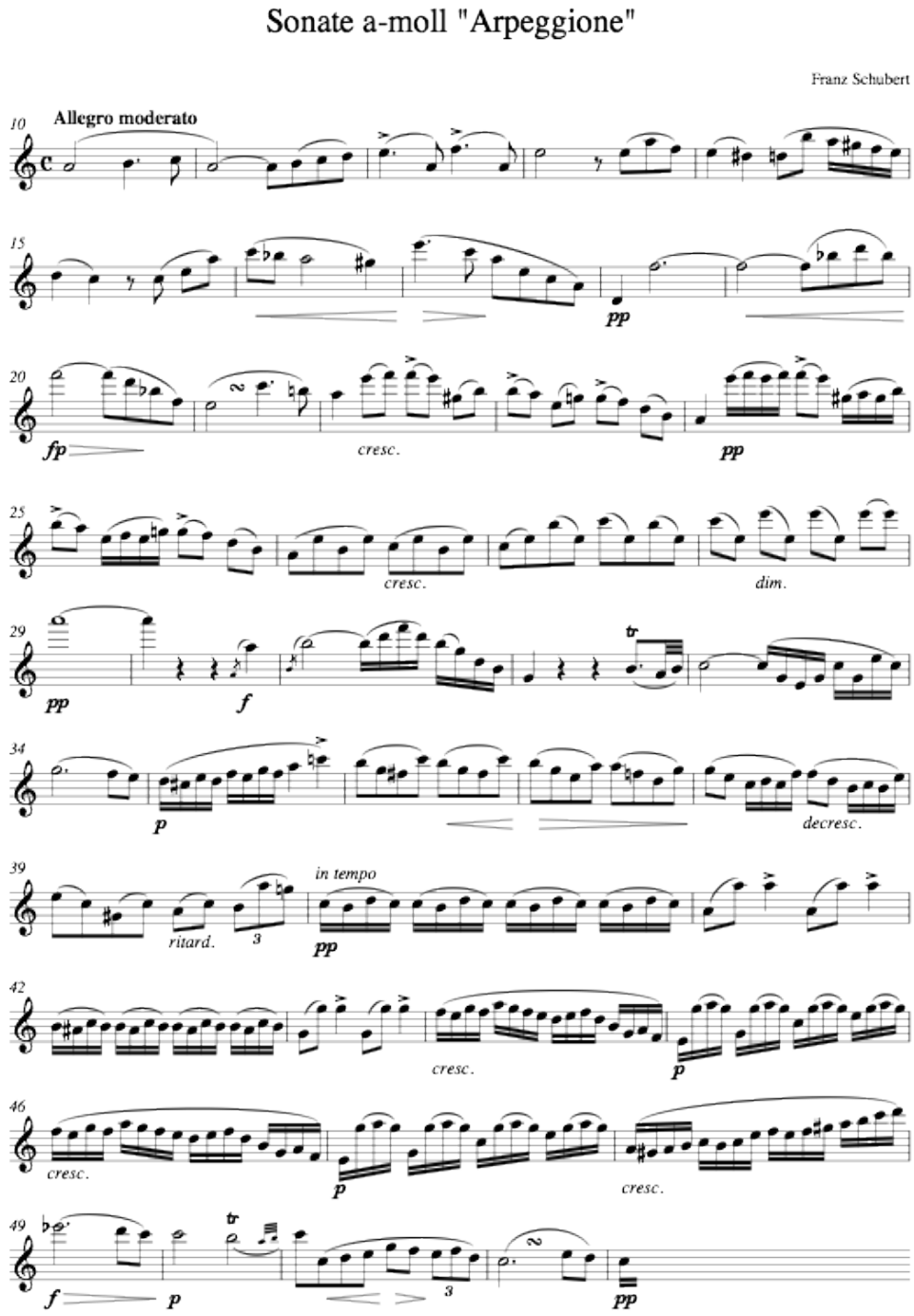


Figure 8: Sonata *Arpeggione* (Schubert) Excerpt

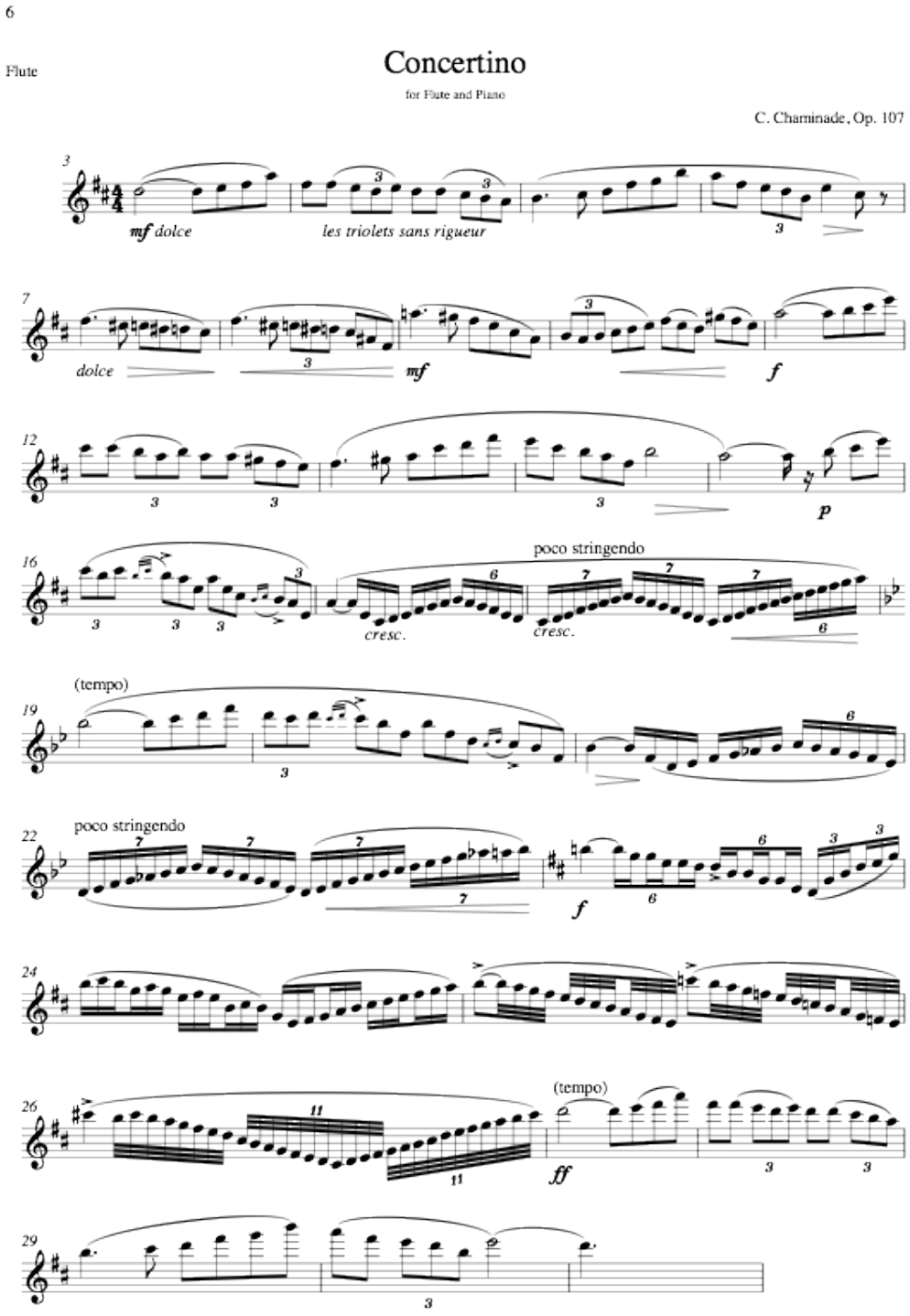


Figure 9: Concertino for Flute and Orchestra (Chaminade) Excerpt

5.4.2 Participants, and Ethics

A 2 x n=1 EMG study comparing the playing by a professional and university undergraduate student was designed to measure upper body muscle responses in the playing of standard repertoire pieces. Both participants were female. At the time, the 21-year-old undergraduate was suffering from neck, left wrist and left forearm pain. She had never experienced pain in the right hand or arm.

The university student was recruited because she was an advanced flutist working at an intense level, learning difficult and sophisticated flute repertoire. The student was also selected as she advised that she was concerned about neck and shoulder pain. The student was also willing and available to travel to the Griffith University School of Physiotherapy and Exercise Science at the Gold Coast. Ethics approval was sought for the EMG study and approved by the Griffith University Ethics Committee.

5.5 Results and Discussion

The results and discussion will be presented synchronously for ease of comprehension.

5.5.1 Participant Characteristics and Playing Posture/Position

There was a large difference in physical size between the players, with the very small framed Asian student being 160cm in height compared with the 179cm tall professional. Simple observation of the playing positions of each flutist demonstrated differences possibly due to the physical characteristics of the flutists. For example, Figure 10 shows the smaller hand of the student, compared with the professional's left fifth finger (Figure 11). Notably, the student's left fifth finger is some distance away from the G# key (Figure 10), unlike the professional's which comfortably touches the key (Figure 11). This requires the student to stretch the left arm further around the body, in order to reach the G# key when needed (see yellow arrow in Figure 10). The photo in Figure 10

shows the closed position of the left upper arm against the student's body, in relation to the angle of the flute. Figure 11 shows the more open position of the professional's upper arm, in relation to the angle of the flute.

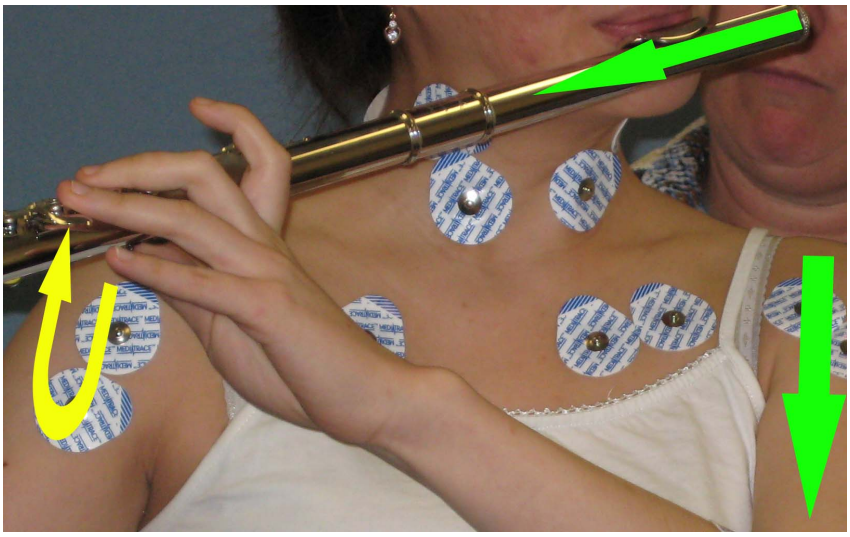


Figure 10: Left Hand Position of the Student Showing the Distance to the G# Key (Yellow Arrow).

Figure 11: Left Hand Position of the Professional, Comfortably Reaching the G# Key.

Following is a comparison of the player responses for each muscle group, where the EMG amplitude represents the percentage of a 100% maximum voluntary contraction (MVC). Where there are notable differences in muscular responses between the professional and student player, these are marked in bold font on the EMG tables and relevant EMG readings are included in the next section.

5.5.2 Comparison of Mean EMG Activity in the Wrist Extensors and Flexors of Both Flutists

The wrist extensors are the group of forearm muscles responsible for extending (straightening) and adducting the hands, wrists, fingers and thumbs. The wrist and finger flexors are responsible for flexing (bending) the wrist and fingers. The thumb has its own set of extensors and flexors (Seeley, Stephens, & Tate, 1996, p.182.) In flute playing, the wrist and finger extensors and flexors are responsible for lifting all of the fingers and the left thumb off the keys (extensors), pressing down the keys (flexors) and partly stabilizing and supporting the weight of the flute in a fixator role. Fry (1988, p.14) states that "Maintaining the flute in position requires static loading on both shoulders and a three point stabilizing grip on the instrument. This requires a surprising amount of muscular use in the small muscles of the hand and forearms, sufficient even to cause digital nerve lesions."

In addition to the static load, there is the additional consideration of how far the fingers are moving away from the key after being depressed and whether the key is being gently depressed or not. In many playing instances, it is not necessary or advisable to move the fingers far from the keys to achieve fluent, even technique. One exception to this would be when using the extended technique of "key slaps", where the fingers are deliberately slapped down on the keys to create a percussive effect. However, this is a

special effect used relatively infrequently in traditional repertoire, and was not required in the musical excerpts chosen for this study.

In the Schubert excerpt, the right wrist flexor activity of each player was very similar between the EMG of the professional (mean EMG output = 5.71%) and the student (mean EMG output = 5.58%). (Table 30)

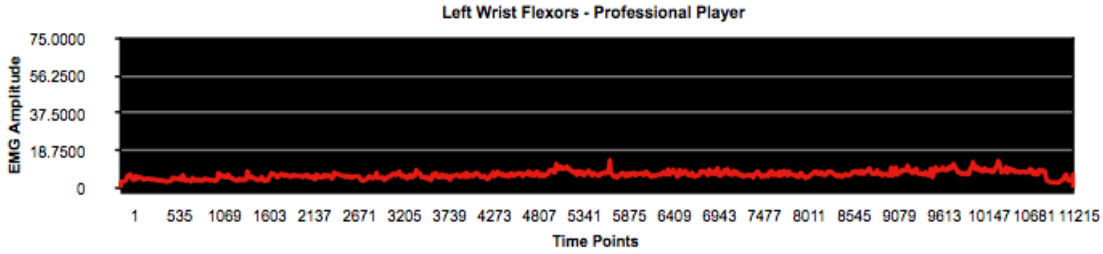
Table 30: EMG Activity of Wrist and Finger Extensors and Flexors

EMG of Wrist and Finger Extensors and Flexors					
Piece of Music	**Muscles Studied**	**Professional**		**Student**	
		Mean	**SD[8]**	**Mean**	**SD**
Schubert	**R Wrist Flexor**	5.71%	1.34	5.58%	2.93
	L Wrist Flexor	**6.66%**	**1.78**	**26.19%**	**10.73**
	R Wrist Extensor	7.1%	2.44	5.3%	2.23
	L Wrist Extensor	**6.48%**	**2.58**	**13.65%**	**6.32**
Chaminade	**R Wrist Flexor**	6.34%	2.15	8.33%	6.26
	L Wrist Flexor	**8.16%**	**2.67**	**26.29%**	**13.29**
	R Wrist Extensor	7.57%	4.14	5.98%	3.65
	L Wrist Extensor	**7.27%**	**3.72**	**16.96%**	**8.03**

However there was a notable difference in muscle contraction between the left wrist flexors of the professional in the Schubert (mean EMG output = 6.66%) and the student

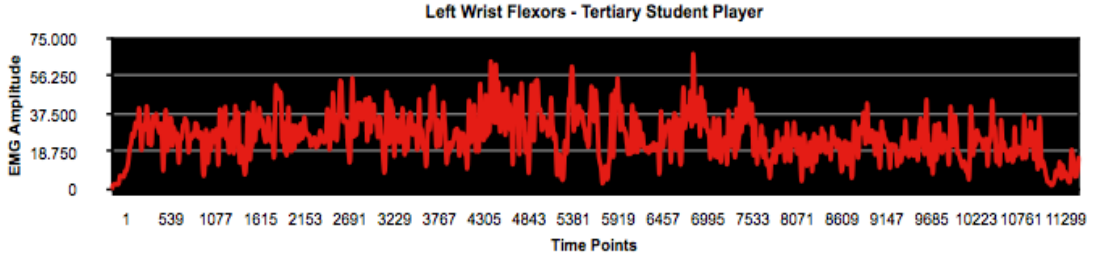
[8] SD = Standard Deviation

whose muscles were working notably more (mean EMG output = 26.19%) as a percentage of MVC. (Figures 12 and 13)



Left Wrist Flexors - Professional (Piece 1 - Schubert)	
Mean	**SD**
6.66%	1.78

Figure 12: EMG Activity of the Professional's Left Wrist Flexors in Schubert



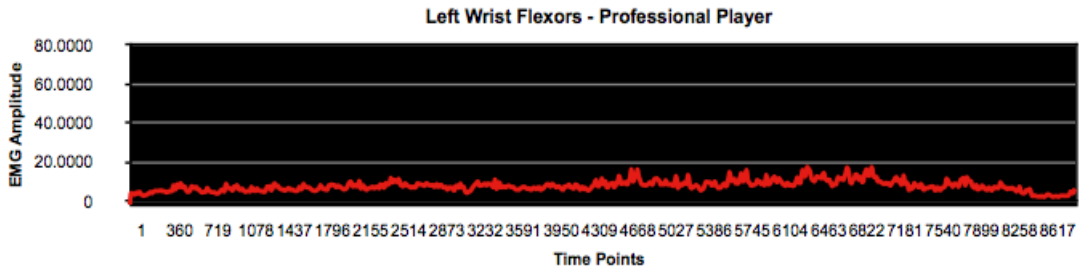
Left Wrist Flexors - Student (Piece 1 - Schubert)	
Mean	**SD**
26.19%	10.73

Figure 13: EMG Activity of the Student's Left Wrist Flexors in Schubert

The visual analysis of the graphs is supported by a basic statistical breakdown. By determining the average (mean) amount of muscle activity over the entire period of the performance piece, it becomes clear that the left wrist flexor muscles of the less experienced player are contracting notably more (mean EMG output = 26.19%) than those of the professional (mean EMG output = 6.66%). The professional's left wrist

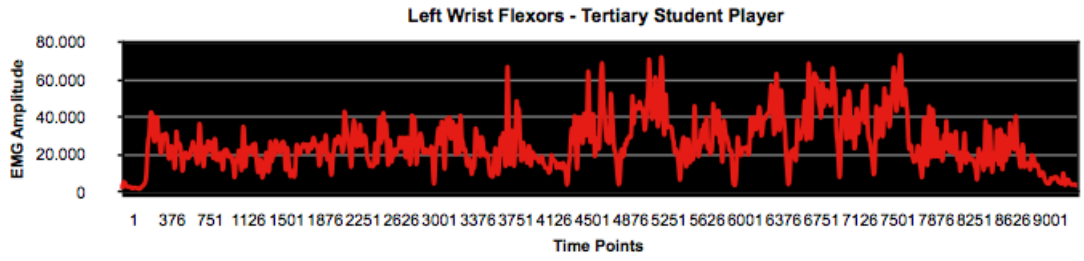
flexor EMG average of percentage MVC was slightly higher in the Chaminade (mean EMG output = 8.16%) than in the Schubert (mean EMG output = 6.66%). (Figures 12 and 14)

However, the student's EMG mean output in the left wrist flexors were almost identical in both pieces (mean EMG output = 26.19% - 26.29%), and as discussed, were notably higher than in the professional. (Figures 13 and 15) Similar outcomes were recorded for the left wrist flexors of both players in the Chaminade (professional's mean EMG output = 8.16% and student's mean EMG output = 26.29%). (Figures 14 and 15)



Left Wrist Flexors - Professional (Piece 2 - Chaminade)	
Mean	**SD**
8.16%	2.67

Figure 14: EMG Activity of the Professional's Left Wrist Flexors in Chaminade

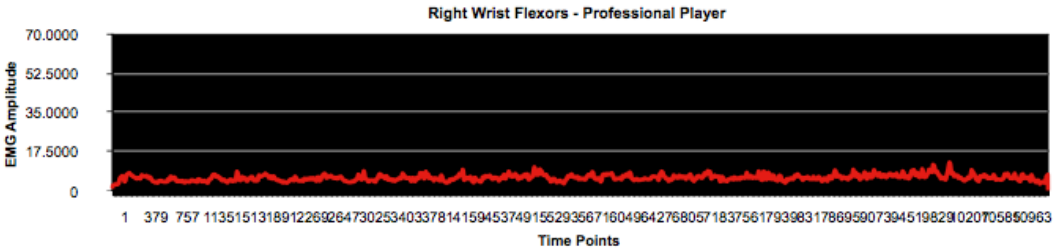


Left Wrist Flexors - Student (Piece 2 - Chaminade)	
Mean	**SD**
26.29%	13.29

Figure 15: EMG Activity of the Student's Left Wrist Flexors in Chaminade

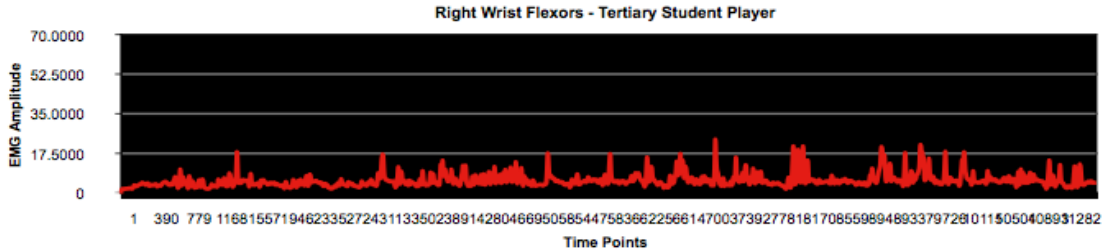
Despite the greater technical challenges in the Chaminade *Concertino*, the EMG mean of the professional's right wrist flexors (mean EMG output = 6.34%) was only slightly higher than it had been in the Schubert (mean EMG output = 5.71%). (Figures 16 and 18)

Correspondingly, the student's right wrist flexor readings were somewhat similar in both pieces (mean EMG output = 5.58% - 8.33%), with a slightly higher EMG mean output in the Chaminade (mean EMG output = 8.33%). (Figures 17 and 19)



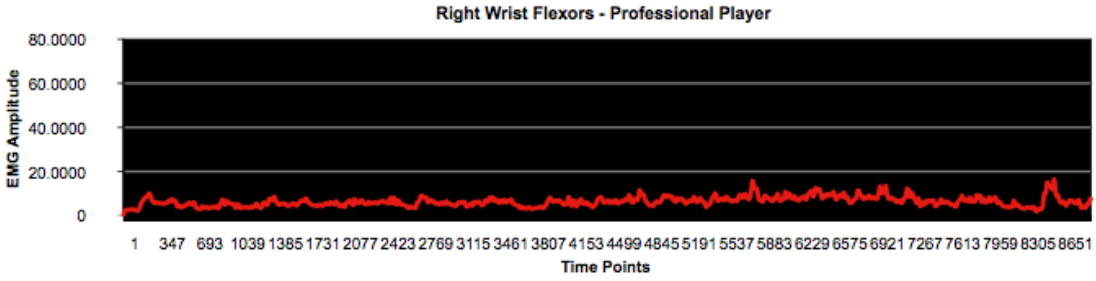
Right Wrist Flexors - Professional (Piece 1 - Schubert)	
Mean	**SD**
5.71%	1.34

Figure 16: EMG Activity of the Professional's Right Wrist Flexors in Schubert



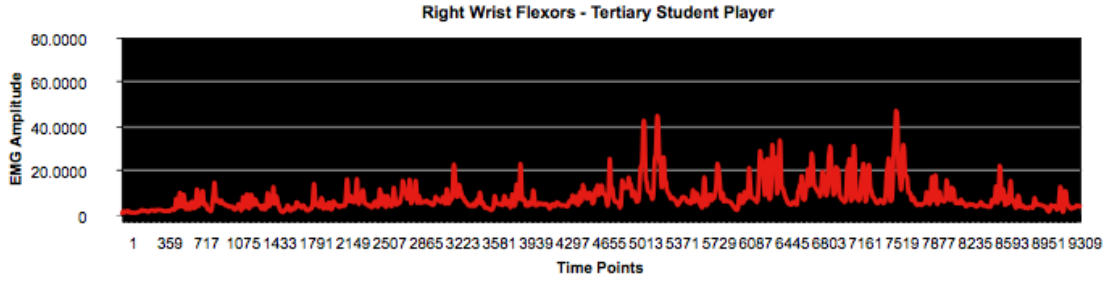
Right Wrist Flexors - Student (Piece 1 - Schubert)	
Mean	**SD**
5.58%	2.93

Figure 17: EMG Activity of the Student's Right Wrist Flexors in Schubert



Right Wrist Flexors - Professional (Piece 2 - Chaminade)	
Mean	**SD**
6.34%	2.15

Figure 18: EMG Activity of the Professional's Right Wrist Flexors in Chaminade



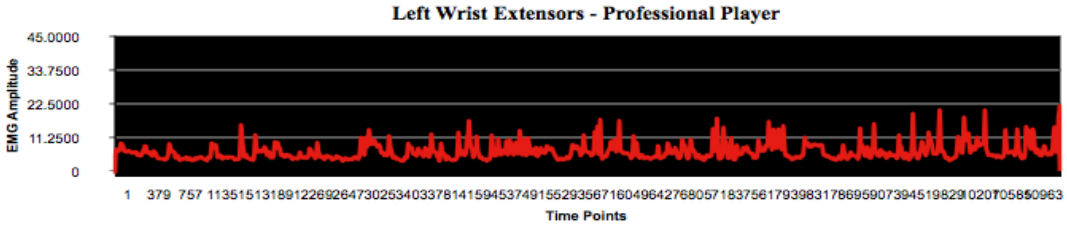
Right Wrist Flexors - Student (Piece 2 - Chaminade)	
Mean	**SD**
8.33%	6.26

Figure 19: EMG Activity of the Student's Right Wrist Flexors in Chaminade

Observation of the video recording of the study indicated a key difference in the technique of the players, in that the student was frequently lifting the right elbow, where the professional player kept the right elbow comparatively still. Lifting and lowering the elbow repeatedly serves no purpose in flute playing, either musically or technically, and may disrupt legato phrasing. This tendency was particularly pronounced when the student took a breath or during crescendos (for example between bars 26-29, or at 41-48 seconds), where there are groups of quavers in leaping intervals (thirds, fifths, sixths, octaves).

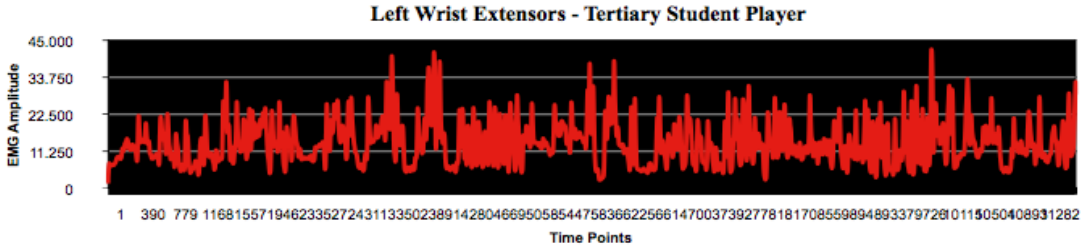
Figures 20 and 21 show the EMG comparison of the left wrist extensors of the flutists, playing bars 10 – 71 of the 1st Movement, *Allegro moderato*, of Schubert's *Arpeggione* Sonata. EMG measurements clearly show that the left wrist extensor muscles of the student (mean EMG output = 13.65%) were working notably more than those of the professional (mean EMG output = 6.48%), whereas the right extensor muscles have a greater similarity in the amount of muscle contraction.

