Winded: Creating a Set of Parameters to Assess the Effectiveness of Popular Breathing Exercises in Asthmatic Wind Instrumentalists

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WINDED: CREATING A SET OF PARAMETERS TO ASSESS THE EFFECTIVENESS OF POPULAR BREATHING EXERCISES IN ASTHMATIC WIND INSTRUMENTALISTS

By

Steven Joseph Eckert

A DOCTORAL ESSAY

Submitted to the Faculty of the University of Miami in partial fulfillment of the requirements for the degree of Doctor of Musical Arts

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Winded: Creating a Set of Parameters to Assess the Effectiveness of Popular Breathing Exercises in Asthmatic Wind Instrumentalists

Abstract of a doctoral essay at the University of Miami.

Doctoral essay supervised by Professor Aaron Tindall. No. of pages in text. (87)

The aim of this study is to develop an understanding of the effects on the respiratory system caused by breathing exercises popular among musicians and to definitively classify which exercises are helpful or hurtful to the asthmatic wind instrumentalist in order that s/he may cope with the difficulties of performing with the breathing disorder. First the identification of breathing exercises most frequently used by wind instrumentalists was necessary to broaden the definition of breathing pedagogy for musicians from all families of woodwind and brass instruments. This was assessed by way of a voluntary pilot survey in which participants indicated the breathing exercises, breath training devices, and breathing pedagogies with which they were familiar and used on a regular basis to train the breath. Once this summary of popular breathing exercises was compiled, a series of interviews were conducted with medical experts in the field of pulmonology to discuss physiological and pathophysiological processes present in the respiratory system during and after these exercises. Finally the body of research in asthma and sports medicine or kinesiology was reviewed in an effort to extrapolate as much information as possible for application to asthmatics in the musical realm.
The survey results yielded an encouraging summary of breathing exercises that were further categorized according to their intended goals, including relaxation breathing exercise, stress-inducing breathing exercises, maximum expansion breathing exercises, and maximum contraction breathing exercises. Interviewees agreed that while the relaxation exercises compiled from the survey were indeed conducive to mitigating asthma symptoms, those that induced a