The video footage also shows that the student had a general tendency to lift her fingers much further off the flute keys than the professional. This habit, in conjunction with "bouncing" the flute, and needing to stretch the left arm further to reach the keys contributed to the higher muscular effort in the student's left wrist flexors (Figure 13) and extensors. (Figure 21)



Left Wrist Extensors - Professional (Piece 1 - Schubert)	
Mean	**SD**
6.48	2.58

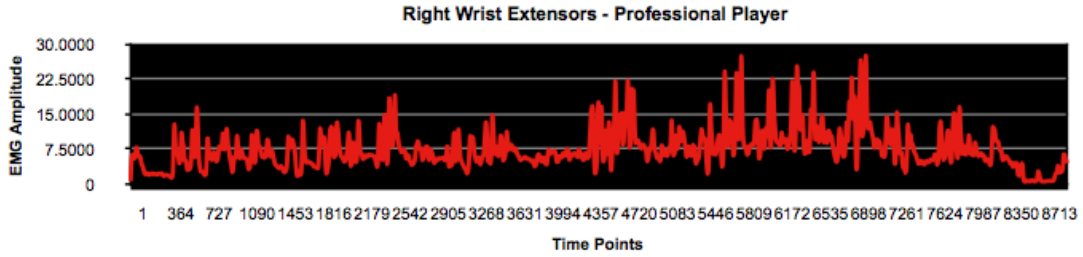
Figure 20: EMG Activity of the Professional's Left Wrist Extensors in Schubert



Left Wrist Extensors - Student (Piece 1 - Schubert)	
Mean	**SD**
13.65%	6.32

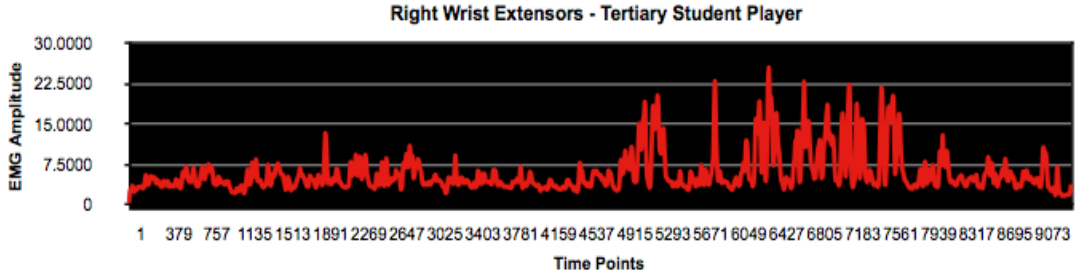
Figure 21: EMG Activity of the Student's Left Wrist Extensors in Schubert

Despite the technical difficulty of the scalic runs in the Chaminade, the mean EMG output for the right wrist extensors in both players was fairly similar (mean EMG output = 5.98% - 7.57%). (Figures 22 and 23)



Right Wrist Extensors - Professional (Piece 2 - Chaminade)	
Mean	**SD**
7.57%	4.14

Figure 22: EMG Activity of the Professional's Right Wrist Extensors in Chaminade



Right Wrist Extensors - Student (Piece 2 - Chaminade)	
Mean	**SD**
5.98%	3.65

Figure 23: EMG Activity of the Student's Right Wrist Extensors in Chaminade

5.5.3 Comparison of Mean EMG Activity in the Middle and Upper Trapezius of Both Flutists

The trapezius is a large, triangular shaped, flat muscle of the back, which is responsible for movements of the head, neck and shoulder. It has three parts (upper, middle and lower), and its roles are to rotate, elevate or depress the scapula, or shoulder blade, a

triangular shaped bone, which has three fossae (bone depressions) into which muscles attach to the arm. The trapezius is also a fixator, in that it assists in stabilizing the scapula when the arm muscles contract (Alcamo, 2003; Seeley, et al., 1996; Tortora, 1980). The trapezius is therefore very important during flute playing for stabilizing the shoulder blades, while both arms are moving, so that the hands can reach the keys. Fain (2009) states:

> Young flutists, when trying to figure out how to hold the instrument, will sometimes rest the end of the head joint 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 position is the lifting of the right shoulder by many flutists in their everyday playing posture as they try to keep the flute horizontal. (p.192)

It also enables movement of the head, such as turning slightly to the left, which is necessary in the basic holding position. A head tilt to the right side, even if only slight, is common in many flutists, and may be much more pronounced in some, particularly those who prefer to hold the flute at an angle. Some players may also have a tendency to drop the head forwards when reading music, or in expressive physical movements during playing.

In both players in the current study, the mean EMG reading of the left upper trapezius was very similar in both pieces, ranging from 25.78% to 26.15% for the professional, and 22.99% to 23.06% for the student. (Table 31)

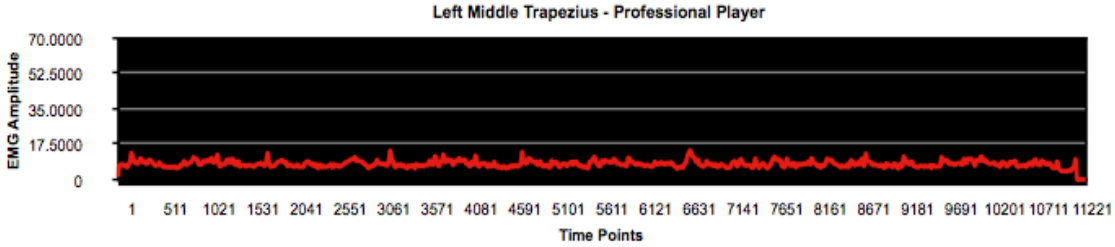
Table 31: EMG Activity of Middle and Upper Trapezius

EMG Activity of Middle and Upper Trapezius					
Piece of Music	**Muscles Studied**	**Professional**		**Student**	
		Mean	**SD[9]**	**Mean**	**SD**
Schubert	**R Mid Trapezius**	**7.79%**	**2.02**	**28.2%**	**10.65**
	L Mid Trapezius	**7.75%**	**1.67**	**22.99%**	**6.21**
	R Upper Trapezius	20.52%	5.22	21.74%	5.25
	L Upper Trapezius	26.15%	6.05	23.06%	4.63
Chaminade	**R Mid Trapezius**	**7.64%**	**2.37**	**31.04%**	**17.58**
	L Mid Trapezius	**7.9%**	**2.28**	**24.34%**	**9.67**
	R Upper Trapezius	20.2%	6.32	22.1%	6.44
	L Upper Trapezius	25.78%	7.23	22.99%	6.52

These left upper trapezius results are consistent with Fortune (2007, p.131) who stated that "EMG values were consistent across all performance items regardless of whether they were playing the difficult or easy scale or piece, or in which order they were played, or whether they were told that their performance would be evaluated by an expert judge." Fortune found, however, that those players who had a history of shoulder or neck pain had higher readings than those players who did not (p.131). In the current study, neither of the players were experiencing shoulder pain, but the student was suffering from neck pain.

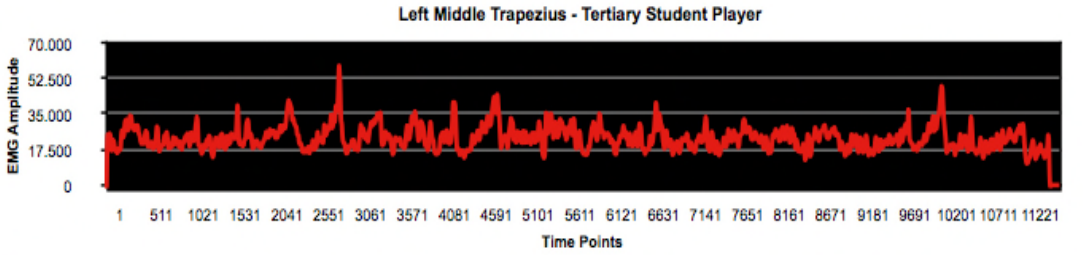
[9] SD = Standard Deviation

The mean EMG reading of the right upper trapezius was also very similar in both players (ranging from mean = 20.2% to 20.52% for the professional, and mean = 21.74% to 22.1% for the student). However, there was a notable difference between the players in the mean EMG readings of both the right and left middle trapezius (Figures 24, 25, 26, 27). In both pieces, the student was using a much higher percentage of MVC than the professional player, as shown in Figures 25 and 27.



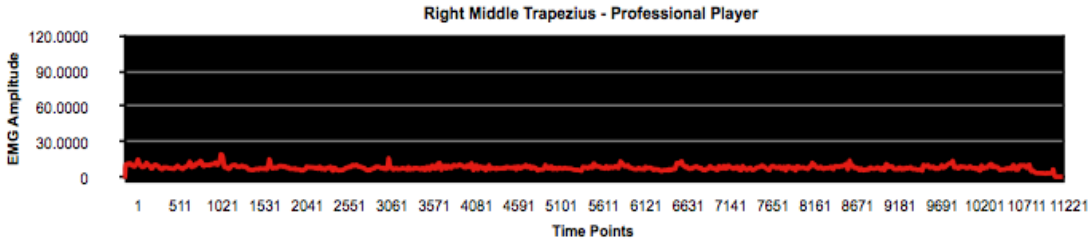
Left Middle Trapezius - Professional Player (Piece 1 - Schubert)	
Mean	**SD**
7.75%	1.67

Figure 24: EMG Activity of the Professional's Left Middle Trapezius in Schubert



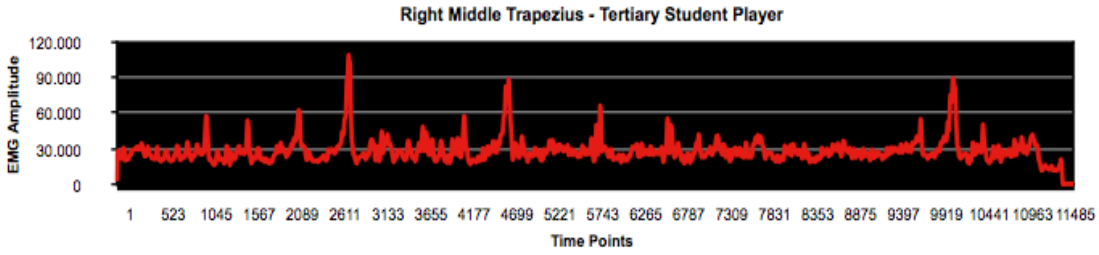
Left Middle Trapezius - Student Player (Piece 1 - Schubert)	
Mean	**SD**
22.99%	6.21

Figure 25: EMG Activity of the Student's Left Middle Trapezius in Schubert



Right Middle Trapezius - Professional Player (Piece 1 - Schubert)	
Mean	**SD**
7.79%	2.02

Figure 26: EMG Activity of the Professional's Right Middle Trapezius in Schubert



Right Middle Trapezius - Tertiary Student Player (Piece 1 - Schubert)	
Mean	**SD**
28.2%	10.65

Figure 27: EMG Activity of the Student's Right Middle Trapezius in Schubert

The student flutist demonstrated greater forearm muscle and middle trapezius activity than the professional flutist who in turn demonstrated greater pectoralis muscle activity than the student. These findings suggest that the student's position and stance was creating greater tension in the small muscles required for fine fingering movements. Long-term over-activity of the fine finger and wrist muscles may result in overuse injuries (Dawson, 2008, pp.38-39; Llobet, 2007, pp.105).

5.5.4 Comparison of Mean EMG Activity in the Anterior and Posterior Deltoid of Both Flutists

The deltoid has its origins in the scapula and clavicle, and inserts into the humerus (upper arm bone). It has three parts: anterior (front), middle and posterior (back). It is responsible for flexing, extending and abducting the arm or moving it away from the body (Seeley, et al., 1996). In flute playing, the three sections of the deltoid are responsible for lifting both arms into the playing position (Fain, 2009, p.198), by rotating the shoulder inwards (anterior portion). The posterior (back) deltoid lengthens to enable this movement. It also stabilizes the shoulder during playing.

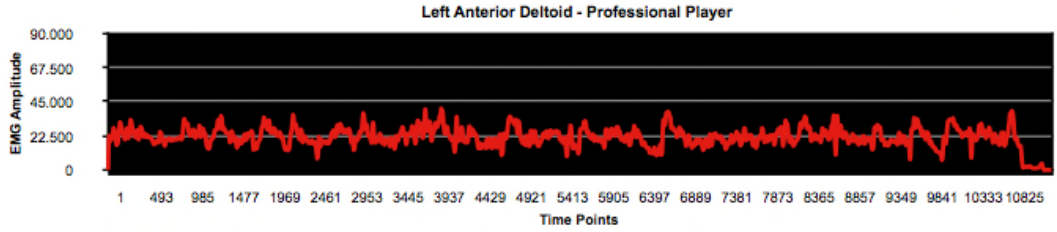
Dawson (1997, p.108) states that "the flutist requires a significant degree of complex forces to hold the instrument correctly, with the shoulders abducted widely; it is impossible for the musician to keep his or her elbows close to the side and thus minimize the amount of force demanded of the deltoids and supraspinati." Similarly, Fain (2009, p.200) explains that to keep the elbows held up and away from the body over a duration "leads to muscle fatigue, a build up of metabolic waste 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." Fry (1988, p.14) also noted the "high occurrence of shoulder and scapula over-use from the static loading" in his sample of flutists.

Table 32: EMG Activity of Anterior and Posterior Deltoid

EMG Activity of Anterior and Posterior Deltoid					
Piece of Music	**Muscles Studied**	**Professional**		**Student**	
		Mean	**SD[10]**	**Mean**	**SD**
Schubert	**R Anterior Deltoid**	13.84%	5.12	10.03%	3.32
	L Anterior Deltoid	**21.61%**	**6.47**	**31.9%**	**10.72**
	R Posterior Deltoid	7.09%	1.87	3.09%	0.87
	L Posterior Deltoid	8.16%	1.35	5.53%	0.89
Chaminade	**R Anterior Deltoid**	14.67%	6.23	12.74%	5.32
	L Anterior Deltoid	**22.89%**	**9.44**	**30.87%**	**13.71**
	R Posterior Deltoid	5.67%	1.62	3.2%	0.91
	L Posterior Deltoid	8.2%	1.47	5.76%	1.18

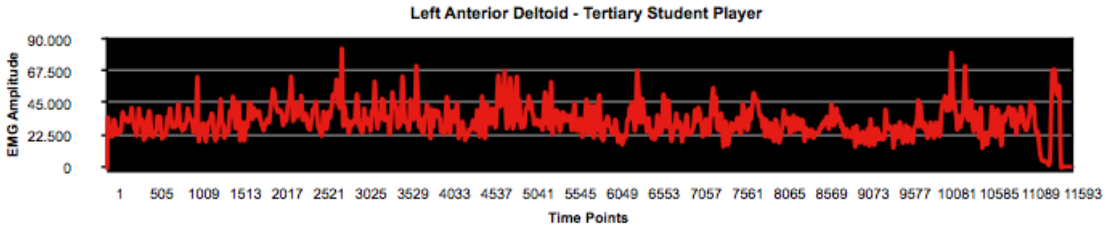
In both pieces in the current study, EMG activity was similar in the right anterior deltoid of both players (professional 13.84% - 14.67%; student 10.03% - 12.74%), as indicated in Table 32. By contrast, in the Schubert piece, the EMG activity in the left anterior deltoid was somewhat higher in the student (31.9%) than the professional player (21.61%). There was a similar difference in the Chaminade with the professional player recording 22.89%, and the student 30.87%. This outcome is likely due to the greater technical facility required in the Chaminade, coupled with the greater reach of the student's shorter left arm to reach the key work on the flute. (Figures 28 – 35)

[10] SD = Standard Deviation



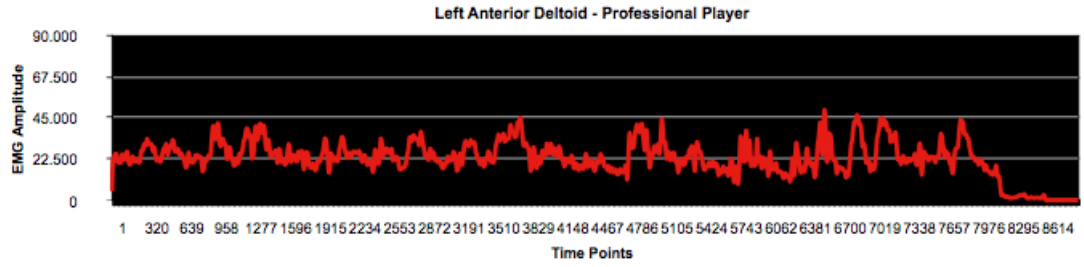
Left Anterior Deltoid - Professional (Piece 1 - Schubert)	
Mean	**SD**
21.61	6.47

Figure 28: EMG Activity of the Professional's Left Anterior Deltoid in Schubert



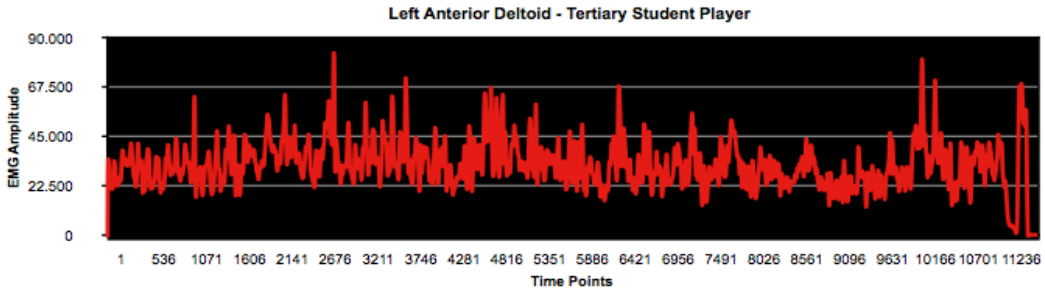
Left Anterior Deltoid - Student (Piece 1 - Schubert)	
Mean	**SD**
31.9%	10.72

Figure 29: EMG Activity of the Student's Left Anterior Deltoid in Schubert



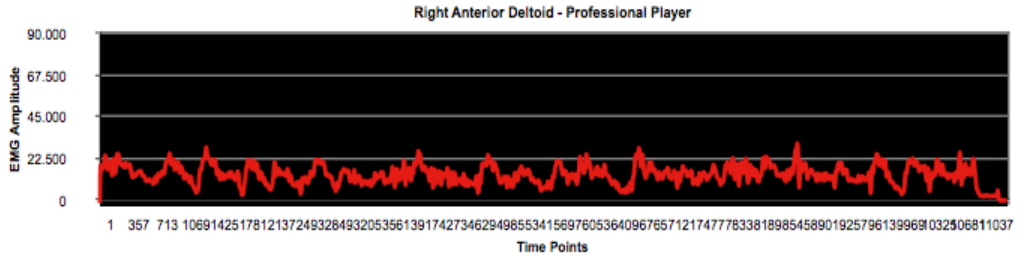
Left Anterior Deltoid - Professional (Piece 2 - Chaminade)	
Mean	**SD**
22.89%	9.44

Figure 30: EMG Activity of the Professional's Left Anterior Deltoid in Chaminade



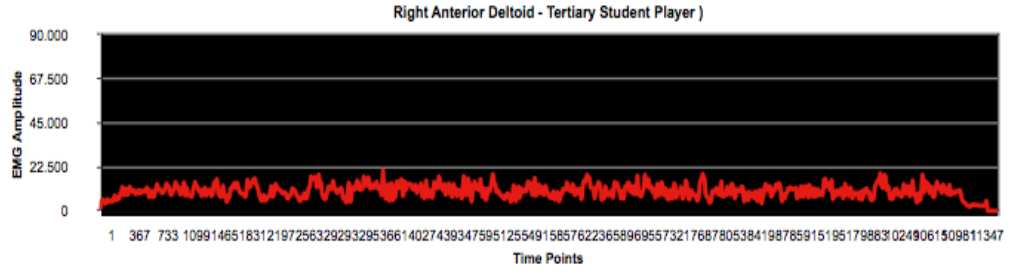
Left Anterior Deltoid - Student (Piece 2 - Chaminade)	
Mean	**SD**
30.87%	13.71

Figure 31: EMG Activity of the Student's Left Anterior Deltoid in Chaminade



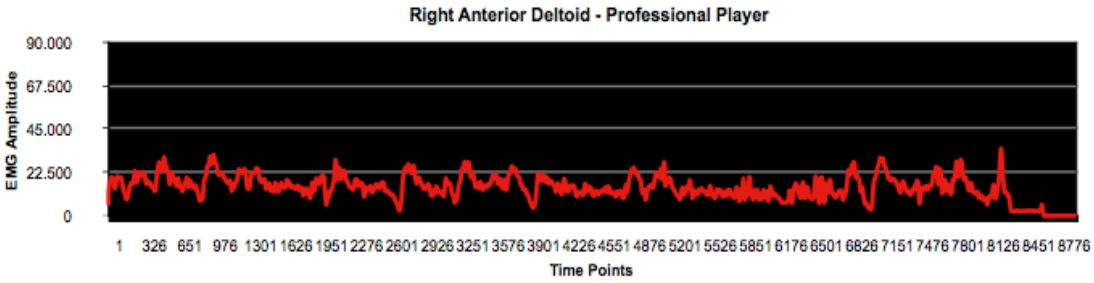
Right Anterior Deltoid - Professional (Piece 1 - Schubert)	
Mean	**SD**
13.84%	5.12

Figure 32: EMG Activity of the Professional's Right Anterior Deltoid in Schubert



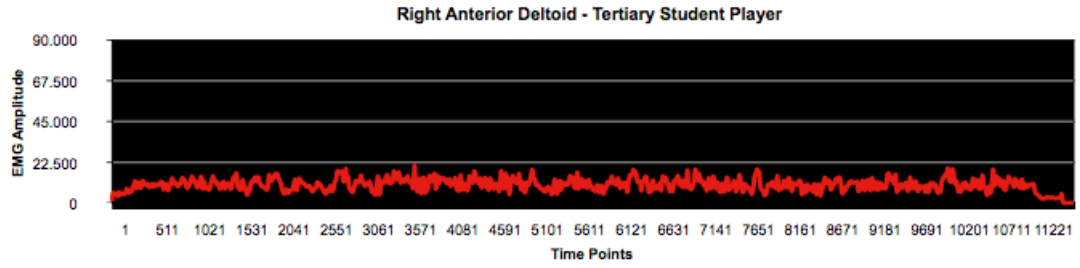
Right Anterior Deltoid - Student (Piece 1 - Schubert)	
Mean	**SD**
10.03%	3.32

Figure 33: EMG Activity of the Student's Right Anterior Deltoid in Schubert



Right Anterior Deltoid - Professional (Piece 2 - Chaminade)	
Mean	**SD**
14.67%	6.23

Figure 34: EMG Activity of the Professional's Right Anterior Deltoid in Chaminade



Right Anterior Deltoid - Student (Piece 2 - Chaminade)	
Mean	**SD**
12.74%	5.32

Figure 35: EMG Activity of the Student's Right Anterior Deltoid in Chaminade

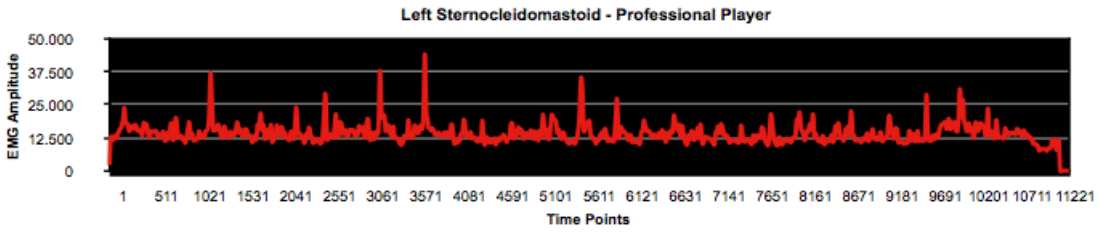
5.5.5 Comparison of Mean EMG Activity in the Sternocleidomastoid of Both Flutists

The sternocleidomastoid is a muscle on either side of the neck, which assists rotation, flexion or extension of the head. A comparison of the EMG activity of the left and right sternocleidomastoid for both players is shown in Table 33.

Table 33: EMG Activity of Sternocleidomastoid (SCM)

EMG Activity of Sternocleidomastoid					
Piece of Music	**Muscles Studied**	**Professional**		**Student**	
		Mean	**SD**[11]	**Mean**	**SD**
Schubert	**R SCM**	**10.37%**	**3.46**	**18.72%**	**5.89**
	L SCM	14.09%	3.81	13.47%	4.92
Chaminade	**R SCM**	**10.22%**	**4.38**	**17.14%**	**7.08**
	L SCM	13.98%	5.21	13.32%	5.53

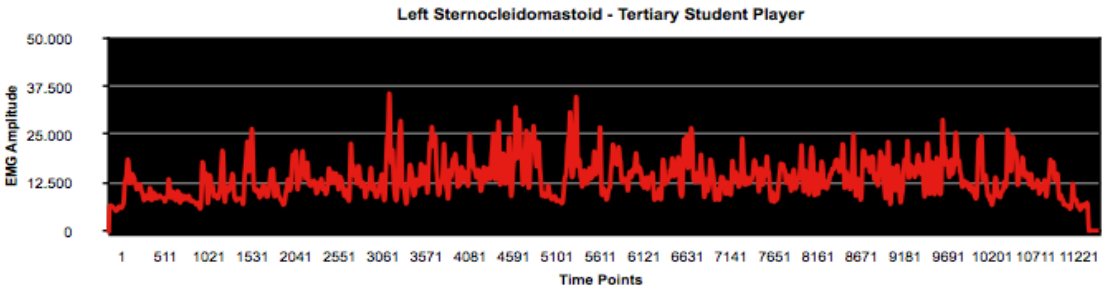
Activity in the left sternocleidomastoid was very similar for both flutists, whether playing the slower or more technically challenging piece. Mean EMG outputs for the left sternocleidomastoid in Schubert are indicated in the Figures 36 and 37.



Left Sternocleidomastoid - Professional Player (Piece 1 - Schubert)	
Mean	**SD**
14.09%	3.81

Figure 36: EMG Activity of the Professional's Left Sternocleidomastoid in Schubert

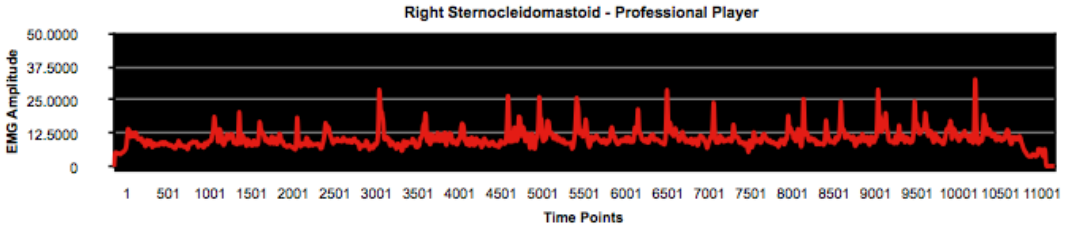
[11] SD = Standard Deviation



Left Sternocleidomastoid - Student (Piece 1 - Schubert)	
Mean	**SD**
13.47%	4.92

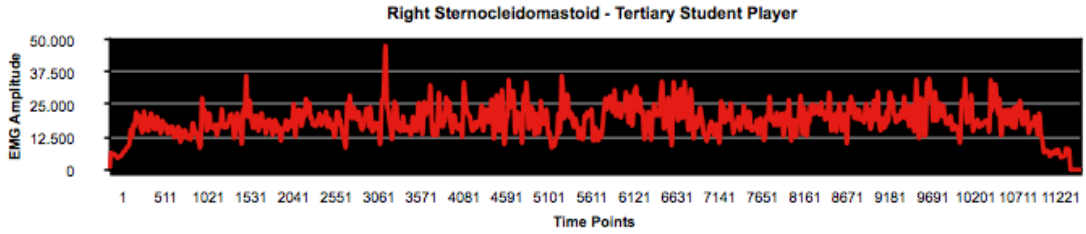
Figure 37: EMG Activity of the Student's Left Sternocleidomastoid in Schubert

The mean EMG outputs for the left sternocleidomastoid for both players was almost identical in the Chaminade (mean = 13.32% - 13.98%). Whether playing Schubert or Chaminade, each player's activity in the right sternocleidomastoid remained consistent, though the student recorded somewhat higher percentages of MVC (mean = 17.14% - 18.72%) than the professional (mean = 10.22% - 10.37%) in this muscle group. (Figures 38 – 41)



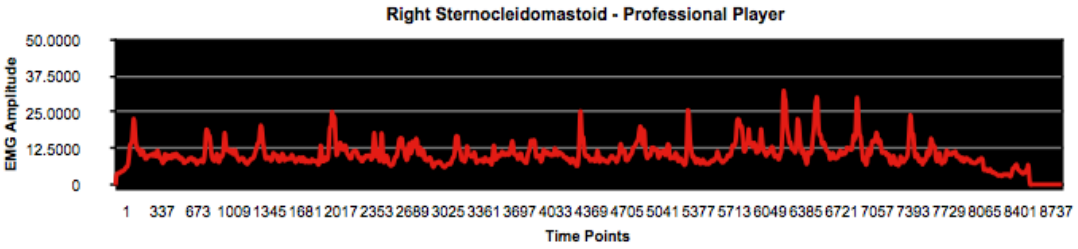
Right Sternocleidomastoid - Professional (Piece 1 - Schubert)	
Mean	**SD**
10.37%	3.46

Figure 38: EMG Activity of the Professional's Right Sternocleidomastoid in Schubert



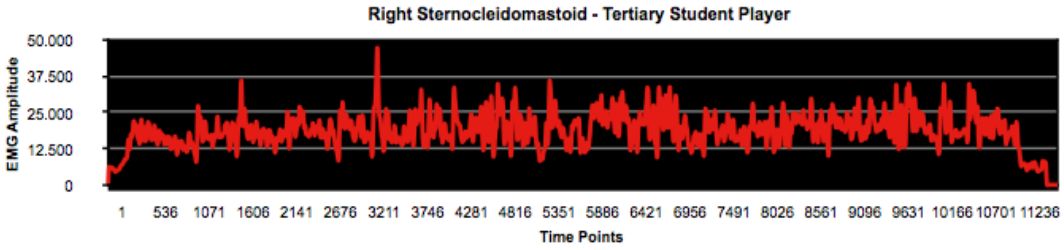
Right Sternocleidomastoid - Student (Piece 1 - Schubert)	
Mean	**SD**
18.72%	5.89

Figure 39: EMG Activity of the Student's Right Sternocleidomastoid in Schubert



Right Sternocleidomastoid - Professional (Piece 2 - Chaminade)	
Mean	**SD**
10.22%	4.38

Figure 40: EMG Activity of the Professional's Right Sternocleidomastoid in Chaminade



Right Sternocleidomastoid - Student (Piece 2 - Chaminade)	
Mean	**SD**
17.14%	7.08

Figure 41: EMG Activity of the Student's Right Sternocleidomastoid in Schubert

Observation of the video recording showed that the professional's neck position was either very slightly tilted to the right, or in a neutral alignment with the spine. The student tended to make "circular" movements with the flute, lifting the elbows and nodding the head, which resulted in a higher reading than the professional player.

5.5.6 Comparison of Mean EMG Activity in the Pectoralis of Both Flutists

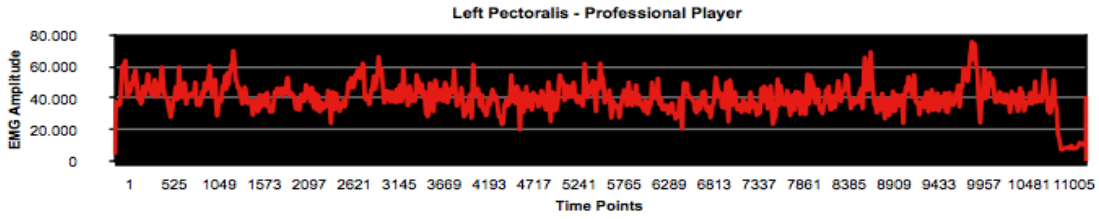
The pectoralis major forms part of the upper chest, originates at the clavicle, sternum, and cartilages of the second to sixth ribs and inserts into the greater tubercle of the humerus. Its role is to adduct (move towards the midline of the body), flex, and extend the arm (Alcamo, 2003; Seeley, et al., 1996). During flute playing the pectoralis enables the left arm to cross the body to reach the keys closest to the head joint, and the right arm to lift and reach the keys closest to the foot joint. It also stabilizes and is in a constant state of contraction to enable the holding of the flute. (Alcamo, 2003; Fain, 2009, p.195)

As the left arm crosses the body to reach the flute keys, predictably, the left pectoralis in both players was the hardest working muscle whether playing the slow piece, or the more technically challenging piece (professional mean = 36.9% - 40.41% and student mean = 29.57% - 30.02%). (Table 34) The EMG readouts for the left pectoralis of both players appear in Figures 42 - 45.

There was a notable difference between the mean EMG output of the left and right pectoralis in both players, when playing Schubert and Chaminade. For example, in the Schubert, the professional's EMG reading for the left pectoralis was 40.41%, compared with only 13.51% for the right side. (Figures 42 and 43)

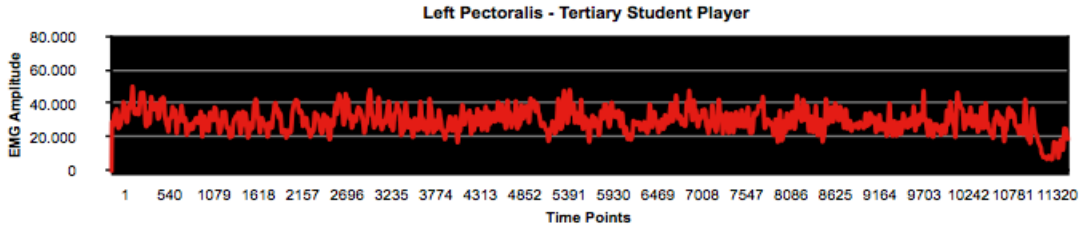
Table 34: EMG Activity of the Pectoralis

EMG Activity of the Pectoralis					
Piece of Music	**Muscles Studied**	**Professional**		**Student**	
		Mean	**SD**[12]	**Mean**	**SD**
Schubert	**R Pectoralis**	13.51%	2.97	13.01%	3.27
	L Pectoralis	**40.41%**	**9.4**	**29.57%**	**6.76**
Chaminade	**R Pectoralis**	13.64%	3.48	14.58%	3.95
	L Pectoralis	**36.9%**	**9.69**	**30.02%**	**6.68**



Left Pectoralis - Professional (Piece 1 - Schubert)	
Mean	**SD**
40.41%	9.4

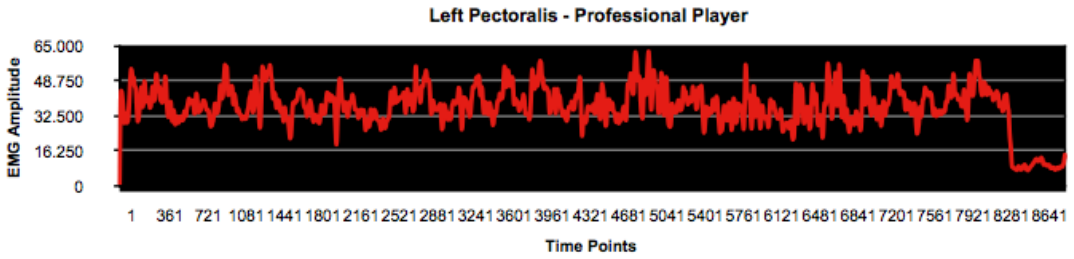
Figure 42: EMG Activity of the Professional's Left Pectoralis in Schubert



Left Pectoralis - Student (Piece 1 - Schubert)	
Mean	**SD**
29.57%	6.67

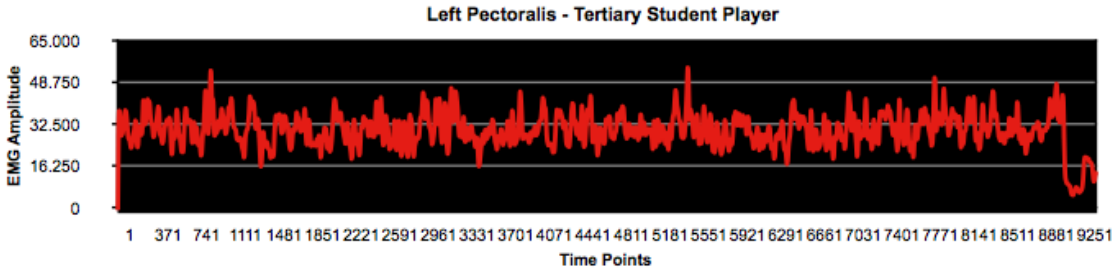
Figure 43: EMG Activity of the Student's Left Pectoralis in Schubert

[12] SD = Standard Deviation



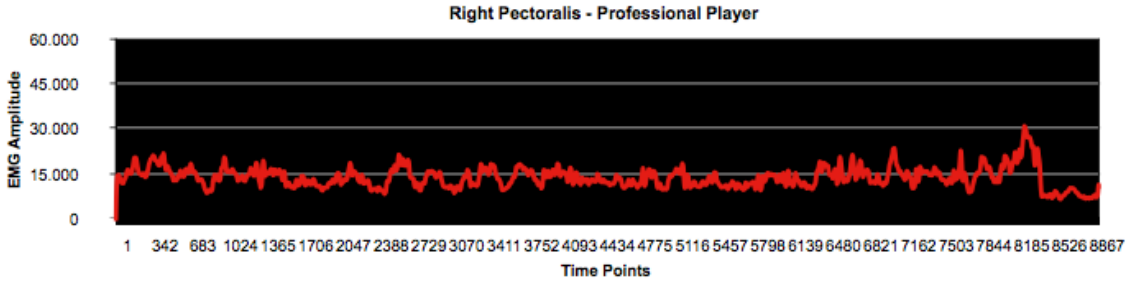
Left Pectoralis - Professional (Piece 2 - Chaminade)	
Mean	**SD**
36.9%	9.69

Figure 44: EMG Activity of the Professional's Left Pectoralis in Chaminade



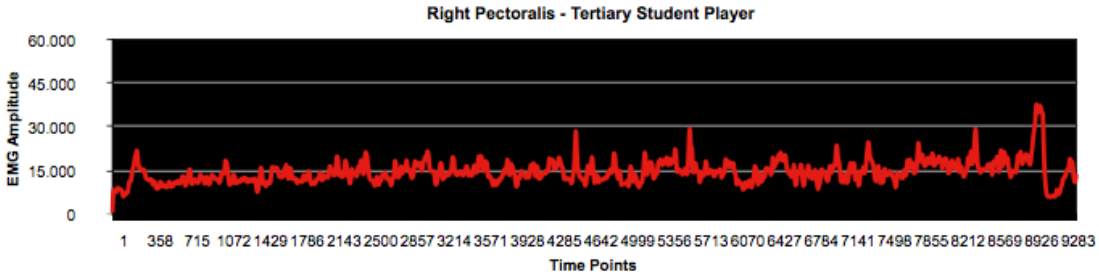
Left Pectoralis - Student (Piece 2 - Chaminade)	
Mean	**SD**
30.02%	6.68

Figure 45: EMG Activity of the Student's Left Pectoralis in Chaminade



Right Pectoralis - Professional (Piece 2 - Chaminade)	
Mean	**SD**
13.64%	3.48

Figure 46: EMG Activity of the Professional's Right Pectoralis in Chaminade



Right Pectoralis - Student (Piece 2 - Chaminade)	
Mean	**SD**
14.58%	3.95

Figure 47: EMG Activity of the Student's Right Pectoralis in Chaminade

Whether playing a slow piece or more technically challenging piece, the EMG activity of the left versus right pectoralis in each individual player indicated almost no difference in activity. (Figures 42 – 47) A further observation is that the mean EMG output for the left pectoralis of the professional player was notably higher than the student's, while their right pectoralis EMG readings were more similar, including in the more technically changing piece. (Figures 46 and 47)

5.6 Large vs. Small Muscle Groups

The EMG output for the professional player was much greater than the student in the left pectoralis, but not in the smaller muscle groups, such as the right sternocleidomastoid, left anterior deltoid, middle trapezius and wrist flexors and extensors. Culf (1998, pp.58-59) suggests that it is preferable for a musician to use the stronger, larger muscles to support the weaker ones. Culf (p.59) states:

> Small muscles have limited strength and endurance and on the whole are suitable for fine precision movements rather than strenuous workloads. Larger muscles have more strength. An action becomes easier to perform and the movement becomes lighter when the larger muscles do the bulk of the work. While playing an instrument, movements of the upper arm are powered by the large, strong muscles of the shoulder, back and chest.

While in theory, the student could attempt to work her larger muscles harder than the small muscle groups, she still has the physical limitation of small arms and hands, which have to reach the same distance to reach the left hand keys as the much taller professional player. Since the concert flute is made only in one size for advanced players, the student would need to look at other options, such as the instrument modification discussed in the next section.

5.7 Modification of Instruments

Importantly, the student was playing an 'inline' mechanism and the professional, an 'offset', so the student had a greater distance to reach the G key. Additionally, the student was playing a platinum (the heaviest precious metal) clad solid silver flute, therefore a heavier instrument compared to the professional's solid silver model. To reduce the student's forearm pain, a number of ergonomic adjustments may be worthwhile, such as a left hand key extension and/or offset G mechanism to ease the stretch to reach the G/G# keys. Additionally, the student could trial a flute made of a lighter metal, to ascertain if the weight of the platinum is contributing to her pain. Dawson (2008, p. 36) states:

> In some cases the size of an individual's hand or arm may not be suited to the playing of a specific instrument. This discrepancy may explain why overuse-related problems are seen in women more than in men and in violists more than in violinists. The female hand is generally smaller than that of the male and has a proportionately lesser degree of muscle strength…Similarly young instrumentalists may develop problems if their instrument is too large to play comfortably. Some performing arts medicine authorities classify this type of problem under the heading of misuse, not overuse; they believe it is caused by an apparent mismatch of personal equipment (body size and structure) with the size of the instrument…
>
> Dealing with these size discrepancies has resulted in modified instruments, such as unusually shaped violas and smaller or more closely spaced keys on some student wind instrument models."

Boyette (2005, p.99) states "the challenge of instrument ergonomics is to adapt the instrument just enough to meet the requirements of the musician, but not to alter the vital components of the original instrument design."

5.7.1 Possible implications for Young or Small Beginners

As the undergraduate was very small in physical stature, the findings may have implications for teaching young beginners who have difficulty maintaining a good hand position. The student was not reaching the G# key (left hand little finger) as easily as the professional player, who had much longer arms and larger hands than the student. The student was also playing on an inline G key, rather than an offset G key, so the professional had slightly less distance to reach the G key than the student, despite any differences in physical characteristics. A key extension is a device which is an add-on key which effectively shortens the distance that the fingers need to reach the flute keys (Still, 2003).

Due to the increased tension in the left forearm of the student, and considering her small physical size, ergonomic devices such as an offset-G key and/or left hand key extensions may be useful in shortening the reach of the left arm to the keys. Such devices could be tested in a larger study.

5.8 Limitations of the Study and Implications for Future Research

The current study was a comparison of only two female players however, there are implications for future research (e.g., carrying out a study with greater participant numbers; or perhaps assessing biomechanics using motion capture analysis). This study can only demonstrate that there are individual differences; and that some muscle groups work harder on one side of the body compared to the other, and this appears to be consistent at least between the two participants in this trial. Such differences may not be

critical or significant for some players but may be in others. This notion needs to be tested in a larger study, which might also investigate what changes in stance or posture make to playing quality and physical outcomes.

Scientific studies on flutists have been minimal despite the prevalence of playing-related pain and injuries reported in several surveys, therefore, further research is warranted. Recommendations for future research would include altering the duration of the musical excerpts, including observing muscle responses over an extended period of time. Another recommendation would be to observe muscle responses with and without flute modification devices, such as the *Thumbport*, or key extensions.

5.8.1 Duration of the Music Excerpts

The duration of each of the excerpts played during muscle testing was approximately 2 minutes. Even during this relatively short time-frame, there were some observable differences between the participants. However, in a recital, ensemble, band or orchestral situation, a flutist could be playing for 60 - 90 minutes with very few breaks. The implications therefore are that if observable differences are noted after such a short excerpt, then inefficient playing positions over extended periods of time could be physically detrimental. This notion would need to be tested in future research.

5.8.2 Repertoire

The chosen repertoire for this study was based on the student's recital program for her university course. The professional had performed both works in the past. Therefore, it was very familiar material for both players. While the Chaminade was more technically challenging than the Schubert, the repertoire was based on standard scale patterns, and therefore highly achievable. Future studies could investigate muscle responses when playing repertoire from different genres, tempi, or intensity, or when sight-reading. Some modern music, for example, uses more physically demanding technical devices,

such as jet whistles (high force airstream), percussive effects such as key slaps, and none of these extended techniques were tested in this study.

Early music can also be demanding in terms of the constancy of playing, for example, in J.S Bach's *Solo Partita in A minor BWV 1013*, *Allemande* (Movement 1), where the flutist must play for around 4:45 minutes (including repeats), all in semiquavers apart from the sole minims in the final bar of each section, with only 4 semiquaver rests throughout the piece. The remainder of the work is similar, so apart from short rests between each movement, in performance, the flutist plays for around 13 minutes. Such a piece may be played as part of a flute recital, which might last around 60 - 90 minutes. Future studies could observe muscle responses when playing a full-length recital program.

5.8.3 Use of the Thumbport Device

In the current 2 x N=1 EMG study, by contrast to the left wrist flexor muscles, both the student and professional, showed more comparable muscular patterns in the right wrist flexor muscles. The student used a *Thumbport* (Figure 48) device for her right hand (designed by Taiwanese American flute maker Ho-Fan Lee), to assist placement of the right thumb, general stability, and more freedom for the fingers to operate the keys. There is no EMG comparison of the student playing with and without the *Thumbport*, and this would be recommended for future studies.

Figure 48: Photograph of Thumbport Device http://www.thumbport.com/ [Accessed 1 August, 2011] Used with Permission

5.9 Conclusion

EMG evidence suggests that there may be physical and equipment-related factors of flutists that contribute to increased strain on musculoskeletal elements of the body. Despite playing two musical works of different speeds, pitch and dynamic range, the two flutists maintained their own playing position or posture, using similar levels of muscular contraction in each piece. The less experienced flutist (student) was working notably harder in certain muscle groups, particularly the left wrist flexors and extensors, the left and right middle trapezius, left anterior deltoid, and right sternocleidomastoid. By contrast, the left pectoralis of the professional player was contracting somewhat more than the student, especially when playing the slower repertoire.

Observation of the video footage and photographs from the study indicate that the left hand of the much smaller participant did not reach the keys (particularly G#) as easily as the taller professional player. This problem may have been compounded by the student playing an inline G mechanism flute, which requires a greater stretch to the G key than an offset model, which the professional was playing. The professional was also playing on a flute made of a lighter metal (silver), than the student's flute (platinum clad). The student also tended to use some unnecessary movements while playing, such as 'bouncing' the flute and lifting the fingers much further away from the keys than the professional. Playing with greater technical efficiency, as well as ergonomic modifications to the student's flute (e.g. offset G mechanism, left hand extension keys, a lighter flute), may be considered to decrease the load on the muscles that are currently working excessively.

6. INJURY PREVENTION AND MANAGEMENT THROUGH THE APPLICATION OF KNOWLEDGE FROM ERGONOMICS, PERFORMING ARTS MEDICINE AND OTHER DISCIPLINES

6.1 Introduction

There is an overall lack of attention in the traditional flute literature to the prevention and management of playing-related musculoskeletal disorders. However, the survey results presented within this thesis indicated that many flutists either agree or strongly agree that all flute teachers and players should receive training in injury prevention and management. This chapter will examine ways in which flutists can implement prevention strategies into their rehearsing, performing and teaching situations, based on research in other disciplines and professions such as ergonomics, performing arts medicine, physiotherapy and exercise science. Ergonomic flutes and flute modifications will be presented as alternatives to standard instrument models, as well as the pros and cons associated with their usage. Common ergonomic challenges for flutists will be articulated and possible solutions suggested for each of these. Many of the principles overlap, so each will be addressed only once under a specific heading.

6.2 Ergonomics

Dul (2008) suggested ways in which tasks can be optimized in order to use the body efficiently in order to avoid injury, pointing out that "posture and movement play a central role in ergonomics" and that guidelines are based on "biomechanical principles of importance" (p.5). Ergonomics is the science of studying people, their work and leisure activities, as well as the physical and mental activities, equipment and environments involved in undertaking the tasks involved. Ergonomics is based on the principle that all tasks, work environments and equipment can be designed to be

compatible with a person's characteristics, which in turn can improve performance, as well as increase health and safety. (Khalil et al, 1993, p.1; Pheasant & Haslegrave, 2006, p.13).

6.2.1 Ergonomics and the Music Industry

Advice on how to adopt ergonomically sound playing positions can be found in the performing arts medicine literature (Horvath, 2009, pp.109-110; 173-194; Llobet & Odam, 2007, pp.45-61; Paull & Harrison, 1997, pp.97-109) and others, yet the music profession as a whole does not appear to have applied ergonomic principles to as great an extent as other professions. There is also little mention of the application of ergonomics to musicians in workplace, health and safety literature. Grant and Brisbin (1992) suggest a possible reason for this:

> Twenty years ago the application of such a science in the workplace was unacceptable to most employers. Today it is the catch phrase of the decade. In the foreseeable future, ergonomic design considerations will be a normal part of virtually all employer operations. This enormous change in attitude has come about primarily because of the escalating costs and high frequency of cumulative trauma claims.
>
> The manifestations of an inappropriate set-up for young musicians may not appear until at least several years later. Additionally, only a small percentage of those being taught instruments in their youth will later move into paid employment as a musician, so few employers could be held accountable. (p.92)

The implementation of occupational or health and safety policies is a legal requirement in all workplaces in Australia. By definition, however, "in practice and under OHS law, it is usually restricted to occupations or workers that are paid either with wages or fees-for-service" (Archer, Borthwick, & Tepe, 2009, p.5). Identifying hazards and risks are central to OHS principles, though many regulations refer to office and plant environments, machinery, chemical substances and manufacturing. (Archer, et al., 2009; Dul, 2008)

Posture and positioning are central to the science of ergonomics, an important component of occupational health and safety which also applies directly to musicians, though this is not made explicit in the OHS literature. (Dul, 2008) explains:

> Poor posture and movement can lead to local mechanical stress on the muscles, ligaments and joints, resulting in complaints of the neck, back, shoulder, wrist and other parts of the musculoskeletal system...In biomechanics, the physical laws of mechanics are applied to the human body. It is thereby possible to estimate the local mechanical stress on muscles and joints, which occurs while adopting a posture or making a movement. A few biomechanical principles of importance to the ergonomics of posture and movement are outlined below (p.5):
>
> - Joints must be in a neutral position
> - Keep the work close to the body
> - Avoid bending forward
> - A twisted trunk strains the back
> - Sudden movements and forces produce peak stresses
> - Alternate postures as well as movements
> - Limit the duration of any continuous muscular effort
> - Prevent muscular exhaustion
> - More frequent short breaks are better than a single long one.
> - Limit the energy expenditure in a task
> - Rest is necessary after heavy tasks
> - Take account of differences in body size
> - Alternate sitting with standing and walking
> - The heights of the seat and back rest of the chair must be adjustable
> - Limit the number of adjustment possibilities
> - Provide proper seating instructions
> - Avoid excessive reaches
> - Avoid carrying out tasks above shoulder level

(Summarized from Dul, pp. 5-41)

Many of these principles can be found in the performing arts medicine literature, but very little of that information is specifically directed towards flutists. Paull & Harrison (1997, p.97) state that as "ergonomists won't understand the fine points of playing an instrument, we need to be our own "ergonomists". "We need to arrive at ergonomic solutions that in no way compromise either our instruments, our playing, or our health." This chapter will examine ways in which flutists and flute teachers could adopt common

ergonomically sound principles into their rehearsing, performing and teaching situations.

6.2.2 Alignment, Posture and Efficiency of Movement

Dul (2008, p.5) states that "in the neutral position the muscles and ligaments that span the joints are stretched to the least possible extent and are thus subject to less stress." Some examples of non-neutral positions that flutists adopt are bent wrists, head tilt, raising one shoulder, trunk bending forwards, or pushing the hips to one side when standing. In school and community band situations, there is sometimes inadequate room between the chairs to allow for a laterally held instrument, so flutists may need to twist their trunks to see the conductor, in order to compensate for the lack of space. Figure 49 shows young flutists in cramped conditions at a music camp rehearsal. One flutist is twisting towards the right, and has her right arm placed directly behind her chair.

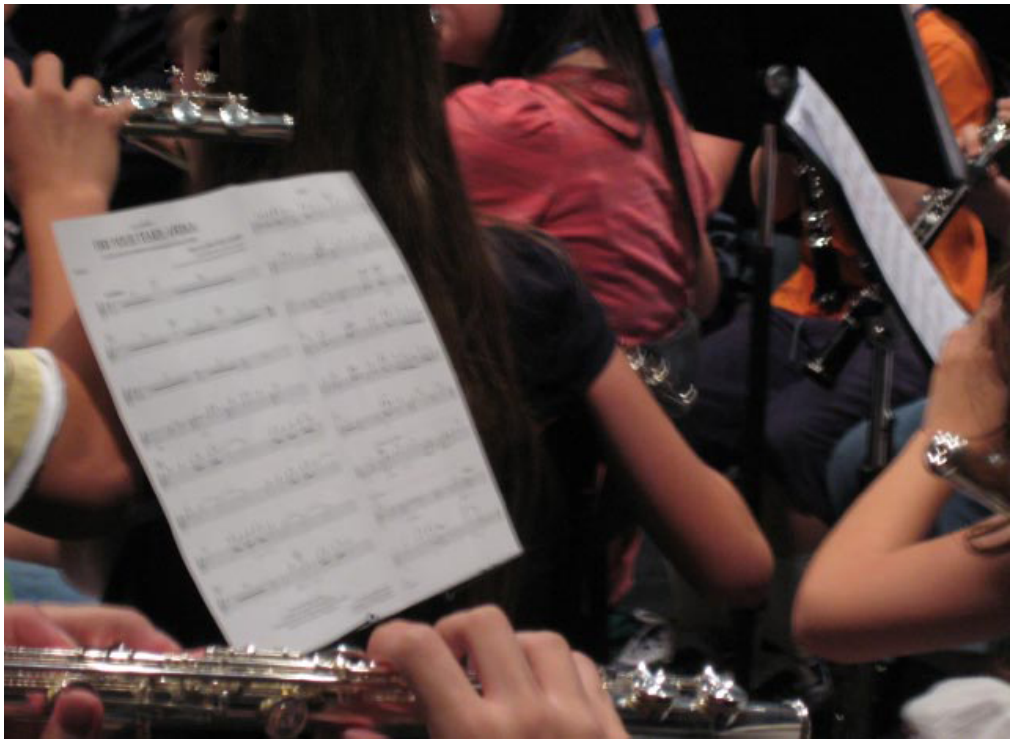


Figure 49: Young Flutists in Cramped Conditions at a Music Camp Rehearsal

Head tilts, trunk twisting, raised shoulders or shoulders rolling forwards, raised or bending wrists, straightened fingers, especially over extended durations, all place additional load on the joints of the body. In some cases, use of carefully chosen instruments, including those with curved head joints, will assist in decreasing the distance of the flute from the body, which facilitates keeping the head neutrally aligned with the rest of the spine. While a perfect position for the spine, and complete neutrality of alignment may not be achievable in a uni-lateral stance, flutists can aim to optimize the way they hold the flute, avoiding excessive or exaggerated movements, resulting in both musical and physical benefits. Flutists should aim to stand upright, while still maintaining freedom of movement. Floyd (1990) states:

> One of the problems with excessive body movements is that it often adds importance to notes where it is not necessary. Gilbert described these movements as "subconscious behaviors caused by not being sure of your ability to communicate expression in the sound. Natural movement from side to side is acceptable, but it must not be associated with certain peaks of the phrase. On the other hand, flutists should avoid looking casual, with one hip slung to the side and rigid or stiff…Dipping and ducking should be avoided, as they also interfere with the phrasing and the line. Additional choreographed movements to avoid include deep-knee bends, which show anxiety; weaving and sweeping; and rocking on tiptoes." (p.37)

Physical movement to music is a natural emotional response, and stiffness in playing is undesirable, but excessive body movement may detract from the musical line, especially in classical styles. The musical line needs to be supported with appropriate body movements for whichever style of music is being performed. Some examples of excessive or exaggerated movements which are mentioned specifically in the flute literature are:

1. **Jutting chin forwards, or dropping chin**. Debost (2002) states that "if the chin is jutted or dropped for any length of time, the equilibrium is displaced, with consequent fatigue, pain, and eventual injury." (p.142)

2. **Excessive use of jaw, especially in playing wide intervals.** Debost refers to this as "jawboning" (p.143) and states that "constant jawboning and forcefulness in technique, like slamming the keys, contribute to pain in playing. They are not recommended in cases of RSI, carpal tunnel syndrome, TMJ syndrome, writer's cramp, focal dystonia, tennis elbow, and many other horrors." (p.145)
3. **Raising shoulders.** Debost cautions that raised or high shoulders "strangle the throat and the tone" (p.184).
4. **Raising wrists or elbows.** Debost recommends keeping the elbows low (p.185) and not to lift them higher than necessary (p.104) Figure 50 shows a flutist raising her right elbow. This is having a flow on effect to the rest of her body, whereby the right shoulder is also lifting, and the left shoulder is lower than the right shoulder.

Figure 50: Flutist Playing With a Significantly Raised Right Elbow. Note the High Right Shoulder Position.

5. **Key slapping** (except where required by the composer). Debost (2002) refers to this as "slam-and-squeeze" or "bringing down the fingers forcefully on the flute (generating unwanted noise) and pressing them tightly (slowing down the fingers' lift)" (p.5). Debost explains his concerns about this technique:

> I am convinced that this forceful and antagonistic muscle action plays an important part in tendinitis, carpal tunnel syndrome, tennis elbow (epicondylitis), writer's cramp - all these plagues of performing artists. The slam-and-squeeze tension has its source at the fingertips. It moves all the way up the arms to the neck and shoulders. This is where tension ends up, but it is not where it originates for a flutist. Having neck therapy is excellent, but it treats the effect and not the cause. (p.232)

While flutists may have a tendency towards these types of movements at times, repeatedly using such inefficient postures may exaggerate the muscle imbalances already involved in the basic playing position. This situation is further aggravated and compromised in some ensemble situations where lack of space makes optimal flute performance all but impossible. For instance, sitting with a twisted trunk is known to place strain on the back (Dul, p.6). The implications for this on seating arrangements are numerous. Band directors, conductors and teachers should ensure that flutists have sufficient room to see the music and conductor. There should ideally be one player per music stand, adjustable seating provided and sufficient lateral space between the chairs to hold the flute without twisting.

6.2.3 Flute Modification

Achieving a more comfortable playing position and more efficient technique may be possible through modifying the flute itself. Instrument modification is commonly suggested in the performing arts medicine literature as a strategy for avoiding pain, discomfort and injury (Dawson, 2008; Horvath, 2009; Llobet & Odam, 2007) and others. A number of flute modifications are presented though not all options will be suitable for everyone. Each player or teacher should decide which option is most

appropriate, through trial and error. The previous chapter on EMG addressed key extensions, one form of modification, while this section will present other available flute modifications.

One area that has been researched with regard to flute posture is instrument modification, to incorporate alternative balance points which would redistribute the weight for player comfort, and ergonomic realignment. Flute rests, supports, platforms, or pads have been suggested as appropriate flute modifications both by general performing arts medicine specialists and flutist authors (Horvath, 2009, p.179; Moratz, 2010, p.123; Paull, 1997, p.102 and others). Llobet (2007, p.48) states that such a device "prevents the flute rolling and helps the hand maintain the correct position". Dawson (2008, p.43) advises that thumb supports "distribute the instrument's weight over a larger area of skin and protect both the skin and underlying nerves from excessive pressure".

One of the better known flute rests is called a *Thumbport*, a small, clip-on plastic device designed by Taiwanese American flutist Ho-Fan Lee, that can be easily attached to the flute tube, where the right hand thumb is normally placed. Like other flute rests, it helps to keep the right thumb from sliding forwards, along the tube, or the flute itself from rolling back towards the player. The common balance points when holding the flute are the chin, first joint of the left index finger, and right thumb. Lee (2007) explains that if the left index finger bears too much of the flute's weight, when the player pushes the embouchure plate against the chin, the right hand must produce a counter force to support the remaining weight and stop the rotation of the flute backwards. The *Thumbport* is purported to work by stabilizing the right hand thumb position, preventing the flute from rolling backwards and therefore, freeing up the fingers to operate the keys. It is also claimed that the *Thumbport* does not scratch or otherwise damage the instrument, unlike some other flute rests. (Lee, 2007; Moratz, 2010, p.123) Figures 51

and 52 show a 10-year-old beginner playing with and without a *Thumbport*. When playing without a *Thumbport*, her left hand is in a poor position, with the hand twisting and leaning on the flute mechanism (Figure 51). When playing with the *Thumbport*, the student achieves a better alignment, with the *Thumbport* allowing the right thumb to be placed further on the tube, creating more freedom of movement for the fingers (Figure 52).

Figure 51: 10 Year Old Beginner with a Cramped and Twisted Hand Position

Figure 52: 10 Year Old Beginner Using a Thumbport, with a Better Hand Position

6.2.4 Physical Size and Instrument Choices for Beginners

Traditionally, flutists of all body shapes and sizes, whether beginners, amateurs or professionals, have played on a standard sized flute, either with the shorter C-foot, or the longer B-foot. Besides this, the main differences in the size or weight of flutes are related to the construction materials used, whether silver plating, various grades of sterling silver, gold, platinum and wood, or combinations of these. Typically, a young beginner would play on a silver-plated C-foot flute, whereas, a professional plays on heavier flutes, either C-foot, or B-foot, and generally made of sterling silver, gold, platinum or wood.

Dul (2008) states that when the arms are outstretched, there is greater stress to the back (p.6). There are many instrument choices which enable the arms to be held closer to the body. This notion is particularly relevant for beginner players, as holding a full length flute for extended periods may be taxing and result in using inefficient postures, such as raising shoulders, or excessive tilting of the head while playing. Dawson (2008, p.24) states:

> The music teacher can and should play a pivotal role in helping students develop healthy playing practices. All music teachers must be aware of their students' potential for developing medical difficulties and have a layperson's working knowledge of their causes, contributing factors, basic diagnostic elements and principles of (nonmedical) treatment and rehabilitation".

Where the instructor is unable to assist the pupil, referral to an appropriate expert is advised. Playing a full-length instrument with a straight head joint could certainly be considered a heavy task for beginner players. Figure 53 is a de-identified photo taken at a primary school rehearsal, where two flutists were playing with significant head tilts to the right, and one girl with a raised right shoulder. Both students were around 11 years of age at the time and played full-length flutes.

Holding the arms in the air, against gravity for extended periods of time, without adequate conditioning, could result in students developing poor posture and technique from an early age. Young string players have long had access to small versions of instruments, including 1/16, 1/8, 1/4 and 3/4 sizes. Yet, many children play full-sized flutes from the outset, typically around age 9 - 11. Dawson (2008, p. 25) cautions that "Physical mismatches between the musician and instrument can also cause difficulties, and music teachers must make sure that students have a properly sized instrument."

For beginners, there are various shorter flutes, including the *Yamaha Fife*, curved head joints, D-foot flutes, piccolo, treble flute in G, or the E flat flute. Each of these options presents both benefits and limitations, therefore, tailoring the choice of flute to the needs of each student is important. Each instrument type will be described and discussed.

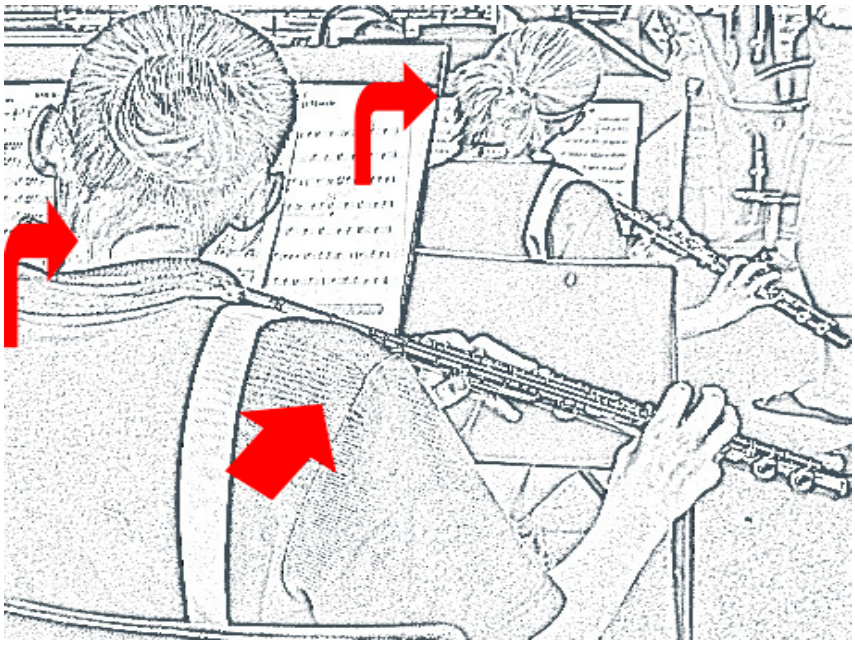


Figure 53: Raised Shoulders and Tilted Heads of Primary School Flutists

The *Yamaha Fife* is a small plastic flute, without keys, that uses the same fingerings as the flute, and is simple to learn for young children. British flutist, Liz Goodwin states:

> One of the main reasons I developed the Fife Book and only use the fife to start people playing was due to physical problems. I'm frequently stunned when I see youngsters being allowed to stand or sit so badly - if a physical education teacher allowed kids to put incorrect pressure on their bodies they would almost certainly be out of a job - but flute teachers do it constantly! (Personal communication, October 22, 2007)

Its limitation is not having a full chromatic range, however it is ideal for teaching sound production, and simple tunes, without the strain of holding up a heavier flute.

Curved head joints are an alternative to the standard straight head joint, and are said to "reduce tension in the shoulders and neck and to reduce the stretch for shorter arms" (Winspur & Wynn Parry, 1998, p.15). They are made in a 'U' shape, and attach to a standard flute body with either a C- or D-foot joint. (Moratz, 2010), p.31 states:

> Curved head joints effectively make the flute shorter without changing anything about the body or foot joint (though some manufacturers leave out the C and B foot joints to lighten the instrument) so that younger folks can be more comfortable playing. Just a generation ago, this option did not exist, so children had to be around age nine or ten in order to start playing the flute. Now, with the advent of curved head joints, kids are picking up the flute as young as five years of age. Some beginning models include both styles of head joints.

Figures 54 and 55 show a small child playing on a straight flute and then a curved flute. When playing on a straight flute, there is a greater internal rotation of the left shoulder, than when the student is playing the curved flute. Both arms are closer to the body when playing the curved flute, in other words, the load of the flute is closer to the midline of the body.

A potential disadvantage of playing on a curved head joint is that the curve itself presents another angle to negotiate, which may make balancing the instrument difficult. To optimize the set up of the curved flute, Visser (2010) recommends turning the head in by about 45 degrees, so that the crown of the head joint lines up with the hinge of the high C sharp key.

Figure 54: Primary School Student Playing on a Full-Length, C-Foot Flute

Figure 55: Primary School Student Playing on a Curved Flute

Some beginner flutes are made without any foot joint, rather an all-in-one style of body, with only an E flat key for the right hand fifth finger. The lowest note on these flutes is a D, below the first line of the staff. These flutes have the advantage of being shorter and weighing less than a standard beginner flute, but the disadvantage of missing the lowest notes (C and C sharp), though beginners in the first months of learning would rarely require these. These flutes may be ideal in size, but eventually beginner players will need to play the C and C sharp. As the D-flute can't be upgraded to include a C-foot joint, the entire flute needs to be replaced. The option to use a D-foot joint is likely to be most appropriate for a very young beginner (6 to 9 years old), or for schools to purchase for beginner band programs.

One variation of a D-foot flute, and a recent introduction to the market is the Azumi *Wave-Line* flute, which features a U-shaped curve between the lip plate and the main body. (Figure 56)

Figure 56: Azumi Wave-Line Flute

http://www.azumi.eu/fileadmin/_azumi/images/Modelle_Neu/Grossansicht_Waveline_WLOC_web.jpg. [Accessed 16 February, 2011] Used with permission .

As discussed in Chapter 3, the fife was a common choice of instrument for young boys in late 19th century France. The fife and other small band flutes have been used for military purposes since medieval times, including in the Swiss "lansquenets", Britain's foot regiments, and during the American Revolution and Civil War (Bate, 1969, pp.5-6;

Moratz, 2010, pp.330-331; Toff, 1979, p.11). Moratz recommends the fife as an instrument suitable for young beginners:

> In starting a six-year-old on the flute, for example, it can prove difficult for the child to hold a concert C flute properly, even if it has a curved head joint to help facilitate correct posture - sometimes the instrument is just too heavy for those small hands and arms. This is where the fife comes in. It's about the size of a piccolo, but has a lighter wall thickness, which means it's freer-blowing and therefore gives the student easier sound production. It's a simple instrument, without the added complications (and expense) of the Boehm system keys. It's the perfect training-wheel flute, because it requires the same type of embouchure as the concert C flute. (Moratz, p.331)

Other small flutes may be considered for beginners, such as the piccolo, treble flute in G (e.g. Guo Grenaditte), or even the E flat flute, as suggested by (Poor, 1983, p.5):

> The E flat flute enjoyed some popularity in the 1960's, and many schools purchased the instrument. If there are any still available, and if they are put in good playing condition, they would be excellent instruments to give to smaller children. The E flat flute has some tonal problems similar to half size violins and cellos, (there is just not very much resonance) but it could be used as a beginning instrument for a year or until the physiological development of the young student warrants the transition to the C flute.

While there is a physical advantage using a smaller flute than a standard one, a potential disadvantage is that both the treble flute in G and the E flat flute, while using the same fingering system, are not pitched in the standard C key. Unless the flute is used purely for solo unaccompanied purposes in the early lessons, transposed scores would be required for many ensemble situations. A piccolo (the smallest concert flute in C) may be an alternative, however, it is also a high air pressure, high-pitched and high volume instrument. If chosen as a beginner instrument, use of appropriate earplugs is particularly important because of the high volume of sound close to the ear.

Most importantly, whatever the choice of instrument, the beginner needs to achieve a good positioning. Wye (1987, p.9) concurs: "When a beginner first takes up the flute, he has no idea whether he is going to be a roaring genius or just a tolerable amateur. If the correct posture is adopted from the very start, at least he has given his body every

chance to contribute to his possible success." Teachers and students are advised to invest thought and time into setting up the beginner student in a healthy playing position, to have the best chance at avoiding later problems with playing-related pain.

6.2.5 Low Flutes

After introducing his concert flute to the market, Boehm constructed an alto flute around 1854 or 1855 (Toff, 1996, p.72). The alto flute has been used commonly in orchestral settings since the early twentieth century, in works such as Stravinsky's *Rite of Spring* and Ravel's *Daphnis and Chloé*. Toff (1996, p.5) states:

> Today, full-time professional flutists are often expected to have expertise on flute, alto flute, bass flute, piccolo, and even historical instruments, particularly the one-keyed baroque flute. The challenges and opportunities for the flutist have never been greater.

Other low flutes such as the bass in C, contr'alto in G, contrabass in C, subcontrabass in G and contrabass in C, in addition to the alto flute, are becoming increasingly popular as solo instruments and in chamber ensembles, flute choirs and flute orchestras (Moratz, pp.326-328). In addition to the standard straight head, alto and bass flutes are now available with a curved head or as a vertical instrument. Playing the straight-head alto or bass flute (at shoulder level) for extended periods of time could be considered a heavy task, so flutists should ensure adequate rest, and alternate instruments where it is possible to do so. Johnson (1997, p.302) states that "if the performer plays beyond fatigue, he or she eventually alters his or her normal performance techniques and begins to use recruited, less efficient muscle combinations. This is a frequent cause of injury." Eva Kingma specialises in constructing low flutes, including alto, contr'alto, bass, contrabass, and subcontrabass that are designed on ergonomic principles. The contrabass flute below (Figure 57) includes an adjustable support under the foot joint, to allow players to adapt the instrument to their height. Other features include left hand

keys which are placed closer together than on standard makes: “The ergonomic side of it varies from person to person and I keep looking for the best possible way to do that. They are heavy and large instruments so you are eager to avoid a situation where all they [flute players] need physiotherapy.” (Kingma, 2009)

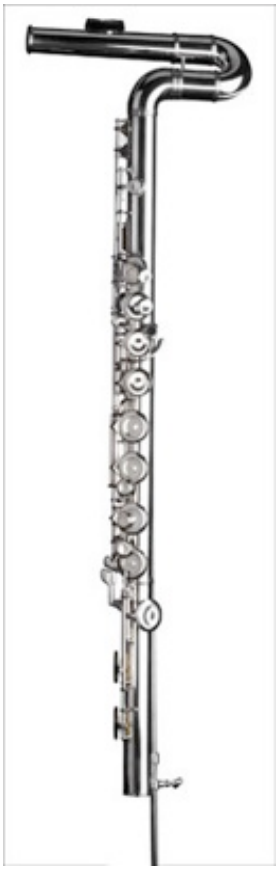


Figure 57: Kingma Upright Bass Flute

http://www.kingmaflutes.com/mySite/Bass.html [Accessed 12 May, 2011]. Used with permission.

6.2.6 Alternative Head Joints

Ergonomic alternatives to standard concert flute head joints are made by various makers internationally. One example is American maker Sandy Drelinger’s “UpRite” head joint (Figure 58) can replace a straight head, allowing a normal concert flute to become a vertically played instrument.

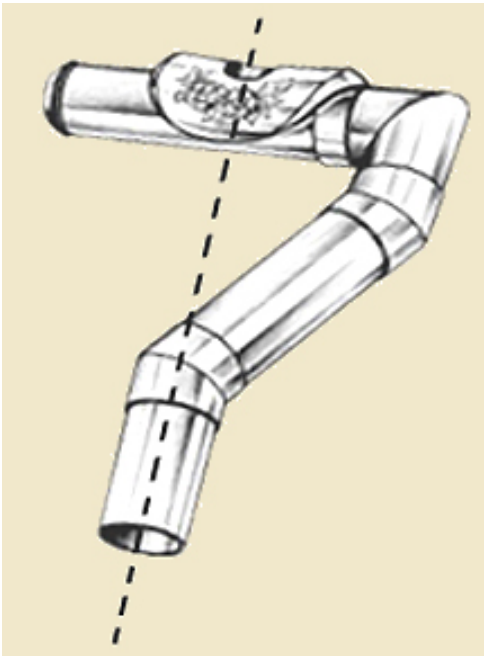


Figure 58: Drelinger UpRite Head Joint

http://drelinger.com/product.htm [Accessed 1 August, 2011] Used with permission.

Similarly, Dutch maker, Maarten Visser has created the 'swan neck' and vertical flute (Figures 59 and 60) to decrease loading on the shoulders, neck and back during playing. He also makes adaptive instruments such as a one-handed flute, for players who only have use of one side of the body.

Figure 59: FluteLab Swan Neck Headjoint

http://www.flutelab.com/swan.html [Accessed 1 May, 2011] Used with permission.

Figure 60: FluteLab Vertical Flute

http://www.flutelab.com/vertcal.html [Accessed 1 May, 2011] Used with permission.

6.2.7 Limitations to Applying Ergonomic Principles

Ergonomics is a science which focuses on optimizing human performance in a range of activities and improving a musician's ergonomic set-up is reported to reduce the risk of injuries occurring. However, Manchester (2008) cautions that "Whatever gains can be made by improving the ergonomics of musical instruments, it is unlikely that this (or any other single strategy) will totally eliminate the problem of repetitive motion injuries." (p.45) It is important therefore that musicians and their teachers are familiar with the causes of playing-related musculoskeletal disorders, and adopt a multi-faceted approach to avoiding injury. Manchester suggests that performing artists are similar to athletes in that they engage in repetitive motion activities through most of the year (p.45). One method that athletes employ to avoid injury is a progressive cycle of training called periodization, and its application to flute playing will be examined.

6.3 Exercise Science

Playing in an asymmetric, awkward position may cause muscular imbalances which place increased load on the body's joints (Watson, 2009, p.33). Not compensating for this asymmetric work is considered a risk factor for playing-related injuries. Llobet (2007, p.25, 90) suggests "carrying out compensatory physical activity", in other words, exercising the muscles used least in instrumental playing and stretching the muscles which are overloaded. There are many ways in which flutists can counterbalance the asymmetric playing position when not playing, such as stretching, strengthening, as well as through therapeutic measures like massage and trigger point therapy. A number of approaches to counterbalancing the flute playing position will be examined in this chapter. One very important method not already discussed, but is prominent in ergonomics, performing arts medicine and exercise science literature is achieving rest and sufficient breaks. Athletes often train in particular phases known as periodization, of which a vital component is rest and recovery. While periodization may not translate directly to the situation of flutists, or musicians in general, some principles that may be of value will be discussed.

6.3.1 Periodization

Periodization refers to sport specific exercise programming whereby the training schedule is divided into phases, focusing on a particular aspect of fitness. Training is gradually increased over a period of weeks, with an initial emphasis on general fitness, as well as stability and control. In the early stages, the aim is on "progressive adaptation" with a view to avoiding the need for later rehabilitation (Bompa & Carrera, 2005, pp.22-23). A greater level of specificity is incorporated into the training thereafter, emphasizing other aspects of physical fitness such as aerobic endurance, muscular hypertrophy, agility, speed, strength, and power. This is followed by a

recovery phase, after which the complete cycle commences again (Manchester, 2008, pp.45-46; Wilmore & Costill, 2004, pp.107-108).

Manchester argues that an adaptation of such a training schedule may assist musicians to "optimize their performance by reducing operator fatigue and discomfort (and overuse injury?)" (Manchester, 2008, p.45). The concept of a "recovery week" is not a formal part of most musicians' training who are encouraged to practice daily from the outset. Toff (1996, p.127), for example, states:

> It is helpful to develop a practice routine, an "order of service" that is observed at least once daily...Remember that a musician's practice is not unlike an athlete's: its aim is to develop muscular skills and agility. It is first and foremost a physical learning process, and, admittedly, not necessarily an intellectual challenge.

Yet, the physical and mental intensity required of a musician in the lead up to major events, such as a national or international audition or competition, could be compared with an athlete in training.

One primary difference between athletes and musicians is that a musician doesn't always know when intense repertoire is coming up. Athletes tend to work towards a particular event or events (Bompa, p.37), which is true to some extent in music; however, there may also be many occasions where a musician may need to play without much lead up to the performance. In a study of Australian students, Fry (1987, p.38) found:

> There was virtually a 100% correlation between the onset of symptoms and an increase in the time multiplied by intensity of music practice. This was usually brought about by preparations for examination, a recital, a competition, study of a new work, a set of exercises, or a change of teacher.

While there is insufficient research to suggest that periodization is a workable concept for musicians, there are aspects which may translate well into a musical context. Manchester (2008, p.46) states that "periodization for performing artists may turn out to be a worthless idea; however, it is a testable idea (as is the more widespread application of ergonomics to instrument design), and we need to start testing some new ideas if

we're going to improve the health of musicians and dancers in the coming decades." A cyclical method of programming practice may not always be realistic, however, some basic principles of periodization that could be implemented are, for example:

1. Prioritize stability and control and correct positioning at any stage of learning music, to avoid unnecessary physical tension (Dawson, p.25). When learning new repertoire, play slowly enough that not only the musical aspects are accurate, but also ensuring an optimal playing position.
2. Schedule breaks throughout the day, as well as full rest days after heavy playing periods. If necessary, non-playing activities, such as studying accompaniment scores, listening to recordings, and marking up parts could be scheduled on rest days. (Llobet, p.12) Apart from any physical benefits, research into the learning of motor skills also suggests that variable practice leads to superior retention, rather than constant practice. (Magill, 2007, pp.372-374, 387)
3. If sudden bursts of learning repertoire are inevitable (e.g. for freelance players who substitute for absentee orchestral musicians), consider programming light load vs. heavier load practice days. Many professional freelancers may already necessarily work like this, especially if their base income is normally derived from private teaching.

6.3.2 Periodization for Beginners

Small beginners are instructed to practice 30 minutes per day, even in the early stages of learning an instrument. Moratz (p.86) states that "30 - 45 minutes per day will do just fine" for beginners, though at age 9 or 10, this could be considered strenuous work for beginners. Louke & George (2010, p.3) take a more cautious approach, advising beginners "to practice a minimum of 20 to 30 minutes per day initially or whatever your

teacher recommends." As some ergonomic beginner flutes have inherent disadvantages, such as not possessing a full chromatic range, therefore being unsuitable for school band programs, an alternative practice schedule is offered in this section for students playing full length concert flutes. Irrespective of what notes are initially introduced, the beginner should always be in a healthy, stable and comfortable position.

Blanchard (2007, p.71) suggests that beginners ease into practice "to gradually accustom them to practice deadlines and the concentration they need during lessons". Blanchard does not expect beginners to reach 30 minutes a day practice until they have been learning for six months (p.71).

Debost (2002, p.34) does not specify exact practice time lengths, but emphasizes a slow and careful approach to learning:

> Common sense at an early stage will bear flute fruit in the long term. Semi - advanced flutists and their teachers may lose many hours correcting bad habits that early care could have avoided. Past the first six months of playing, my principles are not dogmatic: efficiency, comfort, pleasure and beauty…Teacher and beginner should not be afraid of proceeding very slowly at first. Impatience, as well as family pressure, wants to jump ahead and hear results. But the future can be jeopardized by haste. Look how slowly and carefully young violinists start out. The method chosen should reflect this concern. My preference goes to the most progressive, not to the fastest.

Beginners should be taught the value of taking practice breaks from a young age. Some flutist authors do suggest taking regular breaks within a practice session. Wye (1988, p.8) states: "No technical exercise should be practised once pain in the fingers or hand is felt. This is particularly important when re-adjusting your posture or hand position. If this should happen, practise several times a day for short periods." While there is little research on the exact practice schedules of flutists, particularly of younger players, one study suggests that children experience playing-related musculoskeletal problems as commonly as older musicians (Ranelli, et al., 2008, p.182).

Table 35 shows a sample schedule that could be used for training beginners, which gradually increases loading over the first year of practice and includes rest days. The table is based on the suggestion in the flute literature that beginner students practice around 30 minutes per day. This practice schedule builds up gradually to that level of practice, allowing the student to establish stability of posture over a shorter duration before extending the duration of the practice schedule.

Table 35: Sample Daily Home Practice Schedule for Beginners

Sample Daily Home Practice Schedule for Beginners (Over 52 weeks)	
Week 1 - 4	5 - 10 minutes x 4 - 5 times per week
Week 5 - 10	10 - 15 minutes x 4 - 5 times per week
Week 11 - 30	15 - 20 minutes x 5 - 6 times per week
Week 31 - 40	20 - 25 minutes x 5 - 6 times per week
Week 41 - 52	25 - 30 minutes x 5 - 6 times per week

6.3.3 Periodization for Advanced Musicians

Unlike sports training, scheduling rest days in the lead up to major competitions, recitals and auditions may not be practical or realistic for university music students and professional musicians. There are several potential scenarios in which taking a day off could be detrimental to performance, including sight-reading, or quick study competitions, and orchestral auditions where music may arrive only a few days to a couple of weeks before the event. Another example is substituting flutists who replace those who are ill, injured, or unable to play for other reasons, and music needs to be learned very quickly. This also applies to any other situation where a flutist needs to learn a large amount of repertoire quickly, especially where they have been booked to play more than one program in a set period. While these scenarios are very different to

those of the athlete, there may be ways of incorporating periodization into an advanced flutist's practice schedule, such as:

1. Varying lengths of practice sessions to mimic potential peak seasons. For example, instead of sudden onset of practicing during peak times, to build up session lengths, and alternate longer session days with shorter session days. These timings could be based on the typical lengths or intensities of anticipated performance situations. This is graduated approach is referred to as work-hardening (Horvath, pp.169-170).
2. Alternating flute playing with other important musical preparation tasks, such as listening to recordings and studying scores. Mental preparation or visualization is another technique considered to be a similarly effective method of practicing as doing so with the actual instrument (Llobet, p.12)
3. Alternating concert flute, low flutes, and piccolo, to mimic typical playing situations (rather than play the instruments one at a time)

Another strategy for counterbalancing the awkward flute-playing position is to take rest breaks, and this aspect of periodization will be discussed further.

6.3.4 The Importance of Rest and Recovery

The ergonomics, performing arts medicine and exercise science literature all emphasize the importance of achieving sufficient rest, and not achieving adequate rest or breaks is indicated as a risk factor for musculoskeletal conditions. (Brandfonbrener, 1991a; Dawson, 2008; Foxman & Burgel, 2006; Horvath, 2009; LoBuono, 2001; Norris, 1993). Many flutists are required to practice for extended periods of time, especially in the lead up to competitions, auditions, and performances. Preparing music for such events requires intense focus and concentration, as well as repetition to achieve technical accuracy and polished performances. It is essential that flutists schedule regular breaks

into their private practice and rehearsals, and limit unnecessary repetition. In many professional orchestral settings, breaks are set at strict times according to industry award conditions, and flutists who work independently should consider adopting similar conditions. Norris (1993) recommends that musicians limit practice sessions to forty-five minutes with a minimum break of five minutes between sessions (p.2). A recent study of 10 wind players (including 3 flutists) by Drinkwater & Klopper (2010) concluded that "playing a wind instrument is sufficiently physically demanding to elicit deleterious effects on the quality of performance if sustained for a sufficient time period" (p.70).

Flutists should avoid practicing to the point where the muscles are completely fatigued by taking adequate breaks, resting, and aiming to use different muscle groups during the session (Llobet, pp.24-25). This may be as simple as alternating flute with piccolo practice, listening to recordings, or studying the score away from the instrument.

In the early stages of learning, other activities such as theory and aural exercises, clapping or other rhythm games could be alternated with flute playing to reduce the physical load on beginner players. Several flute tutor books provide suggestions for non-playing activities such as general knowledge and theory quizzes (Nightingale, 2011, pp.19, 31, 43, 64), clapping exercises (Haldane, 2001, p.28; Nightingale, 2011, p.45), composition tasks (Nightingale, 2011, pp.21, 39), rhythm games (Haldane, 2001, pp. 33-34), and breathing exercises (Haldane, 2001, p.8).

Gradually, the length of playing time during lessons could be increased when the teacher determines that the child is able to maintain a stable, efficient playing position. Flute teachers and band directors should not expect students to play for extend periods of time without resting, especially considering that even young students are expected to play up to seven or eight hours a day in some band programs and music camps (Norris, 1993, p.2).

The expectation that musicians practice daily may leave an impression that taking rest days may have a negative impact on performance. Sydney Symphony Orchestra physiotherapist Ackermann (2007, p.7) explains how such a belief system influences on injury management:

> During these tours, it was clear that many of the injuries I was seeing were managed poorly and could have been prevented by appropriate management in the early stages. For example, the common rule of thumb in music teaching is that all problems stem from a lack of practice. This includes intonation, speed of playing, and pain. Obviously with increased practice, an overuse injury becomes exacerbated. Like any elite athlete, musicians do not want to rest for extended periods, as some advanced playing skills can deteriorate in a surprisingly short time.

Lieberman (1991, p.15) expresses similar concerns about musical traditions:

> Much of the effort and lack of quality experience involved in music-making can be attributed to the strong beliefs and assumptions we make about exactly what must happen during our practice time in order to "make progress" or in order to become a "great musician".
>
> These beliefs include judgments about the amount of time and repetition necessary, the ideal physical environment, the ideal emotional or psychological state, the amount of material that must be covered, the assumption that the instrument must be present in order to practice, as well as a pervasive attitude that practice isn't the "real thing," that it's just an intermediate stop toward something is always in the future.
>
> Unfortunately, most of these beliefs are seldom questioned and are often held as truth or fact.

Playing away from the instrument itself could be incorporated into practice routines, even if a flutist does wish to have a practice session every day. Other methods of preparation which don't involve holding the flute could include listening to recordings, concert attendance, physical activity (such as walking, exercise classes, swimming and visualization techniques (mental preparation for performance).

6.3.5 Stretching and Flexibility

Stretching is recommended as a preventative strategy for reducing the risk of playing-related injuries by counter-balancing static and asymmetric playing positions (Horvath, 2009, p.117; Llobet & Odam, 2007, p.92; Watson, 2009, p.86). Wilmore & Costill (2004), state that flexibility, an important element of physical fitness is "lost rather quickly during inactivity" and that reduced flexibility has been suggested as a risk factor in serious injury in sports people (p.396). Norris (1993) explains that "Muscles that are tight, weak, and inadequately conditioned are more susceptible to overuse injuries than muscles that are strong and flexible." (p.2)

While studies on the benefits or otherwise of stretching for flutists have not been undertaken, many performing arts medicine authors recommend that musicians stretch to reduce the risk of musculoskeletal disorders occurring. Watson (2009, p.86) suggests dividing practice routines into 35 - 45 minute segments, with stretching exercises between and after the sessions. Some of the potential benefits of stretching for musicians are purported to be increased flexibility and blood circulation, improved joint range, decreased tension, promotes healing, and assists in counter-balancing the playing position (Horvath, 2009, p.117; Paull & Harrison, 1997, p.111). However, it is important to observe the following list of general guidelines to observe when stretching:

- Do not stretch muscles when cold; warm up first
- Stretch slowly and gently
- Avoid ballistic, bouncing or jerky movements
- Do not stretch to the point of pain (should only feel a stretch)
- Stretches should be held for 20 - 30 seconds per side
- Repeat each stretch 3 to 4 times
- Breathe slowly and continuously (do not hold breath)

(Llobet & Odam, 2007, p.94; Paull & Harrison, 1997, p.111)

Stretch all of the muscles which are working constantly during flute playing, such as the neck/throat, chest, upper back, arms, forearms, shoulders. Appropriate stretches for flutists are included in Appendix D.

6.3.6 Strength, Conditioning and General Fitness

Inadequate conditioning is cited as a risk factor for developing playing-related musculoskeletal disorders. Strength training or conditioning is an important tool musicians can use to counter the relatively static nature of instrumental playing, and its associated muscle imbalances. Watson (2009), p. 40 explains:

> Maintaining a fixed posture for prolonged periods can lead to the development of some postural muscle groups at the expense of those that move the joints in the opposite direction. This leads to an undesirable reinforcement of the postural asymmetry, which can only be corrected by strengthening the weaker muscle groups.

There are conflicting opinions in the performing arts medicine literature as to whether strength training is beneficial to musicians, despite the evidence that playing in asymmetrical or static postures create muscular imbalances which may lead to musculoskeletal disorders.

Horvath (2009, p.118) cautions against "launching into a heavy strengthening program of weight-lifting" and recommends avoiding "exercises that require gripping hand-held weights or pulleys". Lieberman (1991, p.134) recommends high repetitions of light weights. Llobet (2007, pp.97-98) suggests that musicians correct playing-related postural imbalances through physical regular activity that does not work the body in a similar way to the muscles used when playing. Llobet "wouldn't recommend swimming to a flautist with back or shoulder problems, especially crawl or breaststroke, as these styles place a great demand on precisely these areas." (pp.97-98) Llobet further recommends activities which involve "gentle use of the large muscle groups", such as walking, running, rowing, cycling and dancing.

In a study of 19 undergraduate music majors at the Canberra School of Music, Australian National University, including 2 flutists (Ackermann, et al., 2002) found that "endurance training had a more direct positive effect on the students' perceptions of the amount of exertion required to practice their instruments" than those trained for strength. Ackermann stated that "Upper-body conditioning that most closely relates to their functional task performance is the most effective in achieving strength gains for undergraduate music majors at a university" (p.40).

Until further research is undertaken on what training types would be most beneficial for flutists, some safe guidelines, based on the literature are to choose activities which emphasize endurance training over strength (high repetition exercises), and to avoid exercises which train the forearm and hands (Ackermann, 2002, p.36). Exercises which emphasize the same muscles which are overworked in flute playing should be avoided (Llobet, p.98), for example, those involve pushing up from the shoulder (shoulder press). Llobet advises exercising between twenty to sixty minutes, three times per week (p.98) to stay in good condition for playing. Based on Llobet's guidelines, examples of general aerobic activities suitable for flutists would be walking, running, rowing, skating, trekking, stair walking and dancing (p.98). Warm-ups and cool downs should be included in the program (Llobet, p.98), and ideally advice should be sought from a physiotherapist, or exercise physiologist about appropriate individual exercise programs.

6.4 Performing Arts Medicine - Preventative Strategies

Many principles of performing arts medicine have already been discussed, such as instrument ergonomics, posture, rest, addressing playing asymmetries, and physical conditioning. This section will focus on other important recommendations highlighted

in the literature review on preventing and managing playing-related musculoskeletal disorders.

6.4.1 Environmental and Lifestyle Issues

Environmental issues such as uncomfortable room temperatures, poor lighting, excessive noise levels, as well as use of tobacco and alcohol are all risk factors for injury. Flutists of any musical background (classical, rock, pop, jazz and others), particularly freelance musicians, may be required to read music in dimly lit rooms, including at private and commercial functions. Where possible, performers should check ahead of time with the organizer to ascertain whether adequate lighting is available, and if not, arrange for extra room lighting, or sconces for music stands. Additionally, smoke should be avoided, and if excessive noise is unavoidable, the use of effective earplugs is recommended. (Brandfonbrener, 1991a; Foxman, 2006; Lederman, 2003; Llobet, 2007)

Poor diet and nutrition, use of tobacco, drug and substance abuse, as well as dehydration are known to increase the possibility of playing-related musculoskeletal conditions. (Brandfonbrener, 1991a; Foxman, 2006; Lederman, 2003; Llobet, 2007) The current survey indicated a very low rate of smoking among respondents, although the question of drug abuse was not addressed. Flutists can decrease their risk of musculoskeletal injury in part by ensuring adequate nutrition and avoiding tobacco and other harmful drugs (Dawson, 2006; Dawson, 2008; Foxman, 2006; Llobet, 2007; LoBuono, 2002; Norris, 1993; Potter, 1995).

6.4.2 Stress and Anxiety

With the large numbers of flutists internationally, there is a strong sense of community and camaraderie, evidenced by large scale flute events such as the National Flute Association Convention (USA), British Flute Society Convention, Brazilian

International Flute Festival, German Flute Festival, and the Australian Flute Festival, among many others. However, the large numbers of players also translates to highly competitive audition processes, whether for professional or amateur symphony orchestras, which typically have only 4 flutists (principal, co-principal or associate principal, second flute, piccolo). Moratz (p.296) states the audition process for professional orchestras can be "an extremely intense affair". Typically, flutists play set excerpts and concerto movements in the first round of a screened audition, which is followed by more elimination rounds, which may or may not be anonymous, depending on the orchestra. Playing principal flute carries with it a particular responsibility, in that the position is considered the leader of the woodwind section, who must play difficult and prominent solos in many programs, whether on stage, or in the pit. Such stresses are not limited to orchestral playing, or professional musicians, as the large number of flutists translates to high levels of competition for places in many amateur ensembles as well.

Stress and anxiety may manifest in physical tension. The survey undertaken as part of this thesis showed that flutists are involved in and recommend body awareness programs such as Alexander Technique and Feldenkrais. These programs are also recommended by performing arts medicine authors (Dawson, 2008; Foxman, 2006; Llobet, 2007, and others) because they help musicians to become aware of tension, and release it when playing. In addition to increased body awareness, musicians can learn management techniques for controlling stress and anxiety from clinical psychologists, sports psychologists and counsellors.

More recently, performing arts counselling has emerged as a specialist discipline, most prominent in the international flute community is American flutist Helen Spielman. Spielman works individually and in groups with flutists of all levels, using techniques

such as visualization, progressive muscle relaxation and positive self-talk to manage anxiety. Spielman (2009, pp. 5-6) states:

> Performance anxiety is so common that it is a normal, natural part of the musician's world. Yet we keep it 'in the closet', a topic only shared on the surface. We tell our friends, 'Oh, I'm so nervous about my solo', when the deeper truth is 'I'm afraid that no one will respect me if I mess up', or 'I'm afraid my students will think I'm a fraud, or 'I'm too fat...too old...too untalented', and the list goes on. What we can do for our young people, and for ourselves, is to be authentic and talk with each other of our performance fears. We can open up this topic so that eventually it will become as much a part of musical training as how to breathe and articulate and phrase...Entering the music business in these times is enormously competitive and difficult; many factors ought to be considered when committing to this choice, but fear of performance does not have to be, and should not be, the deciding factor. Students who experience it should get help and relief, and then decide if music is right for them.

6.4.3 Other Methods of Counterbalancing the Playing Position

Various strategies for counterbalancing the flute playing position have been discussed, including stretching, exercise, and rest. Respondents in the current and previous surveys have reported that they find massage useful in the prevention and management of playing-related discomfort and pain. Llobet (p.102) recommends massage as a method of relieving muscle spasms and tension. Dawson (2008, p.98) also states that massage can be effective for "a variety of muscle problems", as well as provide a greater sense of relaxation and well-being. There are contra-indications to massage (Llobet, p.102), so flutists should ensure they consult with a fully qualified massage therapist who will discuss the nature of the injury, as well as take a medical history, to ensure the treatment is appropriate.

Trigger point therapy may also be considered as a method of counterbalancing the flute playing position. Any skeletal muscle "can develop myofascial trigger points (TPs) that refer pain and other distressing symptoms, usually to a remote location". (Travell & Simons, 1983, p.5) For example, a remote location may be the hand and finger flexors

which are innervated through the spinal nerves (p.535) While a full discussion on this topic is beyond the scope of this research, it's important for flutists to be aware that the pain they experience in the fingers, may be referred from other locations such as the neck. When points within tight muscles in such locations are initially compressed, pain and referred pain may be experienced (Travell, p.3) but with continued digital pressure on the TP (p.13), the pain and tenderness frequently disappears (p.18).

Fain (2009, p.275) provides another potential scenario for flutists:

> 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 the hand, and perhaps neck pain is a signal to the flutist that something is wrong.

The scalenes are muscles at the front of the neck which attach to the cervical vertebrae and the first and second rib. These muscles stabilize the cervical spine (neck) and assist inspiration (Travell, p.344). The scalenes also stabilize the ribs, and tilt the head (Fain, p.274), therefore are crucial in flute playing. Trigger points in the scalenes can refer to the chest, arms, and hands (Travel, p.344)

These are some examples of pain that flutists may be affected by. Flutists suffering from playing-related discomfort or pain should seek the advice of qualified practitioners using trigger point therapy, such as physiotherapists and massage therapists who can advise whether the treatment will be effective for particular individuals.

6.4.4 General Health and Medical Conditions

It is beyond the scope of this research to comment on the full range of medical conditions which may predispose a flutist to a greater risk of injury. If in doubt, a physician should be consulted to discuss any specific conditions, such as hypermobility (or joint laxity) which is known to predispose musicians to injury. Early identification and referral to a physiotherapist or physician in such a case is essential. Similarly,

flutists with vision issues such as near-sightedness should ensure these problems are corrected, as straining to see the music may lead to tension in other parts of the body. If there are any pre-existing medical conditions, flutists should seek the advice of medical professionals to discuss the pertinent issues. Teachers are advised to refer flute students onto qualified medical professionals to discuss medical conditions and not attempt to give advice that is beyond their qualifications.

6.5 Performing Arts Medicine - Treatment

In order to become a convincing performer, flutists need to play with reliable, fluent technique, accuracy of rhythm and intonation, controlled phrasing, and a beautiful tone. Stylistically informed performances also require a knowledge of musical traditions, history and harmony. Flutists also need to develop skills such as performance confidence, sight-reading, ensemble playing awareness, stagecraft, memorization and effective communication. All of these skills take a great deal of time, focus, education and on-stage experience to develop to full maturity. Dawson (2008, p.25) states that "In an ideal world, music teachers would be familiar with the basic anatomy and physiology of music making, but this is often not the case." There is limited time for performers to concentrate on learning anatomy and physiology, but adhering to some of the principles presented in this chapter may assist flutists to understand risk factors for injury. However, if flutists develop playing-related pain which becomes unmanageable, and musical, postural, technical and instrument issues have been addressed, it is crucial that the performer seeks out someone who is qualified to diagnose and treat the problem. Music teachers should ideally collaborate with medical and allied health professionals when assisting students in dealing with pain or injuries. (Chapman, 2006, pp.258–259 stresses the importance of such a collaboration in her approach to vocal performance, which could serve as a model for instrumentalists:

> One of the major factors shaping the future of singing and the teaching of singing is the emergence of multidisciplinary education in voice. Medicine, science, therapies, and performance in both spoken and sung voice have input into the general pool of knowledge. Although each discipline has developed new knowledge in its specific field, it is the interaction between the disciplines that has changed the way we think about, understand, use, evaluate, and work with voice. In the 21st century, singing teachers no longer have to work in isolation. Other professions with an interest in voice are able to provide information and support to the teacher as well as working with the student directly should the teacher wish to refer them.

Often these problems are not related to a single cause, but may be related to any of the stated risk factors, such as flawed technique or a poor playing position, stress, anxiety, instrument ergonomics, physical characteristics, lack of sufficient rest. Medical and allied health professionals, such as primary care and specialist physicians, physiotherapists, chiropractors and osteopaths are qualified to diagnose musculoskeletal conditions and should be consulted if pain is persistent. (Hoppmann & Patrone, 1991, p.107) concluded:

> "...it should be emphasized that the majority of injuries, if identified early, can be treated with minimal intervention and excellent results. Those musicians in whom the diagnosis is delayed may take longer to recover, but the prognosis is still quite good. Those with chronic problems such as osteoarthritis, even though they may continue to have minor problems, can anticipate some degree of improvement in their symptoms and continued performing. It is hoped that musicians will be healthier and their careers will be longer as a result of the partnership being formed among musicians, music educators, and health care providers. The ultimate goal of prevention of injuries now seems more likely as a result of this partnership as well.

6.6 Conclusion

Musicians are sometimes compared with athletes (Edmund-Davies, 2008; Llobet & Odam, 2007; Manchester, 2008, 2011; Paull & Harrison, 1997; Wye 1987) yet athletes tend to prepare more strategically for the possibility of injury through approaches such as periodization. Survey responses indicate that a large number of flutists have experienced playing-related discomfort, pain or injuries, yet have little knowledge or training in injury prevention and management. This chapter has highlighted common

risk factors for playing-related musculoskeletal disorders and has examined flute-specific strategies for reducing those risks. Through adapting principles drawn from ergonomics, performing arts medicine and exercise science, flutists can better prepare for the possibility of injury. Setting up a beginner in a healthy and comfortable playing position will not only assist in avoiding later injuries, but make the process of learning more expedient, than if a child is struggling with an instrument that is too big for their physical size. Adult flutists, particularly those already experiencing pain symptoms, may consider ergonomic alternatives and adaptions, such as offset keys, key extensions, and flute modification devices which may assist in achieving a more comfortable playing position. While the flute playing position is not optimal, there are many approaches that flutists can take to improve their playing conditions, and avoid later musculoskeletal problems.

7. SUMMARY AND IMPLICATIONS

Through a better understanding of the physical characteristics of playing, flutists can prevent and manage playing-related musculoskeletal disorders. This chapter will summarize the findings of the research, including the results of a large scale international survey on injury prevention and management for flutists, a descriptive EMG study investigating upper body muscular responses in playing, and the potential benefits in applying principles from disciplines such as ergonomics, performing arts medicine, physiotherapy and exercise science to flute playing.

7.1 Survey Findings

The survey described in Chapter 4 supports the findings from previous flute surveys which indicate that playing-related musculoskeletal disorders are common in the flute community. Despite the topic of injury prevention and management receiving little attention in the flute literature, respondents voiced their concerns about playing-related discomfort and pain. Flutists indicated overwhelming support and need for further research and training on injury prevention and management.

At the time of the survey 26.7% of respondents were suffering from flute playing-related discomfort or pain. Half of the respondents (49.7%) had experienced flute playing-related discomfort or pain that was severe enough to distract while performing, and a quarter of the total group (25.8%) had taken an extended period of time off playing because of discomfort or pain. Over half of the respondents (56.5%) had consulted with allied health and medical professionals such as physiotherapists, massage therapists, chiropractors and doctors about their playing-related conditions.

The survey is consistent with earlier studies showing that the most common types of pain flutists suffer from is in the fingers, hands, arms, neck, middle and upper back, and shoulders. While gender was not a factor in the group currently suffering from

discomfort or pain, significantly, women were more likely to suffer from playing-related aching and stiffness than men in the arms, neck, shoulder and middle/upper back. Females were also significantly more likely to suffer from burning pain in the arms, numbness, tingling and radiating pain into the fingers, as well as sharp pain into the wrist and neck.

Flutists reported that they were able to prevent and manage playing-related discomfort and pain through massage, stretching, general exercise and fitness, Alexander Technique and through using a heat pack. Factors which worsened the condition were fatigue, not taking sufficient breaks, stress or worry, poor posture in non playing activities such as computing, not stretching, playing in cold environments, lack of exercise, poor playing postures and performance anxiety.

Flutists were concerned about the lack of emphasis on posture and positioning in teaching, particularly by band teachers. There was a strong interest in further information and training in injury prevention and management strategies. Flute teachers showed particular concern about school and community band seating, reporting that many conductors and band directors seem to ignore poor postural tendencies in the flute section. Teachers were also divided on what defines good posture and playing position, and this is reflected in the flute literature.

This large-scale study has provided insight into strategies teachers use to prevent, manage and treat playing-related discomfort, tension and pain. This is an area which has received limited focus in the literature, yet the survey showed that flute teachers are actively involved in recommending strategies such as taking regular practice breaks, altering playing position, getting the flute serviced, stretching, and using ergonomic modifications, such as thumb rests. Many flutists find that awareness programs such as Alexander Technique, Body Mapping, and Feldenkrais, as well as massage, stretching

and general exercise and fitness are valuable in preventing or managing playing-related musculoskeletal problems.

7.2 EMG Findings

The outcomes of EMG analysis demonstrated that there are individual differences in flutists and that some muscles work harder on one side of the body compared to the other. While such differences may be significant for some players and not others, these findings need to be tested using a bigger sample, which may also look at muscular response rates over longer durations than were included in this study.

The EMG study highlighted the additional upper body muscular activity that is required by a small player where the left hand cannot reach the keys of the flute comfortably. Ergonomic modifications such as key extensions were suggested as a way of reducing the left hand stretch for a physically smaller player. The study may, therefore, have implications for teaching children, or other physically small players, who may find this stretch to the keys more difficult than adults, or larger players generally. Performing arts medicine authors recommend that suitably sized musical instruments are matched to the physical size of the player. Another way the smaller player in this study could have decreased the load on her body would have been to choose a lighter flute, such as a sterling silver, rather than a platinum clad model.

Where playing-related discomfort or pain is an issue, there are certainly ways in which flutists can optimize their set-up, so that loading on the body is reduced.

7.3 Application of Knowledge from Other Disciplines

The research has drawn upon well-researched disciplines and professions such as ergonomics, exercise science, and physiotherapy to suggest ways in which flutists can counter-balance the asymmetrical playing position. A number of alternative instruments and ergonomic devices have been presented, to assist flutists in achieving a more

comfortable and efficient playing position. Practice methods have also been discussed, stressing the importance of breaking up flute playing, with other activities such as rest, exercise, and non-playing forms of preparation such as listening to recordings.

7.4 Recommendations for Future Studies

7.4.1 Gender Comparison Studies

Consistent with earlier studies, the current survey showed that female flutists suffer to a greater extent from playing-related musculoskeletal discomfort or pain than men, especially with particular types of pains and body sites. Further research is needed to establish possible links between gender, instrument types, and ergonomic set up. Further investigation is recommended in order to ascertain whether certain types of physical training, educational approaches and practice methods may be more suited to females than current methods, to better prepare them for the physical requirements of flute playing.

7.4.2 Children and Youth

It was not possible to draw a correlation between early flute education and later musculoskeletal disorders. As playing-related conditions develop over time, a longitudinal study researching the relationship between of early education, playing position, and ergonomic set-up and prevalence of injury would be recommended. The literature shows that playing-related discomfort and pain has been found in children, therefore attention needs to be given to creating ergonomically sound playing environments for them, to avoid the risk of later injuries occurring.

7.4.3 EMG Studies

Scientific studies on flutists have been minimal and the relationships between flute playing-related discomfort, tension or pain and physical size, gender, instrument types, posture, and playing styles need to be better understood. Future studies on flute populations utilizing EMG could compare the muscular responses of female and male flutists to varying playing loads, or to analyse the muscular responses of small-framed vs. large-framed players to varying playing loads. A further recommendation would be to evaluate muscular endurance capability, as well as the ability to maintain good positioning over longer playing periods, than was tested in the current EMG study.

7.4.4 Training for Performers, Flute Teachers and Band Directors

The implementation of risk management strategies in work places is a legal requirement in many countries, including Australia. Flute teachers and performers should familiarize themselves with current research in ergonomics, performing arts medicine, so that flutists have the best chance possible at maintaining long and healthy playing lives. A one-size-fits-all approach may not necessarily be in the best interests of every student, therefore teachers need to tailor programs according to the physical characteristics of individual students in order to prevent future physical problems. Players need to be willing to consider different types of flutes, and ergonomic devices that may optimize injury prevention and management. Additionally, educational programs in injury prevention and management need to be part of the core training of all flutists.

7.5 Conclusion

Flutists want to be able to fully enjoy making music, which is an important means of self-expression for many. It can be distressing to have to take time off playing because of discomfort, tension or pain. Throughout the process of learning musical repertoire, a greater understanding of the physical characteristics of playing can assist in the prevention and management of musculoskeletal playing-related disorders. Athletes prepare for the possibility of injury yet traditional flute training has not offered scientifically-based advice on how to address the potential for injuries.

A review of the history of flute construction shows that the western flute has undergone dramatic changes since the Middle Ages. The flute continues to evolve, and some of the recent changes have come about as a result of contemporary flute makers addressing injury concerns in the flute community. Through ergonomic instruments and modifications, flutists now have a greater range of options to choose from which make flute playing more comfortable. The flute continues to be a popular instrument around the world and therefore, the flute community needs to commit to putting into place whatever strategies are necessary to prevent future playing-related injuries. This will come about through better training of flute teachers and band directors, who must ensure that flute playing is tailored to the physical characteristics of individual flutists and not just their musical needs.

The flute literature in general does not currently reflect knowledge in performing arts medicine, and other professions and disciplines such as ergonomics, exercise science and physiotherapy. To ensure flutists have access to accurate information on how to prevent and manage injuries, future pedagogical books needs to be based on sound anatomical principles and current knowledge in performing arts medicine. This research has provided the foundation for a continued growth of knowledge that will contribute to the comfort, health, enjoyment and performance longevity of flutists.

GLOSSARY

Closed Hole Flute - A type of flute which has fully covered or closed keys (that is, no holes in the keys). Beginners, students, or instrument doublers often, but not always, play this type of flute.

Classic Alignment - The traditional alignment of the flute, when assembled with the foot joint rod lining up with the centre of the keys on the body of the flute, and the centre of the lip plate or embouchure hole.

Curved Head Joint - A U-shaped flute head joint that is commonly used on both beginner flutes, and low flutes such as the alto and bass to shorten the distance from the head joint to the keys. This enables the arms to be held closer to the body. Some flute models can be purchased with both straight and curved head joints.

Electromyography (EMG) - A scientific method of recording the electrical changes occurring in muscles during contraction (Karpovich & Sinning, 1971). It has been used extensively in the analysis of movement for a variety of purposes including sports and music performance, as well as in medicine.

Ergonomics - A scientific discipline which "aims to design appliances, technical systems and tasks in such a way as to improve human safety, health, comfort and performance." (Dul & Weerdmeester, 2008, p.1)

Foot Joint - The smallest section of the flute held furthest from the midline of the body. It is made in either a C or B version, enabling the flute to be played down to middle C, or the B a semitone below it.

Four-point Hold - A method of holding the flute utilising four balance points: chin, knuckle of left index finger, right thumb, right small finger.

Flute - Unless otherwise mentioned, refers to the modern concert flute based on the mid-nineteenth century design by German maker, Theobald Boehm. This flute is used

in a range of musical contexts, including western art music, musical theatre, jazz, folk, rock, pop, beatboxing, among other styles. The flute is made in three sections: head joint, body, and foot joint.

Flutist - Standard terminology for a flute player in the United States of America and France. The term is used interchangeably with "flute player" and "flautist".

Head Joint - The end of the flute which is blown and includes the lip plate and aperture hole (embouchure hole).

Inline G - A type of flute mechanism where the G key is inline with the rest of the mechanism.

Low Flutes - Any of the Boehm system flutes which are lower in pitch than the standard concert flute, including, but not limited to the alto flute, contr'alto, bass flute, octabass flute, contrabass and subcontrabass flute.

Offset G - A type of flute mechanism where the G key is slightly offset from the rest of the keywork, to allow for a slightly shorter stretch of the left arm and hand to reach to the G key.

Modified Rockstro Position - Any flute alignment which lies between a standard or traditional alignment and the Rockstro Position. (Fain, 2009)

Multi-Instrumental Teacher – A music teacher who teaches several instruments, often within a school band program. Some multi-instrumental teachers may be required to teach all or most band or orchestral instruments, depending on their job posting. Lessons by multi-instrumental teachers are often conducted in groups, or band situations.

Musculoskeletal - Refers to the muscular and skeletal system, including muscles, bones, joints, bursa, ligaments and tendons. The musculoskeletal system enables human movement to occur.

National Flute Association (NFA) – The national flute society of the United States of America. This organisation runs an annual large-scale international flute convention in many different cities throughout the USA. The convention features leading flutists from around the world as performers, workshop presenters and lecturers.

Open Hole Flute - This type of flute has holes in five of the keys and is typically played by intermediate level flutists up to professional players, however, some beginner and student models are also made with this feature. The holes may be closed with small plastic plugs if needed, especially when transitioning from a closed hole model. Open hole flutes are sometimes referred to as "French model" or "French system".

Playing-Related Musculoskeletal Disorder (PRMD) - A term used to encompass a range of musculoskeletal problems related to playing musical instruments. (Ranelli, 2008, p.178) This includes "pain, weakness, numbness, tingling, or other symptoms that interfere with your ability to play your instrument at the level you are accustomed to". (Zaza & Farewell, 1997, p.293) PRMDs include repetitive strain injury or disorder, overuse syndrome, and cumulative trauma disorder.

Rockstro Position - Where the outer edge of the embouchure hole in the head joint is turned inwards, to be in line with the centre of the keys (Fain 2009; Rockstro, 1967).

SPSS (or PASW) - A computer application used in the statistical analysis of data.

Thumb Rest - Generally made of plastic, cork, PVC, or other clip on or stick on materials, which provide the thumb with greater comfort and support. There are several commercially made clip on versions.

Thumbport - A type of thumb rest made by Taiwanese American Ho Fan Lee that assists in placing the right thumb back further on the flute tube, purportedly to enable greater stability of flute hold and freedom of movement for the fingers.

Three-point Hold - A method of holding the flute utilising three balance points: chin, knuckle of left index finger and right thumb.

Vertical Flute - An ergonomically designed flute that is played symmetrically, held in front of the trunk of the body, rather than asymmetrically.

APPENDIX A: ETHICS

INJURY PREVENTION AND MANAGEMENT FOR FLUTE PLAYERS INFORMATION SHEET

Research Team
Karen Lonsdale, DMA Student
Dr. Vanessa Tomlinson, Principal Supervisor
Dr. Stephen Emmerson, Associate Supervisor
Dr. Liisa Laakso, Associate Supervisor

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6 Russell St, South Bank, Queensland, Australia 4101
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Why is the research being conducted?

There have been very few studies internationally on Injury Prevention and Management for flute players. The research is being undertaken to establish the injury concerns of flute players and teachers of ALL backgrounds, as well as their knowledge and awareness of playing related Injury Prevention and Management. The research will examine what gaps in knowledge might exist in order to prepare materials, such as a Guidebook and DVD, which may assist flute players and teachers in preventing and managing injuries. The research is also expected to inform the music community in general and the broader fields of Music Education, Performing Arts Medicine and Health and Fitness.

What you will be asked to do
If you consent to being part of this study, you will be asked to participate in an Electromyography study at the School of Physiotherapy and Exercise Science at the Gold Campus, Griffith University. The study may be recorded. These recordings may be used for conference presentations (with your permission), and future research.

The basis by which participants have been selected
You have been selected because you are a flute player working at an intense level (i.e. a Conservatorium student involved in the learning of difficult and sophisticated flute repertoire) and mentioned that you are concerned about neck/shoulder issues. This study may help us to understand more about the nature of the flute playing position, by comparing EMG results.

The expected benefits of the research
The key benefit of this project lies in its contribution to the flute community's increased understanding of injury prevention and management.

Risks to you & your confidentiality
Your identity will only be used in the resulting publications and documentation with your written consent (the consent form follows this information sheet). Should you wish your identity to remain anonymous the research team will omit your name from any resulting documentation.

About EMG
The EMG data obtained from selected flute repertoire will be compared directly against the maximum voluntary contractions (MVCs) of the flute player analysed, in order to gain information about the percentage activity in each muscle group during playing of the works described above. Percentage outputs of EMG will give some indication of the amount of work required by the major muscle groups for playing instrumental pieces of varying complexity. This data will provide a baseline against which to assess any later research which might compare different body positions, or flautist experience.

The EMG studies will gather primary data, showing the muscular responses to varying loads, such as technically easy versus technically complex passages, as well as those requiring sustained or forceful airflows, and repertoire for difficult breathing. The EMG study has been filmed to assist in the analysis of data so that musical considerations may be directly compared with physical responses. The EMG study will provide basic information on flute positioning, and comparing muscular responses to three contrasting pieces of repertoire.

The outcomes of the EMG analysis will be used to provide quantitative information to clarify possible causes of injuries and symptoms reported in the 2007 survey (Lonsdale), as well as previous studies. From this, a recommendation may be made for further EMG studies. The results are expected to be useful in preparing basic guidelines on which flute playing position, postures or practices may be most helpful in reducing the risk of injuries.

Victor Popov, Specialist Physiotherapist from Queensland Sports Medical has worked with elite sports people and professional musicians. Popov suggested the following hypothesis for the electromyography studies, based on his clinical experience:

> There will be some abnormality or excessive activation of Pectoralis, Scalene, Upper Trapezius and a decreased activation of Rhomboids, and Mid/Lower Trapezius. In other words, there will be: Over activation of the elevators and protractors of the scapula and a lack of activation of the retractors and depressors. (Popov, 2007, personal communication)

Associate supervisor of the project, Dr. Liisa Laakso provided the following description of electromyography (Laakso, personal communication, 30 Jan, 2008):

> Non-invasive, surface electromyography (EMG) will be used to collect information on muscle activity during flute playing. This technique is an accepted method for determining the activation sequence and amount of muscle activity used in a range of different research including functional assessment, biomechanical assessment and rehabilitation.

To reduce skin resistance, the EMG technique requires cleaning of the participant's skin overlying the muscle to be assessed & specifically underlying the position on which the disposable surface EMG electrodes are placed. Two electrodes are positioned in the middle of the muscle belly where accessible superficially. A third (ground) electrode is placed at a site distant to the muscle of interest. Cleaning is by initial swabbing with an alcohol wipe & light surface abrasion with a proprietary agent to reduce skin impedance & aid in detection of the EMG signal. Electrodes are self-adhesive & placed directly on the pre-determined locations. There should be no pain associated with this technique.

Your participation is voluntary
Your participation in this study is voluntary. You are free to withdraw from the study at any time.

Questions / further information
For additional information about the project, please contact Karen Lonsdale. Phone: (07) 3342 5534 or email: lonsdale.ka@optusnet.com.au

The ethical conduct of this research
Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Research Involving Humans. If you have any concerns or complaints about the ethical conduct of the research project they should contact the Manager, Research Ethics on (07) 3735 5585 or research-ethics@griffith.edu.au

Feedback to you
Access to a copy of the publications arising as a result of this research will be provided if requested.

Privacy statement
The conduct of this research involves the collection, access and / or use of your identified personal information. As outlined elsewhere in this information sheet, your identified personal information may be reported in resulting publications. Other than this disclosure, the information collected is confidential and will not be disclosed to third parties without your consent, except to meet government, legal or other regulatory authority requirements. A de-identified copy of this data may be used for other research purposes. However, your anonymity will at all times be safeguarded. For further information consult the University's Privacy Plan at www.griffith.edu.au/ua/aa/vc/pp or telephone (07) 3735 5585.

INJURY PREVENTION AND MANAGEMENT FOR FLUTE PLAYERS
CONSENT FORM

Research Team
Karen Lonsdale, DMA Student
Dr. Vanessa Tomlinson, Principal Supervisor
Dr. Stephen Emmerson, Associate Supervisor
Dr. Liisa Laakso, Associate Supervisor

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Phone: +61 7 3735 6111
Facsimile: +61 7 3735 6282
Email: lonsdale.ka@optusnet.com.au

By signing below, I confirm that I have read and understood the information package and in particular have noted that:

- ❑ I understand that my involvement in this research will include participation in an electromyography study;
- ❑ I understand that the study may be sound and video recorded;
- ❑ I have had any questions answered to my satisfaction;
- ❑ I understand the risks involved;
- ❑ I understand that there will be no direct benefit to me from my participation in this research;
- ❑ I understand that my participation in this research is voluntary;
- ❑ I understand that if I have any additional questions I can contact the research team;
- ❑ I understand that I am free to withdraw at any time, without comment or penalty;
- ❑ I understand that I can contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on (07) 3735 5585 (or research-ethics@griffith.edu.au) if I have any concerns about the ethical conduct of the project; and
- ❑ I agree to participate in the EMG project.

Name: _____
Signature: _____
Date: _____

GRIFFITH UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE

13-Mar-2008

Dear Ms Lonsdale

I write further to the additional information provided in relation to the conditional approval granted to your application for ethical clearance for your project "Electromyographic Studies of the Muscular Imbalances in Flute Playing" (GU Ref No: QCM/01/08/HREC).

This is to confirm receipt of the remaining required information, assurances or amendments to this protocol.

Consequently, I reconfirm my earlier advice that you are authorised to immediately commence this research on this basis.

The standard conditions of approval attached to our previous correspondence about this protocol continue to apply.

Regards

Dr Gary Allen Manager, Research Ethics Office for Research Bray Centre, Nathan Campus Griffith University ph: 3735 5585 fax: 3735 7994 email: g.allen@griffith.edu.au web:

Cc:

PRIVILEGED, PRIVATE AND CONFIDENTIAL This email and any files transmitted with it are intended solely for the use of the addressee(s) and may contain information which is confidential or privileged. If you receive this email and you are not the addressee(s) [or responsible for delivery of the email to the addressee(s)], please disregard the contents of the email, delete the email and notify the author immediately

GRIFFITH UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE

28-Oct-2007

Dear Ms Lonsdale

I write further to the additional information provided in relation to the conditional approval granted to your application for ethical clearance for your project "Injury Prevention and Management for Flute Players" (GU Ref No: QCM/08/07/HREC).

This is to confirm receipt of the remaining required information, assurances or amendments to this protocol.

Consequently, I reconfirm my earlier advice that you are authorised to immediately commence this research on this basis.

The standard conditions of approval attached to our previous correspondence about this protocol continue to apply.

Regards

Dr Gary Allen
Manager, Research Ethics Office for Research
Bray Centre, Nathan Campus
Griffith University ph: 3735 5585
fax: 3735 7994
email: g.allen@griffith.edu.au
web:

Cc:

PRIVILEGED, PRIVATE AND CONFIDENTIAL This email and any files transmitted with it are intended solely for the use of the addressee(s) and may contain information which is confidential or privileged. If you receive this email and you are not the addressee(s) [or responsible for delivery of the email to the addressee(s)], please disregard the contents of the email, delete the email and notify the author immediately

APPENDIX B: SURVEY QUESTIONS

About the Research

Research Team:
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lonsdale.ka@optusnet.com.au

Principal Supervisor: Dr. Vanessa Tomlinson
V.Tomlinson@griffith.edu.au

Associate Supervisor: Dr. Stephen Emmerson
s.emmerson@griffith.edu.au

Queensland Conservatorium Griffith University
16 Russell St, South Bank, Queensland, Australia 4101
PO Box 3428 South Bank, Queensland, Australia 4101
Phone: +61 7 3735 6335; or 3735 6253

Thank you very much for your interest in this research which is being undertaken to establish the injury concerns of flute players and teachers of ALL backgrounds, as well as their knowledge and awareness of playing related Injury Prevention and Management. The research will examine what gaps in knowledge might exist in order to prepare materials, such as a Guidebook and DVD, which may assist flute players and teachers in preventing and managing injuries. The research is also expected to inform the music community in general and the broader fields of Music Education, Performing Arts Medicine and Health and Fitness.

There have been very few studies internationally on Injury Prevention and Management for flute players, so your honest answers will be appreciated. We are interested in hearing from ALL flute players, whether they have had injury concerns, or not.

If you consent to being part of this study, you are asked to complete this survey no later than 6th January, 2008. The survey should take approximately 15 minutes to complete. Your participation in this study is voluntary. You are advised that you do not need to answer every question unless you wish to do so, although the first two questions require an answer (Age/Gender). In order to minimise any risks associated with the identification of participants, all completed surveys will be de-identified. The identity of participants will remain anonymous during the research process, and in the reporting of findings. If you complete this survey, you will be deemed to have consented to your participation in the research. Please print out this sheet for future reference.

Participants wishing to give more feedback to the research team, or who want to receive a summary of the overall results of the research, as well as notification about any materials arising as a result of this research are invited to provide their contact details.

Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Research Involving Humans. If you have any concerns or complaints about the ethical conduct of the research project you should contact the Manager, Research Ethics on + 61 7 3735 5585 or research-ethics@griffith.edu.au

Questions/Further Information: please email Ms Karen Lonsdale at lonsdale.ka@optusnet.com.au

About You

The following questions are about you and your flute playing activities. All responses will remain anonymous.

1. What is your age?

11 or under	26 - 30	51 - 60
12 - 18	31 - 40	61 - 70
19 - 25	41 - 50	71 and over

2. What is your gender?

Male Female

3. Which country do you live in? (Listed)

4. How long have you been playing the flute?

Less than 1 year	1 - 5 years	6 - 10 years	11 - 20 years	More than 20 years

5. Flute is my:

Main instrument	Second instrument	Third instrument
Other (please specify)		

6. Which of the following describes YOU as a flute player/teacher? Tick/check all that apply.

Professional Performer	Music Student (undergraduate)	Private Studio Flute Teacher
Semi-professional Performer	Music Student (postgraduate)	Multi-Instrumental Teacher
Adult Amateur	University/College/Conservatory Flute Professor/Lecturer/Teacher	Other (please specify)
School Student	School (Elementary/Primary/Middle/High) Flute Teacher	

7. Which of the following best describes the FLUTE TEACHER WHO TAUGHT YOU in the first 12 months of lessons? Tick/check any that apply.

Specialist flute teacher	Multi-instrumental teacher whose main instrument was NOT flute	Other (please specify)
Multi-instrumental teacher whose main instrument was flute	Self-taught	

8. Which of the following describes the type of instruction you received in the first 12 months of learning flute? Tick/check any that apply.

Private lessons	Group lessons with flute players and players of other instruments	Self-taught
Group lessons with only flute players	Suzuki Method	Other (please specify)

9. How much emphasis did your flute teacher/s place on good posture or playing position? Leave blank any that do not apply.

By "Band Programme Teacher", we mean the person who taught you in the flute/group lessons, not the band conductor (unless the conductor was ALSO your teacher).

	None	Hardly any	Some	Much	Can't remember	Not applicable
Private Teacher 1						
Private Teacher 2						
Private Teacher 3						
Band Programme Teacher 1						
Band Programme Teacher 2						
Band Programme Teacher 3						
University Flute Professor 1						
University Flute Professor 2						
University Flute Professor 3						

Comments welcome:

10. What types of flute playing activities are you involved with, AS A PLAYER (i.e. NOT conductor/teacher etc)? Tick (check) all that apply.

Orchestral (Symphony/Chamber/Pops)	Rock/Pop Band	Session Musician (Recording)
Pit Musician (Opera, Ballet, Dance, Musicals)	Marching Band	Gig Musician (weddings, functions, restaurants etc)
Flute Choir or Ensemble	Folk/World Music Ensemble	Church Musician
Concert or Symphonic Band	Flute Recitals/Performances	Busking/Street Performer
Jazz Ensemble	Chamber Music	Other (please specify)
Big Band	Contemporary Music Ensemble	

11. Do you hold any of the following MUSIC qualifications, or their equivalents? Tick (check) all that apply.

You may also outline any other relevant music industry experience in the box provided if you wish.

Diploma of Music	Graduate Diploma of Music	Licentiate Diploma (e.g. LTCL, LMus, LRSM, LMusNZ)
Bachelor of Arts (Music major)	Master of Music	Fellowship Diploma (e.g. FTCL, FMus, FRSM)
Bachelor of Music Education	DMA	None of the above
Bachelor of Music	PhD	
Bachelor of Music Studies	Associate Diploma (e.g. ATCL, AMus, DipABRSM, AMusNZ)	

1. **Are you currently a member of a Flute Club, Guild or Society? Please tick/check any that apply.**

Albuquerque Flute Association	Flute Society of Kentucky	Ottawa Flute Association
Atlanta Flute Club	Flute Society of New South Wales	Polish Flute Society
Atlantic Flute Society	Flute Society of Saint Louis	Pittsburgh Flute Club
Auckland Flute Society	Flute Society of South Australia	Queensland Flute Guild
Brazilian Flute Association - ABRAF	Flute Society of Washington, DC	Raleigh Area Flute Association (North Carolina)
British Flute Society	Greater Boston Flute Association	Rose City Flute Society
Central Ohio Flute Association	Greater Los Angeles Flute Society	Rochester (NY) Flute Association
Chicago Flute Club	Greater Portland Flute Society	Seattle Flute Society
Christchurch Flute Society	Hamilton Flute Society	Slovenian Flute Association
Club de la Flauta Travessera dels Països Catalans	Houston Flute Club	Società Italiana del Flauto Traverso Storico (S.I.F.T.S.)
Colorado Flute Association	Japan Flutists Association	Southern Illinois Flute Society
Deutsche Gesellschaft für Flöte e.V. (German Flute Society)	Los Vegas Flute Club	Swedish Flute Society
Dutch Flute Society	Madison Flute Club	Texas Flute Society
Finnish Flute Association	Mid South Flute Society	Upper Midwest Flute Association
Florida Flute Club at Gainesville	New York Flute Club	Victorian Flute Guild
Florida Flute Society	National Flute Association (NFA)	Wellington Flute Club
Flute Society of Greater Philadelphia	New Zealand Flute Society	West Australian Flute Society
FLUFSA Flute Federation of South Africa	Oklahoma Flute Society	Other (Please specify)

13. Which of the following flute magazines do you subscribe to?

Flute Focus	Pan	Woodwind Quarterly
Flute Network	Flutewise	American Piper
Flutist Quarterly	Traverso	None of the above
Flute Talk	Traversieres	Other (please specify)

14. Are you currently a member of any online flute discussion groups?

FLUTE (Larry Krantz)	Flutemakers	None of the above
Flute Chat (James Galway)	NFA Forum	Other (please specify)
Flutenet	Piccoloist.com	

15. How often do you attend the following events?

	Never	**At least every 6 months**	**At least every year**	**At least every 2 years**	**Less often than every 2 years**
Flute Convention/Fair/Festival/Workshop/Masterclass					
Other Music workshops					

Other (please specify)

16. Describe the flutes you most regularly play on. If you don't play some of the following, then leave that line blank.

	Material	Head Joint	Offset/Inline	Foot Joint	Open/Closed Hole
Concert Flute					
Alto Flute					
Bass Flute					
Contrabass Flute					
Piccolo					
Baroque Flute					
Other (please specify)					

Lifestyle, General Health and Fitness

The following questions relate to your lifestyle, general health and fitness.

Remember that all answers will remain anonymous.

1. My body weight:

Quite Underweight	A Little Underweight	Normal	A Little Overweight	Quite Overweight

2. How would you rate your General Health and Fitness?

	Poor	Fair	Average	Good	Excellent
General Health					
Fitness					

3. All in all, rate how happy are you with your life these days:

	Very unhappy	Unhappy	A Little Unhappy	Neither Unhappy Nor Happy	A Little Happy	Happy	Very Happy
Level of happiness							

4. How many times per week, on average, do you participate in the following activities?

	1 - 2 Times Per Week	3 - 5 Times Per Week	6 or More Times Per Week	Less Often Than Once a Week	Not at All
Aerobic Activity (Walking, running, cycling, swimming etc)					
Strength/Resistance Training (using free weights, machine weights, body weight, resistive bands etc)					

Other (please specify)

5. Do you smoke or drink alcohol?

	Never	Rarely	Socially/ Occasionally	Regularly	Heavily	Recently given up
Do you smoke?						
Do you drink?						

6. Have you ever been medically diagnosed with any of the following conditions? Tick/check any that apply. Also, in the comment box provided, it would be helpful to know in which way these conditions affect your flute playing, if at all.

Anxiety	Fibromyalgia	Rheumatoid Arthritis
Bursitis	Focal Dystonia	Tendonitis
Carpal Tunnel Syndrome	Kyphosis (excessive/hunch back)	Thoracic Outlet Syndrome
Chronic Fatigue Syndrome	Lordosis (excessive/sway back)	Sciatica
Cubital Tunnel Syndrome	Lupus	Scoliosis
Degenerative Arthritis	Multiple Sclerosis	TMJ (temporomandibular joint) Syndrome
De Quervain's Syndrome	Myositis	None of the above
Depression	Osteoarthritis	
Double-jointed (hypermobile) fingers, wrists or elbows	Osteoporosis	
Any other conditions which may cause discomfort? Include any old injuries, such as broken bones. How do these conditions affect your flute playing, if at all?		

7. Typically, how many hours a day are you SITTING or STANDING, either flute playing, or other activities?

	Less than 1 Hour	**Up to 2 Hours**	**Up to 3 Hours**	**Up to 4 Hours**	**4 or More Hours**
Sitting?					
Standing?					

Describe any symptoms you experience from sitting or standing for extended periods:

8. How often...?

	Never	Rarely	Occasionally	Regularly	Very Often
...do your eyes feel strained or uncomfortable while playing?					
...do you practise or perform in conditions of low to moderate light levels?					
...do you suffer from frontal headache during playing?					
...do you suffer from frontal headache after playing?					
...do you suffer from migraines?					
...do you suffer from other headaches?					

9. Do you have a tendency towards any of the following playing positions, either normally, or after becoming fatigued? Please answer this question whether you ever feel discomfort/pain, or not.

Bending trunk forwards (excessively)	Neck falling to the side	Straight fingers
Chin jutting forward	Pressing flute too hard against chin	Thumb sliding up length of tube
Collapsed finger joints	Right thumb protruding	Twisted spine
Elbow resting on waist/hip	Shoulders raised	Standing with one hip pushed to side
Fingers hanging over edge of keys	Shoulders rolled forwards/inwards	None of the above
Gripping flute too tightly	Slumping in chair	Other (please specify)

10. Please answer the following questions with either 'Yes', 'No' or 'Not applicable':

	Yes	No	N/A
Have you ever experienced flute playing related discomfort or pain that was severe enough to distract you while performing?			
Have you ever had to take an extended period of time off flute playing because of flute playing related discomfort/pain?			
Does the level of discomfort/pain/tension you experience tend to dictate the length of your practice sessions?			
Have you ever made specific changes to your flute playing position on the recommendation of a MEDICAL or HEALTH PRACTITIONER for the purpose of avoiding injuries?			
Do you use your voice extensively as part of your work or regular activities (singing, speaking, shouting)?			
Are you currently suffering from flute playing related discomfort or pain?			
Do you feel that during your flute studies you received sufficient information or advice on Injury Prevention and Management?			
Do you have hypermobile (double-jointed) fingers, wrists or elbows?			

Management and Prevention of Playing-Related Discomfort/Pain/Injury

This section deals with how you manage and/or prevent flute playing related discomfort/pain/injury. Remember that all answers will remain anonymous.

1. How long in total do you typically PLAY FLUTE, whether in practice, rehearsal, teaching or performance in a day?

Up to 15 minutes	Up to 3 hours	More than 6 hours
Up to 30 minutes	Up to 4 hours	Not applicable
Up to 1 hour	Up to 5 hours	
Up to 2 hours	Up to 6 hours	

2. How many days per week do you typically play flute?

1 - 2	3 - 4	5 – 6	Every day	Sporadic	Not at all

3. Which of the following best describes how often you take practice breaks?

At least every 15 minutes At least every 30 minutes	At least every hour Whenever I need to	Rarely/Never take breaks Not applicable
Comments welcome		

4. Which of the following medications, if any, have you ever used to alleviate flute playing related pain, tension or injury? Tick/check any that apply. If you have never used any, please choose 'None of the above'.

Over the counter pain killers (Aspirin/Paracetamol/Ibuprofen etc) Non steroidal anti-inflammatory (such as Voltaren, Naproxen, COX-2 inhibitors) Muscle Relaxant Drug (such as Valium) Oral Steroid (such as Prednisone)	Steroid Injection (such as Cortisone) Anaesthetic Injection None of the above Other (please specify)

5. Which of the following practitioners have you ever consulted for the specific purpose of preventing or managing flute playing discomfort/pain?

Acupuncturist	Chiropractor	Natural Therapist (e.g. Homeopath/Herbalist/Naturopath)
Performing Arts Medical Doctor/Specialist	Dentist/Orthodontist	Speech Pathologist/Therapist
Medical Doctor/Specialist	Optometrist	Podiatrist
Physiotherapist/Physical Therapist	Osteopath	None of the above
Myofascial Therapist	Occupational Therapist	Other (please specify)
	Massage Therapist	
	Sports Psychologist/Psychologist/ Counsellor	

6. Which of the following have you personally found to be beneficial in preventing or managing playing related discomfort or pain? Tick/check all that apply.

Massage	Feldenkrais	Heat Pack
Trigger Point Therapy (with tennis ball/muscle mate or by therapist etc)	Dalcrose	Ice Pack
Physiotherapy/Physical Therapy	Body Mapping	Electrotherapy (such as Ultrasound, Interferential, T.E.N.S)
Myofascial Therapy	Tai Chi	Biofeedback
Chiropractic	Qigong	Lying on Noodle (foam cylinder)
Osteopathy	Pilates	Thumbport/Flute Crutch/Bo Pep
Acupuncture	Stretching	General Exercise/Fitness
Yoga	Strengthening (including bodyweight, therabands, weights etc)	None of the above
Alexander Technique	Meditation	Other (please specify)

7. To what extent do you agree with the following statements?

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
A knowledge of basic anatomy is useful in the prevention and management of flute playing injuries.					
All flute TEACHERS should receive training in injury prevention and management					
All flute PLAYERS should receive training in injury prevention and management.					

8. If further information or training were available on the topic of Injury Prevention and Management for Flute Players, which of the following would you be interested in? Tick/check any that apply.

Workshops/Lectures	Book	Articles in journals
Website	DVD	None of the above

Playing Related Discomfort/Pain

This section has questions about the types of Discomfort/Pain (Aching/Pain/Numbness/Stiffness/Swelling/Tingling and so on) that you have experienced. If you have NEVER experienced these kind of symptoms, please SKIP this section and proceed to the next page.

1. Have you EVER experienced flute playing related PAIN (Aching/Stiffness, Burning, Radiating or Sharp Pain) in the following areas of your body? Does/did this happen during or after playing? Is/was the pain constant or intermittent? (Use drop down menu for your response.) Leave blank any which don't apply.

	Aching/ Stiffness	Burning	Radiating	Sharp
Fingers/Hands Lower Back				
Arms				
Elbow				
Wrist				
Neck				
Shoulder				
Chest				
Middle/Upper Back				
Lower Back				
Jaw				

Are these symptoms worse on your left or right side?

2. Have you EVER experienced Swelling, Numbness or Tingling in your hands/elbows as a result of flute playing? Does/did this happen during or after playing? Is/was the pain constant or intermittent? (Use drop down menu for your response.) Leave blank any which don't apply.

	Swelling	Numbness	Tingling
Fingers/Hands			
Elbow			

Are these symptoms worse on your left or right side?

3. What factors do you know make YOUR condition worse?

Shoulders rolling forwards	Not stretching	Playing in hot/warm rooms/spaces
Neck falling to side	Not doing strengthening/resistance exercises	Poor posture in non-flute playing activities, including computing
Trunk twisting	Lack of exercise/fitness	Sight-reading
Lifting/reaching above head	Dietary changes (please specify)	Playing other instruments (please specify)
Not taking sufficient breaks	Performance Anxiety	No idea
Feeling unhappy/negative	Stress/Worry	Other (please specify)
Tiredness/Fatigue	Playing in cold rooms/spaces	
Your comments would be of great help to the research team:		

4. This question is for flute players who stay free of discomfort/pain AT LEAST SOME of the time. To what do you attribute your tendency to stay discomfort/pain free at least some of the time? Please answer this question only as it TRUE FOR YOU personally, not what you know or suspect has worked for others.

Ability to relax/deal with stress	Freedom of movement while playing	Left Hand Extension
Good/improved playing position in general	Strength or resistance exercises	Use of Ergonomic Flute (egg. Vertical/Swan Neck etc)
Accurate body/mind map	Stretching	Rockstro Grip/Modified Rockstro Grip
Knowledge of Anatomy/Physiology	Feeling happy/satisfied/positive/confident	Sheer luck/Good genes
Being fit/exercising	Healthy diet/nutrition	No idea
Good teaching	Good/Better posture in non flute playing activities	Not applicable
Rest	Thumbport/Flute Crutch/Bo Pep	Other (please specify)
Low level of performance anxiety		

Questions for Flute Teachers

The following questions are intended for FLUTE TEACHERS only. If you are not a flute teacher, please skip this section. All answers will remain anonymous.

1. How many flute and/or piccolo students do you regularly teach per week?

1 - 5	11 - 20	41 or more
6 - 10	21 - 40	None at the current time (on leave/teaching break)

2. What type of teaching activities do you do? Tick/check any that apply.

Individual (private) lessons	Conducting	Pedagogy Teacher
Group lessons (flutes only)	Masterclass/Workshop Presenter	Other (please specify)
Group lessons (flute and other instrument/s)	Lecturer/Professor	

3. How many years in total have you been teaching?

1 - 5 years	11 - 15 years
6 - 10 years	Over 15 years

4. Which of the following students do you teach at any time (including workshop or masterclass participants)? Please tick (check) all that apply.

Primary/Elementary/Middle School age	University music student - postgraduate	Adult amateurs
High School age	Semi-professionals/Professionals	Other (please specify)
University music student - undergraduate		

5. Have you ever undertaken any training (i.e. workshops/lectures), that you feel gave you a better understanding about Injury Prevention and Management for Flute Players? Please outline if you wish.

Yes No
The following workshops/programmes/events were of great value:

6. Which of the following have you ever recommended to your students, for the specific purpose of avoiding or managing injury? There is space for further comments if you wish to give further advice to the research team.

Change Flute Playing Position	Trigger Point Therapy	Podiatrist
Check Posture in Non-Flute Playing Activities	Heat Pack	Natural Therapies
Take Regular Practice Breaks	Ice Pack	Specialist Doctor
Alternate Instruments During Practice	Flute Crutch/Thumbport/Bo Pep	Speech Therapy/Pathology
Change seating position in band/orchestra	Use Vertical or Other Ergonomic flute	Counsellor/Psychologist
Curved Headjoint	Change to a Different Flute	Massage
Yamaha Fife	Change to a Different Instrument Altogether	Yoga
Jupiter Prodigy Flute (D foot)	Rockstro Grip/Modified Rockstro Grip	Tai Chi
Stretching	Offset G Key	Meditation
Strength/resistance training	Get Flute Service (repair leaks)	Pilates
	Left Hand Key Extension	Exercise/Get Fit
	Physiotherapist/Osteopath/ Chiropractor	Attend a Specific Flute Workshop/Event
		Other (please specify)
Further comments would be appreciated:		

7. In your own words, describe what you believe to be the essential aspects of good flute playing posture or position:

8. The following questions require a 'Yes', 'No', or 'Not applicable' answer:

	Yes	No	Not applicable
1. Have you ever attended a school or community band/ensemble rehearsal and observed flute players sitting too close together, which resulted in them sitting in poor playing postures? (i.e. spines twisted, necks falling to the side, arms on backs of chairs etc)?			
2. Have you ever asked a conductor to change the seating position to improve the playing posture of flute players?			
3. Have you ever asked the flute players concerned to change their seating position to improve playing posture?			
4. Have you ever recommended that a student should play on a different instrument (i.e. curved head joint) to prevent later injuries, but the student/parent/school was either unwilling or financially unable to make the change?			

Further comments welcome:

Further Comments and Contact Details

1. Please feel free to make any other comments in the textbox provided.

2. If you are willing to provide the research team with further advice, please provide your contact details. Your details will not be passed on to anyone and will only be used for the purpose of discussing this research with you.

If you do NOT wish to leave further comments or contact details, please SKIP to the next page.

1. We welcome any further comments:

2. Contact Information:

Name:
Email:
Address:
City/Town:
State/Province:
ZIP/Postal Code:
Country:

APPENDIX C: SURVEY RESULTS – ADDITIONAL TABLES

Table 36: Age

What is your age?		
Answer Options	**Response Percent**	**Response Count**
11 or under	0.0%	0
12 - 18	22.3%	91
19 - 25	17.6%	72
26 - 30	5.6%	23
31 - 40	14.5%	59
41 - 50	20.1%	82
51 - 60	14.7%	60
61 - 70	3.9%	16
71 and over	1.2%	5
answered question		408
skipped question		0

Table 37: Gender

What is your gender?		
Answer Options	**Response Percent**	**Response Count**
Male	18.1%	74
Female	81.9%	334
answered question		408
skipped question		0

Table 38: Country of Residence

Which country do you live in?		
Answer Options	**Response Percent**	**Response Count**
Argentina, Brazil	0.5%	2
Australia	36.0%	147
Canada	4.7%	19
China, including Hong Kong, Singapore, Taiwan	1.5%	6
Denmark, Finland, Germany, Greece, Netherlands, Poland, Portugal, Russia, Switzerland, Turkey	3.7%	15
New Zealand	4.4%	18
South Africa	0.5%	2
Egypt, United Arab Emirates	0.5%	2
United Kingdom, Bermuda	8.6%	35
United States of America	39.2%	160
answered question		406
skipped question		2

Table 39: Length of Time Playing

How long have you been playing the flute?		
Answer Options	**Response Percent**	**Response Count**
Less than 1 year	0.2%	1
1 - 5 years	10.8%	44
6 - 10 years	22.1%	90
11 - 20 years	22.1%	90
More than 20 years	44.9%	183
answered question		408
skipped question		0

Table 40: Main Instrument

Flute is my:		
Answer Options	**Response Percent**	**Response Count**
Main instrument	90.1%	364
Second instrument	5.9%	24
Third instrument	1.7%	7
Other (please specify)	2.2%	9
answered question		404
skipped question		4

Table 41: Type of Player

Which of the following describes YOU as a flute player/teacher? Tick/check all that apply.		
Answer Options	**Response Percent**	**Response Count**
Professional Performer	22.3%	91
Semi-professional Performer	22.5%	92
Adult Amateur	23.3%	95
School Student	17.6%	72
Music Student (undergraduate)	13.2%	54
Music Student (postgraduate)	7.6%	31
University/College/Conservatory Professor/Lecturer/Teacher	8.8%	36
School (Elementary/Primary/Middle/High) Flute Teacher	15.2%	62
Private Studio Flute Teacher	38.7%	158
Multi-Instrumental Teacher	13.5%	55
Other (please specify)	3.9%	16
answered question		408
skipped question		0

Table 42: Playing Activities

What types of flute playing activities are you involved with, AS A PLAYER (i.e. NOT conductor/teacher etc)? Tick (check) all that apply.		
Answer Options	**Response Percent**	**Response Count**
Orchestral (Symphony/Chamber/Pops)	58.8%	235
Pit Musician (Opera, Ballet, Dance, Musicals)	35.8%	143
Flute Choir or Ensemble	41.3%	165
Concert or Symphonic Band	41.5%	166
Jazz Ensemble	7.5%	30
Big Band	5.3%	21
Rock/Pop Band	3.0%	12
Marching Band	8.0%	32
Folk/World Music Ensemble	7.8%	31
Flute Recitals/Performances	53.8%	215
Chamber Music	46.5%	186
Contemporary Music Ensemble	10.8%	43
Session Musician (Recording)	11.5%	46
Gig Musician (weddings, functions, restaurants etc)	33.8%	135
Church Musician	29.5%	118
Busking/Street Performer	3.8%	15
Other (please specify)	7.0%	28
answered question		400
skipped question		8

Table 43: Highest Formal Music Qualification

Highest Qualification		
Answer Options	**Response Percent**	**Response Count**
Bachelor of Music (performance) or equivalent	12.9%	50
Graduate Diploma of Music	4.1%	16
Master of Music (performance) or equivalent	13.95%	54
Bachelor of Music (education) or Bachelor of Arts (Music Major or Minor)	10.34%	40
DMA, PhD	2.85%	11
Master of Music (Education)	0.26%	1
Diploma of Music (performance)	1.3%	5
Diploma of Music Teaching	0.26%	1
Associate, Licentiate, or Fellowship Diploma (AMEB, Trinity or equivalent)	4.4%	17
None of the above	49.6%	192
answered question		387
skipped question		21

Table 44: Membership of Flute Guilds, Clubs, or Societies

Are you a Member of a Flute Guild, Club or Society?		
Answer Options	**Response Percent**	**Response Count**
Yes, 1	41.82%	156
Yes, 2	12.87%	48
Yes, 3 or more	2.68%	10
No	42.63%	159
answered question		373
skipped question		35

Table 45: Flute Magazine Subscriptions

Which of the following flute magazines do you subscribe to?		
Answer Options	**Response Percent**	**Response Count**
Flute Focus	12.6%	45
Flute Network	8.1%	29
Flutist Quarterly	23.0%	82
Flute Talk	24.7%	88
Pan	8.4%	30
Flutewise	5.3%	19
Traverso	0.8%	3
Traversieres	0.8%	3
Woodwind Quarterly	0.3%	1
American Piper	0.0%	0
None of the above	49.2%	175
Other (please specify)	3.7%	13
answered question		356
skipped question		52

Table 46: Membership of Online Flute Discussion Groups

Are you currently a member of any online flute discussion groups?		
Answer Options	**Response Percent**	**Response Count**
FLUTE (Larry Krantz)	35.9%	124
Flute Chat (James Galway)	17.1%	59
Flutenet	12.2%	42
Flutemakers	0.9%	3
NFA Forum	3.8%	13
Piccoloist.com	4.1%	14
None of the above	51.0%	176
Other (please specify)	4.6%	16
answered question		345
skipped question		63

Table 47: Attendance at Flute Events and Other Music Workshops

How often do you attend the following events?						
Answer Options	**Never**	**At least every 6 months**	**At least every year**	**At least every 2 years**	**Less often than every 2 years**	**Response Count**
Flute Convention/Fair/Festival /Workshop/Masterclass	27.6% (108)	12.3% (48)	19.9% (78)	16.9% (66)	23.3% (91)	391
Other Music workshops	23.3% (76)	19.0% (62)	28.8% (94)	11.7% (38)	17.2% (56)	326
Other (please specify)						19
					answered question	396
					skipped question	12

Table 48: First Flute Teacher

Which of the following best describes the FLUTE TEACHER WHO TAUGHT YOU in the first 12 months of lessons? Tick/check any that apply.		
Answer Options	**Response Percent**	**Response Count**
Specialist flute teacher	44.3%	180
Multi-instrumental teacher whose main instrument was flute	14.0%	57
Multi-instrumental teacher whose main instrument was NOT flute	37.9%	154
Self-taught	5.7%	23
Other (please specify)	4.7%	19
	answered question	406
	skipped question	2

Table 49: Instruction in the First 12 Months of Learning

Which of the following describes the type of instruction you received in the first 12 months of learning flute? Tick/check any that apply.		
Answer Options	**Response Percent**	**Response Count**
Private lessons	55.2%	224
Group lessons with only flute players	32.3%	131
Group lessons with flute players and players of other instruments	21.4%	87
Suzuki Method	1.2%	5
Self-taught	5.7%	23
Other (please specify)	2.7%	11
	answered question	406
	skipped question	2

Table 50: Type of Head Joint Played

Head joint					
Answer Options	**Straight**	**Curved**	**Swan Neck**	**Vertical**	**Response Count**
Concert Flute	99.0% (390)	0.3% (1)	0.5% (2)	0.3% (1)	394
Alto Flute	57.9% (55)	42.1% (40)	0.0% (0)	0.0% (0)	95
Bass Flute	5.4% (2)	91.9% (34)	0.0% (0)	2.7% (1)	37
Contrabass Flute	50.0% (2)	50.0% (2)	0.0% (0)	0.0% (0)	4
Piccolo	100.0% (218)	N/A	N/A	N/A	218
Baroque Flute	100.0% (22)	N/A	N/A	N/A	22

Table 51: Body Weight

My body weight:		
Answer Options	**Response Percent**	**Response Count**
Quite underweight	0.5%	2
A little underweight	9.8%	38
Normal	49.4%	191
A little overweight	35.7%	138
Quite overweight	4.7%	18
answered question		387
skipped question		21

Table 52: General Health and Fitness

How would you rate your General Health and Fitness?						
Answer Options	**Poor**	**Fair**	**Average**	**Good**	**Excellent**	**Response Count**
General Health	1.3% (5)	6.8% (26)	20.8% (80)	46.2% (178)	24.9% (96)	385
Fitness	4.3% (16)	16.4% (61)	40.1% (149)	28.5% (106)	10.8% (40)	372
answered question						387
skipped question						21

Table 53: Level of Happiness

All in all, rate how happy are you with your life these days:								
Answer Options	Very unhappy	Unhappy	A little unhappy	Neither unhappy nor happy	A little happy	Happy	Very happy	Response Count
Level of happiness	0.5% (2)	3.4% (13)	8.3% (32)	7.8% (30)	16.6% (64)	43.1% (166)	20.3% (78)	385
							answered question	385
							skipped question	23

Table 54: Aerobic Activity and Strength/Resistance Training

How many times per week, on average, do you participate in the following activities?						
Answer Options	**1 - 2 times per week**	**3 - 5 times per week**	**6 or more times per week**	**Less often**	**Not at all**	**Response Count**
Aerobic Activity (Walking, running, cycling, swimming etc)	28.6% (110)	37.9% (146)	15.8% (61)	10.1% (39)	7.8% (30)	385
Strength/Resistance Training (using free weights, machine weights, body weight, resistive bands etc)	24.4% (89)	14.0% (51)	1.9% (7)	11.0% (40)	48.8% (178)	365
Other (please specify)						40
					answered question	387
					skipped question	21

Table 55: Use of Smoke or Alcohol

Do you smoke or drink alcohol?							
Answer Options	**Never**	**Rarely**	**Socially/ Occasionally**	**Regularly**	**Heavily**	**Recently given up**	**Response Count**
Do you smoke?	92.2% (356)	2.8% (11)	1.3% (5)	3.1% (12)	0.3% (1)	0.3% (1)	386
Do you drink?	24.5% (95)	21.9% (85)	36.3% (141)	17.3% (67)	0.0% (0)	0.0% (0)	388
						answered question	388
						skipped question	20

Table 56: Diagnosed Medical Conditions

Have you ever been medically diagnosed with any of the following conditions?		
Answer Options	**Response Percent**	**Response Count**
Anxiety	16.0%	52
Bursitis	3.7%	12
Carpal Tunnel Syndrome	8.6%	28
Chronic Fatigue Syndrome	3.1%	10
Cubital Tunnel Syndrome	1.2%	4
Degenerative Arthritis	1.9%	6
De Quervain's Syndrome	0.6%	2
Depression	17.9%	58
Double-jointed (hypermobile) fingers, wrists or elbows	9.3%	30
Fibromyalgia	3.1%	10
Focal Dystonia	1.2%	4
Kyphosis (excessive/hunch back)	0.6%	2
Lordosis (excessive/sway back)	0.3%	1
Lupus	0.3%	1
Multiple Sclerosis	1.2%	4
Myositis	0.3%	1
Osteoarthritis	6.2%	20
Osteoporosis	1.9%	6
Rheumatoid Arthritis	2.5%	8
Tendonitis	16.0%	52
Thoracic Outlet Syndrome	1.9%	6
Sciatica	4.9%	16
Scoliosis	8.3%	27
TMJ (temporomandibular joint) Syndrome	11.4%	37
None of the above	34.3%	111
Any other conditions which may cause discomfort? Include any old injuries, such as broken bones. How do these conditions affect your flute playing, if at all?	43.2%	140
answered question		324
skipped question		84

Table 57: Vision Problems and Headaches

How often....?						
Answer Options	**Never**	**Rarely**	**Occasionally**	**Regularly**	**Very often**	**Response Count**
..do your eyes feel strained or uncomfortable while playing?	31.0% (119)	29.9% (115)	29.7% (114)	8.9% (34)	0.5% (2)	384
...do you practise or perform in conditions of low to moderate light levels?	16.3% (62)	34.1% (130)	40.9% (156)	7.9% (30)	0.8% (3)	381
...do you suffer from frontal headache during playing?	66.1% (252)	21.3% (81)	11.0% (42)	1.0% (4)	0.5% (2)	381
...do you suffer from frontal headache after playing?	64.8% (248)	21.1% (81)	11.7% (45)	1.8% (7)	0.5% (2)	383
...do you suffer from migraines?	64.3% (247)	15.9% (61)	13.0% (50)	5.5% (21)	1.3% (5)	384
...do you suffer from other headaches?	20.9% (80)	33.2% (127)	34.0% (130)	8.1% (31)	3.7% (14)	382
					answered question	386
					skipped question	22

Table 58: Tendencies Towards Particular Playing Positions

Do you have a tendency towards any of the following playing positions, either normally, or after becoming fatigued? Please answer this question whether you ever feel discomfort/pain, or not.		
Answer Options	**Response Percent**	**Response Count**
Bending trunk forwards (excessively)	10.1%	38
Chin jutting forward	9.5%	36
Collapsed finger joints	8.7%	33
Elbow resting on waist/hip	9.0%	34
Fingers hanging over edge of keys	8.2%	31
Gripping flute too tightly	43.1%	163
Neck falling to the side	23.0%	87
Pressing flute too hard against chin	22.0%	83
Right thumb protruding	9.8%	37
Shoulders raised	23.5%	89
Shoulders rolled forwards/inwards	22.5%	85
Slumping in chair	26.5%	100
Straight fingers	6.6%	25
Thumb sliding up length of tube	4.2%	16
Twisted spine	13.5%	51
Standing with one hip pushed to side	25.4%	96
None of the above	14.0%	53
Other (please specify)	8.5%	32
	answered question	378
	skipped question	30

Table 59: Playing-Related Discomfort or Pain, Hypermobility and Vocal Usage

Please answer the following questions with either 'Yes', 'No' or 'Not applicable':				
Answer Options	**Yes**	**No**	**Not applicable**	**Response Count**
Have you ever experienced flute playing-related discomfort or pain that was severe enough to distract you while performing?	49.7% (192)	49.0% (189)	1.3% (5)	386
Have you ever had to take an extended period of time off flute playing because of flute playing-related discomfort/pain?	25.8% (99)	73.2% (281)	1.0% (4)	384
Does the level of discomfort/pain/tension you experience tend to dictate the length of your practice sessions?	50.0% (191)	44.2% (169)	5.8% (22)	382
Have you ever made specific changes to your flute playing position on the recommendation of a MEDICAL or HEALTH PRACTITIONER for the purpose of avoiding injuries?	27.2% (105)	68.9% (266)	3.9% (15)	386
Do you use your voice extensively as part of your work or regular activities (singing, speaking, shouting)?	57.9% (223)	40.8% (157)	1.3% (5)	385
Are you currently suffering from flute playing related discomfort or pain?	26.7% (103)	73.3% (283)	0.0% (0)	386
Do you feel that during your flute studies you received sufficient information or advice on Injury Prevention and Management?	26.6% (101)	70.8% (269)	2.6% (10)	380
Do you have hypermobile (double-jointed) fingers, wrists or elbows?	19.8% (76)	79.9% (307)	0.3% (1)	384
Please feel free to comment				76
			answered question	386
			skipped question	22

Table 60: Total Time Playing Flute Per Day

How long in total do you typically PLAY FLUTE, whether in practice, rehearsal, teaching or performance in a day?		
Answer Options	**Response Percent**	**Response Count**
Up to 15 minutes	1.1%	4
Up to 30 minutes	4.0%	15
Up to 1 hour	16.2%	61
Up to 2 hours	26.1%	98
Up to 3 hours	17.8%	67
Up to 4 hours	14.1%	53
Up to 5 hours	6.6%	25
Up to 6 hours	7.7%	29
More than 6 hours	3.2%	12
Not applicable	3.2%	12
Please feel free to explain, as it is understood that routines may vary daily or dramatically.		111
answered question		376
skipped question		32

Table 61: Daily Practice Schedules

Indications of Daily Practice Schedules
2. Can range from 30 minutes to 3 1/2 hours at a time, a few times a day
3. Average over the last 40 years has been about 2 hours a day. It varies widely though. 4 or 5 times I've gone months without playing, but most often I play several times a day.
16. Currently on a break...Previously, 2-8 hours depending on circumstances.
32. I teach up to 6 hours Monday to Friday & frequently play along with students in lessons.
33. Weekly rehearsal of 60-90 minutes playing. I do not play continuously or keep going if in pain. I might rest for a bit and then start again. Weekly rehearsal varying from 15 - 60 minutes depending nature of chamber music.
35. 4-5 hours twice a week, 2-3 hours twice a week & 0-1 hour the remaining 3 days
36. Depends on the day how much I practice and how I feel like.
41. I practice 2 hours every day but I also have rehearsals up to 2 hour every week, so the day of rehearsal, I end up playing for 4 hours
43. I try to practice everyday that I am not performing. As I do many different types of gigs throughout the year, playing length is dictated by the gig schedule. I do a lot of musicals & that is an 8 show a week schedule so I can be playing up to six hours a day twice a week when I'm in a show but on different instruments. I do play in one Pops orchestra that has a three and a half hour to four hour rehearsal in the afternoon and then the actual gig that night. I play only flute/piccolo on that one.
49. During the week, I practice about an hour a day 3 days a week; an hour and a half once a week for rehearsal; & once or twice a month I have gigs that last for 4 hours.
51. Varies but practice sessions are usually broken up into 2 hour slots, will do up to 3 in any one day. On concert days, we usually have a 3 hour rehearsal/set up followed by a 90 minute concert, but with many breaks.
55. Daily I practice anywhere from 45 to 90 minutes, but on Saturdays I attend music school where I am playing for around 4-5 hours.
56. The school where I am working on my undergraduate degree has band rehearsals from 3pm to 6pm every day, and we play for most of that time, and I usually try to get at least an hour of practice a day in each day.
58. I teach 6 hours a day during the week 3 days a week; 3 hours a day 1 day a week, play concerts on weekends & practice at least 2-6 hours a day depending upon the amount of teaching.
67. Regular practise of between 1 and 3 hrs per day either sitting or standing. Community band rehearsals of 2.5hrs duration (with 20min tea break) two to three times a week. 1/2 hr private flute lesson each week.
72. Honestly, it would be rare for me to play for more than 4 hours a day. However, on days with heavy teaching or double rehearsals etc it can be much longer. Also, I practice in bursts - for example if a concert is approaching, I do longer sessions.
91. We have band practice for 2 hours, one afternoon a week. Then I just practice whenever, the times change regularly depending on homework and other extra curricular activities
107. Practice: 2-6 hours Teaching: 2-4 hours rehearsal/performance: up to 2.5 hours In various combinations; if I have a light teaching/performance day, I practice more.

Table 62: Number of Playing Days Per Week

How many days per week do you typically play flute?		
Answer Options	**Response Percent**	**Response Count**
1 - 2	7.5%	28
3 - 4	20.3%	76
5 - 6	33.1%	124
Every day	33.6%	126
Sporadic	4.3%	16
Not at all	1.3%	5
answered question		375
skipped question		33

Table 63: Medications Used to Alleviate Playing-Related Pain, Tension or Injury

Which of the following medications, if any, have you ever used to alleviate flute playing-related pain, tension or injury? Tick/check any that apply. If you have never used any, please choose 'None of the above'.		
Answer Options	**Response Percent**	**Response Count**
Over the counter pain killers (Aspirin/Paracetamol/Ibuprofen etc)	46.2%	168
Non steroidal anti-inflammatory (such as Voltaren, Naproxen, COX-2 inhibitors)	19.5%	71
Muscle Relaxant Drug (such as Valium)	4.1%	15
Oral Steroid (such as Prednisone)	2.7%	10
Steroid Injection (such as Cortisone)	5.5%	20
Anaesthetic Injection	1.4%	5
None of the above	48.6%	177
Other (please specify)		17
answered question		364
skipped question		44

Table 64: Practitioners Consulted

Which of the following practitioners have you ever consulted for the specific purpose of preventing or managing flute playing-related discomfort/pain?		
Answer Options	**Response Percent**	**Response Count**
Acupuncturist	11.1%	40
Performing Arts Medical Doctor/Specialist	8.9%	32
Medical Doctor/Specialist	24.4%	88
Physiotherapist/Physical Therapist	25.2%	91
Myofascial Therapist	2.8%	10
Chiropractor	18.0%	65
Dentist/Orthodontist	10.5%	38
Optometrist	3.3%	12
Osteopath	6.4%	23
Occupational Therapist	4.4%	16
Massage Therapist	25.5%	92
Sports Psychologist/Psychologist/Counsellor	3.0%	11
Natural Therapist (e.g. Homeopath/Herbalist/Naturopath)	6.1%	22
Speech Pathologist/Therapist	0.6%	2
Podiatrist	3.0%	11
None of the above	43.5%	157
Other?	13.6%	49
answered question		361
skipped question		47

Table 65: Beneficial Methods for Preventing or Managing Discomfort or Pain

Which of the following have you personally found to be beneficial in preventing or managing playing related discomfort or pain? Tick/check all that apply.		
Answer Options	**Response Percent**	**Response Count**
Massage	45.9%	168
Trigger Point Therapy (with tennis ball/muscle mate or by therapist etc)	12.0%	44
Physiotherapy/Physical Therapy	16.4%	60
Myofascial Therapy	2.2%	8
Chiropractic	11.7%	43
Osteopathy	4.4%	16
Acupuncture	6.8%	25
Yoga	14.8%	54
Alexander Technique	26.2%	96
Feldenkrais	6.8%	25
Dalcrose	0.5%	2
Body Mapping	7.9%	29
Tai Chi	4.4%	16
Qigong	2.5%	9
Pilates	9.3%	34
Stretching	45.4%	166
Strengthening (including bodyweight, therabands, weights etc)	19.1%	70
Meditation	11.5%	42
Heat Pack	26.2%	96
Ice Pack	16.1%	59
Electrotherapy (such as Ultrasound, Interferential, T.E.N.S)	5.7%	21
Biofeedback	1.6%	6
Lying on Noodle (foam cylinder)	6.0%	22
Thumbport/Flute Crutch/Bo Pep	13.4%	49
General Exercise/Fitness	36.1%	132
None of the above	17.5%	64
Other (please specify)	13.1%	48
answered question		366
skipped question		42

Table 66: Questions About Training in Injury Prevention and Management

To what extent do you agree with the following statements?						
Answer Options	**Strongly Disagree**	**Disagree**	**Not Sure**	**Agree**	**Strongly Agree**	**Response Count**
A knowledge of basic anatomy is useful in the prevention and management of flute playing injuries.	2.1% (8)	1.6% (6)	17.9% (67)	48.1% (180)	30.2% (113)	374
All flute TEACHERS should receive training in injury prevention and management	2.4% (9)	0.3% (1)	6.4% (24)	45.9% (173)	45.1% (170)	377
All flute PLAYERS should receive training in injury prevention and management.	2.4% (9)	0.8% (3)	6.9% (26)	45.1% (169)	44.8% (168)	375
					answered question	378
					skipped question	30

Table 67: Interest in Further Information and Training

If further information or training were available on the topic of Injury Prevention and Management for Flute Players, which of the following would you be interested in? Tick/check any that apply.		
Answer Options	**Response Percent**	**Response Count**
Workshops/Lectures	60.3%	226
Website	78.9%	296
Book	54.9%	206
DVD	41.1%	154
Articles in journals	55.5%	208
None of the above	4.0%	15
	answered question	375
	skipped question	33

Table 68: Aching Pain[13]

Have you EVER experienced flute playing related PAIN (Aching/Stiffness, Burning, Radiating or Sharp Pain) in the following areas of your body? Does/did this happen during or after playing? Is/was the pain constant or intermittent?							
Aching/ Stiffness	Constant During	Constant After	Intermittent During	Intermittent After	Constant During/ After	Intermittent During/ After	Total
Fingers/ Hands	6.7% (14)	4.3% (9)	27.1% (57)	14.3% (30)	8.6% (18)	39.0% (82)	210
Arms	4.9% (6)	0.8% (1)	36.6% (45)	11.4% (14)	13.8% (17)	32.5% (40)	123
Elbow	14.6% (6)	2.4% (1)	24.4% (10)	14.6% (6)	12.2% (5)	31.7% (13)	41
Wrist	9.5% (9)	4.2% (4)	15.8% (15)	13.7% (13)	15.8% (15)	41.1% (39)	95
Neck	9.2% (13)	6.4% (9)	14.2% (20)	17.7% (25)	19.1% (27)	33.3% (47)	141
Shoulder	7.5% (12)	6.3% (10)	17.0% (27)	15.1% (24)	23.3% (37)	30.8% (49)	159
Chest	25.0% (3)	0.0% (0)	25.0% (3)	16.7% (2)	25.0% (3)	8.3% (1)	12
Middle/ Upper Back	7.6% (9)	5.9% (7)	13.4% (16)	14.3% (17)	24.4% (29)	34.5% (41)	119
Low Back	6.0% (7)	6.0% (7)	17.2% (20)	13.8% (16)	17.2% (20)	39.7% (46)	116
Jaw	9.1% (8)	5.7% (5)	18.2% (16)	25.0% (22)	10.2% (9)	31.8% (28)	88

[13] These figures were originally part of a bigger table. A total count for this table appears at the end of Table 71.

Table 69: Burning Pain[14]

Have you EVER experienced flute playing related PAIN (Aching/Stiffness, Burning, Radiating or Sharp Pain) in the following areas of your body? Does/did this happen during or after playing? Is/was the pain constant or intermittent?							
Burning	Constant During	Constant After	Intermittent During	Intermittent After	Constant During/ After	Intermittent During/ After	Count
Fingers/ Hands	9.1% (3)	3.0% (1)	42.4% (14)	12.1% (4)	9.1% (3)	24.2% (8)	33
Arms	0.0% (0)	9.1% (2)	40.9% (9)	9.1% (2)	9.1% (2)	31.8% (7)	22
Elbow	0.0% (0)	16.7% (1)	16.7% (1)	0.0% (0)	16.7% (1)	50.0% (3)	6
Wrist	0.0% (0)	0.0% (0)	17.6% (3)	23.5% (4)	11.8% (2)	47.1% (8)	17
Neck	3.6% (1)	0.0% (0)	21.4% (6)	7.1% (2)	17.9% (5)	50.0% (14)	28
Shoulder	10.3% (4)	5.1% (2)	15.4% (6)	15.4% (6)	20.5% (8)	33.3% (13)	39
Chest	0.0% (0)	0.0% (0)	100.0% (1)	0.0% (0)	0.0% (0)	0.0% (0)	1
Middle/ Upper Back	9.7% (3)	16.1% (5)	16.1% (5)	6.5% (2)	32.3% (10)	19.4% (6)	31
Low Back	9.1% (1)	0.0% (0)	27.3% (3)	9.1% (1)	36.4% (4)	18.2% (2)	11
Jaw	0.0% (0)	0.0% (0)	28.6% (2)	42.9% (3)	14.3% (1)	14.3% (1)	7

[14] These figures were originally part of a bigger table. A total count for this table appears at the end of Table 71.

Table 70: Radiating Pain[15]

Have you EVER experienced flute playing related PAIN (Aching/Stiffness, Burning, Radiating or Sharp Pain) in the following areas of your body? Does/did this happen during or after playing? Is/was the pain constant or intermittent?							
Radiating	Constant During	Constant After	Intermittent During	Intermittent After	Constant During/ After	Intermittent During/ After	Count
Fingers/ Hands	6.5% (2)	3.2% (1)	16.1% (5)	12.9% (4)	9.7% (3)	51.6% (16)	31
Arms	5.6% (1)	0.0% (0)	5.6% (1)	27.8% (5)	11.1% (2)	50.0% (9)	18
Elbow	0.0% (0)	0.0% (0)	25.0% (2)	25.0% (2)	0.0% (0)	50.0% (4)	8
Wrist	10.0% (2)	5.0% (1)	10.0% (2)	20.0% (4)	15.0% (3)	40.0% (8)	20
Neck	9.5% (2)	0.0% (0)	9.5% (2)	14.3% (3)	33.3% (7)	33.3% (7)	21
Shoulder	25.0% (4)	6.3% (1)	6.3% (1)	0.0% (0)	25.0% (4)	37.5% (6)	16
Chest	0.0% (0)	0.0% (0)	100.0% (2)	0.0% (0)	0.0% (0)	0.0% (0)	2
Middle/ Upper Back	7.1% (1)	14.3% (2)	14.3% (2)	7.1% (1)	21.4% (3)	35.7% (5)	14
Low Back	10.0% (1)	0.0% (0)	10.0% (1)	0.0% (0)	40.0% (4)	40.0% (4)	10
Jaw	20.0% (1)	20.0% (1)	0.0% (0)	0.0% (0)	20.0% (1)	40.0% (2)	5

[15] These figures were originally part of a bigger table. A total count for this table appears at the end of Table 71.

Table 71: Sharp Pain[16]

Have you EVER experienced flute playing related PAIN (Aching/Stiffness, Burning, Radiating or Sharp Pain) in the following areas of your body? Does/did this happen during or after playing? Is/was the pain constant or intermittent?							
Sharp	Constant During	Constant After	Intermittent During	Intermittent After	Constant During/ After	Intermittent During/ After	Count
Fingers/ Hands	6.6% (4)	3.3% (2)	29.5% (18)	16.4% (10)	14.8% (9)	29.5% (18)	61
Arms	6.3% (1)	0.0% (0)	25.0% (4)	12.5% (2)	12.5% (2)	43.8% (7)	16
Elbow	16.7% (2)	8.3% (1)	8.3% (1)	8.3% (1)	25.0% (3)	33.3% (4)	12
Wrist	6.5% (2)	0.0% (0)	25.8% (8)	16.1% (5)	19.4% (6)	32.3% (10)	31
Neck	7.7% (2)	3.8% (1)	15.4% (4)	23.1% (6)	7.7% (2)	42.3% (11)	26
Shoulder	23.5% (4)	5.9% (1)	17.6% (3)	0.0% (0)	5.9% (1)	47.1% (8)	17
Chest	0.0% (0)	0.0% (0)	50.0% (1)	0.0% (0)	0.0% (0)	50.0% (1)	2
Middle/ Upper Back	11.8% (2)	11.8% (2)	29.4% (5)	0.0% (0)	29.4% (5)	17.6% (3)	17
Low Back	0.0% (0)	0.0% (0)	35.7% (5)	7.1% (1)	28.6% (4)	28.6% (4)	14
Jaw	0.0% (0)	0.0% (0)	26.7% (4)	26.7% (4)	26.7% (4)	20.0% (3)	15
							Totals
Are these symptoms worse on your left or right side?							242
						answered question	318
						skipped question	90

[16] These figures were originally part of a bigger table. The total refers to the combined counts in Tables 68 - 71.

Table 72: Swelling, Numbness and Tingling Pain

Have you EVER experienced Swelling, Numbness or Tingling in your hands/elbows as a result of flute playing? Does/did this happen during or after playing? Is/was the pain constant or intermittent?							
Swelling	Constant During	Constantly After	Intermittent During	Intermittent After	Constant During/ After	Intermittent During/ After	Count
Fingers Hands	5.1% (2)	12.8% (5)	12.8% (5)	30.8% (12)	15.4% (6)	23.1% (9)	39
Elbow	0.0% (0)	22.2% (2)	11.1% (1)	44.4% (4)	22.2% (2)	0.0% (0)	9
Numb-ness	Constant During	Constantly After	Intermittent During	Intermittent After	Constant During/ After	Intermittent During & After	Count
Fingers Hands	5.3% (4)	4.0% (3)	17.3% (13)	24.0% (18)	13.3% (10)	36.0% (27)	75
Elbow	0.0% (0)	0.0% (0)	20.0% (2)	30.0% (3)	20.0% (2)	30.0% (3)	10
Tingling	Constant During	Constant After	Intermittent During	Intermittent After	Constant During/ After	Intermittent During & After	Count
Fingers Hands	4.8% (6)	4.0% (5)	21.6% (27)	22.4% (28)	10.4% (13)	36.8% (46)	125
Elbow	8.7% (2)	0.0% (0)	13.0% (3)	34.8% (8)	17.4% (4)	26.1% (6)	23
							Total
Are these symptoms worse on your left or right side?							117
						answered question	152
						skipped question	256

Table 73: Factors Which Worsen Condition

What factors do you know make YOUR condition worse?		
Answer Options	**Response Percent**	**Response Count**
Shoulders rolling forwards	25.2%	82
Neck falling to side	26.2%	85
Trunk twisting	12.6%	41
Lifting/reaching above head	3.7%	12
Not taking sufficient breaks	46.5%	151
Feeling unhappy/negative	15.7%	51
Tiredness/Fatigue	54.5%	177
Not stretching	36.0%	117
Not doing strengthening/resistance exercises	16.9%	55
Lack of exercise/fitness	28.3%	92
Dietary changes (please specify)	1.8%	6
Performance Anxiety	24.6%	80
Stress/Worry	41.5%	135
Playing in cold rooms/spaces	30.2%	98
Playing in hot/warm rooms/spaces	4.0%	13
Poor posture in non-flute playing activities, including computing	39.7%	129
Sight-reading	4.9%	16
Playing other instruments (please specify)	7.7%	25
No idea	9.8%	32
Other (please specify)	7.1%	23
Your comments would be of great help to the research team:		86
answered question		325
skipped question		83

Table 74: What Flutists Attribute to Staying Free of Discomfort and Pain

This question is for flute players who stay free of discomfort/pain AT LEAST SOME of the time. To what do you attribute your tendency to stay discomfort/pain free at least some of the time? Please answer this question only as it TRUE FOR YOU personally, not what you know or suspect has worked for others.		
Answer Options	Response Percent	Response Count
Ability to relax/deal with stress	38.7%	121
Good/improved playing position in general	65.2%	204
Accurate body/mind map	17.3%	54
Knowledge of Anatomy/Physiology	22.0%	69
Being fit/exercising	38.0%	119
Good teaching	30.7%	96
Rest	50.5%	158
Low level of performance anxiety	28.1%	88
Freedom of movement while playing	39.6%	124
Strength or resistance exercises	15.3%	48
Stretching	38.0%	119
Feeling happy/satisfied/positive/confident	32.6%	102
Healthy diet/nutrition	17.9%	56
Good/Better posture in non flute playing activities	31.6%	99
Thumbport/Flute Crutch/Bo Pep	12.5%	39
Left Hand Extension	2.9%	9
Use of Ergonomic Flute (egg. Vertical/Swan Neck etc)	2.2%	7
Rockstro Grip/Modified Rockstro Grip	5.4%	17
Sheer luck/Good genes	8.6%	27
No idea	4.8%	15
Not applicable	2.2%	7
Other (please specify)	10.5%	33
answered question		313
skipped question		95

Table 75: Number of Students Taught per Week

How many flute and/or piccolo students do you regularly teach per week?		
Answer Options	**Response Percent**	**Response Count**
1 - 5	31.0%	66
6 - 10	12.7%	27
11 - 20	17.4%	37
21 - 40	16.0%	34
41 or more	5.6%	12
None at the current time (on leave/teaching break)	17.4%	37
answered question		213

Table 76: Teaching Activities

What type of teaching activities do you do? Tick/check any that apply.		
Answer Options	Response Percent	Response Count
Individual (private) lessons	96.6%	196
Group lessons (flutes only)	35.0%	71
Group lessons (flute and other instrument/s)	12.3%	25
Conducting	25.1%	51
Masterclass/Workshop Presenter	20.2%	41
Lecturer/Professor	9.4%	19
Pedagogy Teacher	8.4%	17
Other (please specify)		10
answered question		203
skipped question		205

Table 77: Length of Time Teaching

How many years in total have you been teaching?		
Answer Options	Response Percent	Response Count
1 - 5 years	31.2%	64
6 - 10 years	14.1%	29
11 - 15 years	11.2%	23
Over 15 years	43.4%	89
answered question		205
skipped question		203

Table 78: Type of Students Taught

Which of the following students do you teach at any time (including workshop or masterclass participants)? Please tick (check) all that apply.		
Answer Options	Response Percent	Response Count
Primary/Elementary/Middle School age	84.6%	170
High School age	84.6%	170
University music student - undergraduate	30.8%	62
University music student - postgraduate	10.9%	22
Semi-professionals/Professionals	12.4%	25
Adult amateurs	60.2%	121
Other	0.5%	1
Other (please specify)		11
answered question		201
skipped question		207

Table 79: Teachers' Recommendations for Avoiding or Managing Injuries

Which of the following have you ever recommended to your students, for the specific purpose of avoiding or managing injury?		
Answer Options	Response Percent	Response Count
Change Flute Playing Position	92.9%	184
Check Posture in Non-Flute Playing Activities	32.3%	64
Take Regular Practice Breaks	63.6%	126
Alternate Instruments During Practice	4.5%	9
Change seating position in band/orchestra	59.1%	117
Curved Head Joint	28.8%	57
Yamaha Fife	8.6%	17
Jupiter Prodigy Flute (D foot)	9.1%	18
Stretching	54.5%	108
Strength/resistance training	18.7%	37
Trigger Point Therapy	2.0%	4
Heat Pack	13.6%	27
Ice Pack	10.6%	21
Flute Crutch/Thumbport/Bo Pep	26.3%	52
Use Vertical or Other Ergonomic flute	3.0%	6
Change to a Different Flute	9.1%	18
Change to a Different Instrument Altogether	3.5%	7
Rockstro Grip/Modified Rockstro Grip	6.6%	13
Offset G Key	48.0%	95
Get Flute Service (repair leaks)	56.1%	111
Left Hand Key Extension	8.1%	16
Physiotherapist/Osteopath/Chiropractor	21.2%	42
Podiatrist	0.5%	1
Natural Therapies	6.6%	13
Specialist Doctor	9.6%	19
Speech Therapy/Pathology	1.0%	2
Counsellor/Psychologist	2.5%	5
Massage	24.2%	48
Yoga	18.2%	36
Tai Chi	2.5%	5
Meditation	7.6%	15
Pilates	6.6%	13
Exercise/Get Fit	25.8%	51
Attend a Specific Flute Workshop/Event	31.3%	62
Other (please specify)	5.1%	10
Further comments would be appreciated:		22
answered question		198
skipped question		210

Table 80: Support for the Research

Support for the Research
1. I appreciated doing this survey. It got me to reflect on my own flute-playing posture and well-being
16. Good luck with this. This is needed.
19. I have been teaching 45 years and it was only in the last maybe 10 years that anyone addressed these issues.
26. Well done Karen. This is so important.
28. I think it is great that you are conducting this research, and hope I can be of any assistance. Good work and good luck!
30. I'm very thankful that someone is taking the time to dig into issue that should concern EVERY musician out there. I feel very strongly about it because I had to stop playing for a whole semester due to severe injuries in my right arm. Although my posture was never a problem, practising long hours, not taking breaks, not sleeping enough, not eating enough, not having a good posture when doing OTHER stuff (like typing or handwriting) ended up causing tendinitis and epicondylitis. Musicians should be more aware of how straining practise is for our muscles, and act in consequence! Thanks again for taking the time doing this research, and for giving me the chance to help others through my experience!
32. This is very valuable research. Hopefully, students, teachers and professional players can benefit from greater understanding of the causes of injury. Prevention is far easier than treatment of playing-related injuries.
33. What a well thought out and valuable survey. I hope the information gathered will be used to inform and help. Thank You!
34. Thank you for undertaking this!! I see a real need, and after having my wrists in such terrible shape for so long, I really see a need for a resource that can help prevent/treat flute injuries.
56. This is a vastly under publicised area and I'm pleased it's being looked into. Any chance of doing the same for other instruments??? Clarinets and saxes especially!!
57. What a great survey Karen!!!! Kudos! I greatly look forward to seeing the fruits of your labor.
62. Excellent survey! Thank you for doing this - all music teachers need to address this problem!
69. I think this is a wonderful, valuable study for flutists and other musicians.

Table 81: Interest in the Findings

Interest in the Findings
3. I would be very interested in having a look at your findings, if possible, as it is so difficult to find information about TMJ and playing woodwind instruments, other than reading about other people who are in the same position with no idea what they can try next! I was half way through my B.Mus when I had to give up playing so any advice on how to get back to it, or if you have any contacts who may be willing to help, I would really appreciate it. Thank you for researching such an important aspect of flute playing.
4. I would love to hear about your findings from this survey, please advise of any further publications, etc on the topic.
11. I would be interested to learn of your conclusions. I could certainly learn more about the prevention and treatment of flute-related injuries. Thank you.
13. I often suspect that part of my problem was from trying to play music that was too difficult for me before I was ready. Also, I am barely 5 ft tall and have small hands and the flute was always a stretch for me. I also struggled to take large enough breaths, which added to body tension. I would be interested in receiving a summary of the results of this study when it becomes available.
17. This is a good survey. I would be interested in knowing the results.
18. I would like to know the results of the survey once you have compiled them.
19. I have been teaching 45 years and it was only in the last maybe 10 years that anyone addressed these issues.
39. I am very interested in the results of your research. I will be more than happy to publish it on my web site flutelab.com. Thank you for your good work!
42. I am interested in the results of this survey and your study. I have been looking for some answers for years!
46. Please provide me of how I can read this research once it is complete. Thanks
59. Would like to see the results of your research when complete. Can you forward a copy?
69. I'd be interested in the results of the study when it is completed.

Table 82: Interest in Further Information or Training

Interest in Further Information or Training
3. I was half way through my B.Mus when I had to give up playing so any advice on how to get back to it, or if you have any contacts who may be willing to help, I would really appreciate it.
6. I would LOVE to attend some workshops on injury prevention.
7. I feel that my arthritis keeps me from enjoying playing the flute more. I am seeing a Rheumatologist now and trying different non steroidal anti-inflammatory drugs. So far I have yet to try one that makes much of a difference. I know a couple of women who have had surgery on the basal thumb joint (also known as the carpometacarpal joint or cmc joint). The surgery is referred to as "Excisional Arthroplasty" where the arthritic joint surfaces are removed as well as the trapezium bone and replaced by a piece of tendon harvested from one near the thumb, that has been sewn into a small ball. I would like to know what you think about this procedure and what effect it might have on flute playing. Or if you have any other advice for me to improve my comfort while playing my instrument.
29. I'd love to see the results, and would welcome any articles on injury prevention and alleviation! I'd also be interested in any research that has been done on the effects of depression and ADHD on musicians.
35. A handbook distributed to students at a decent price would be useful.
37. This is really interesting study - as a teacher I sometimes feel inadequate with my knowledge of how to get a students body into the best position so that they do prevent injuries from playing. There is not enough attention given to this in university degrees.
56. This is a vastly under publicised area and I'm pleased it's being looked into. Any chance of doing the same for other instruments??? Clarinets and saxes especially!!

APPENDIX D: STRETCH DIAGRAMS

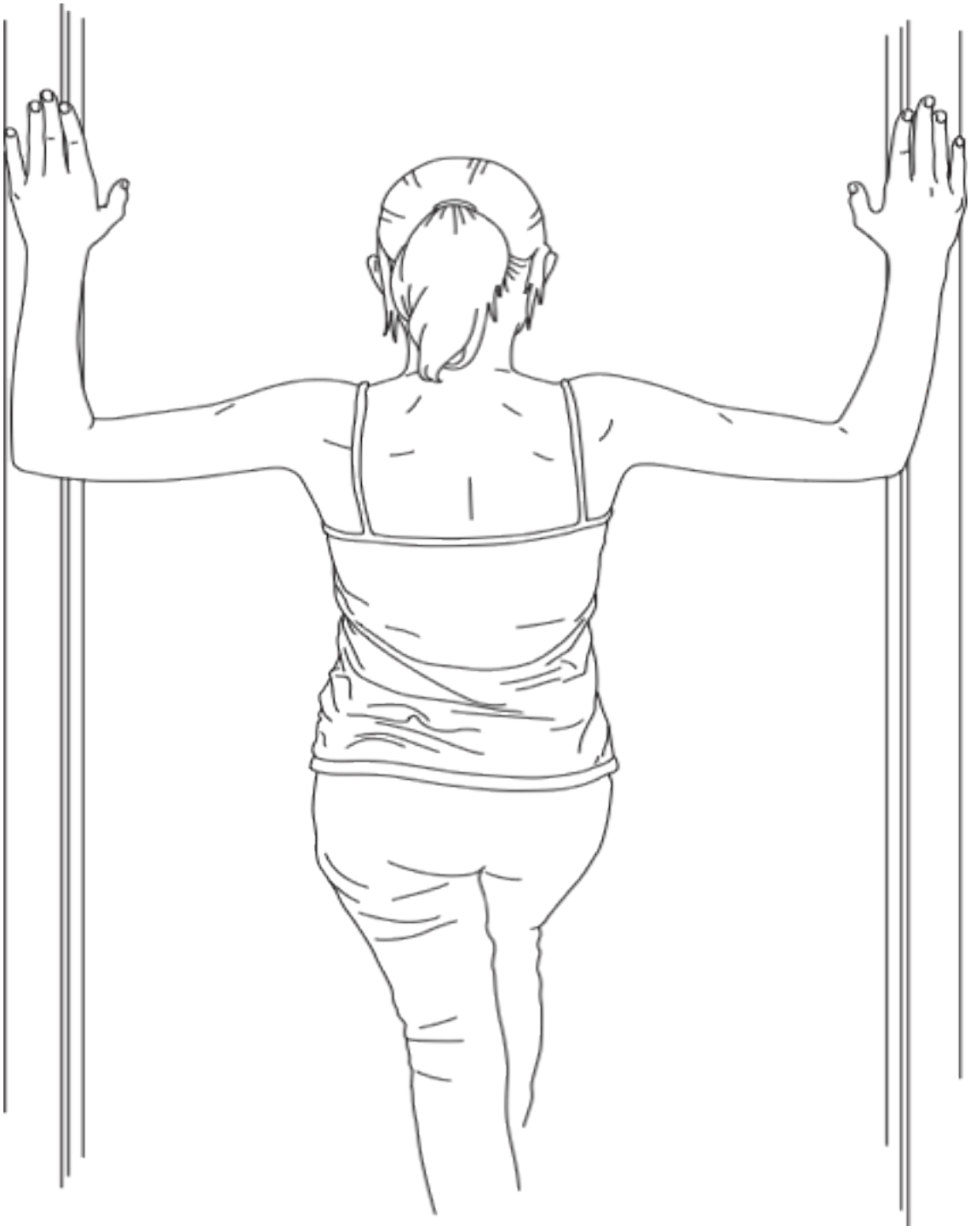

Figure 61: Chest Stretch Through Doorway

(Wilson, 2009b)

Figure 62: Chest Stretch Against Wall

(Wilson, 2009a)

Figure 63: Nerve Stretch on Wall

(Wilson, 2009f)

Figure 64: Tricep Stretch

(Wilson, 2009j)

Figure 65: Tricep Stretch Against Wall

(Wilson, 2009k)

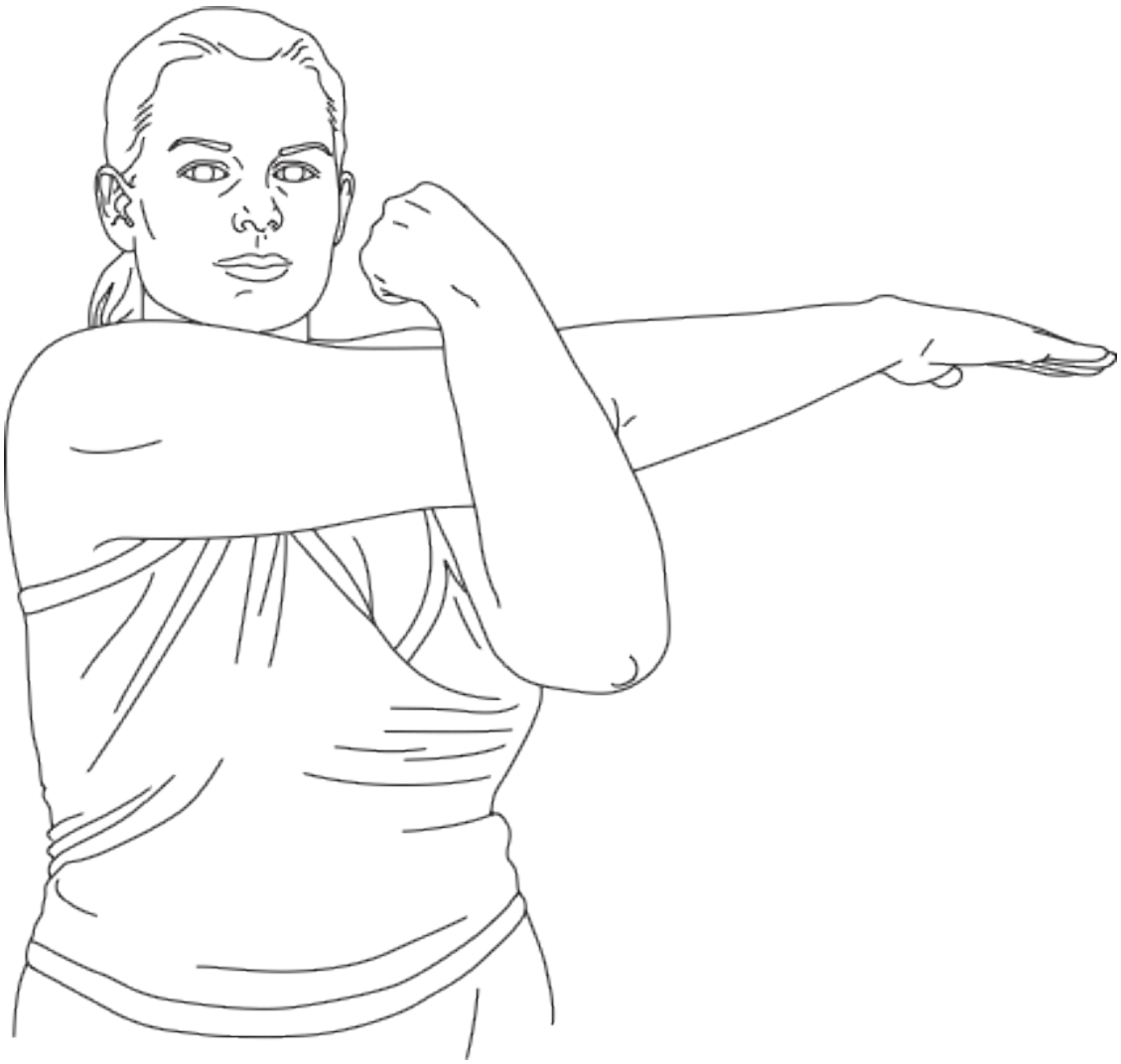

Figure 66: Shoulder Stretch

(Wilson, 2009h)

Figure 67: Neck Stretch

(Wilson, 2009d)

Figure 68: Neck Stretch to Side

(Wilson, 2009e)

Figure 69: Latissimus Dorsi Stretch

(Wilson, 2009c)

Figure 70: Shoulder Shrug

(Wilson, 2009g)

Figure 71: Upper Back Stretch

(Wilson, 2009l)

Figure 72: Throat Stretch

(Wilson, 2009i)

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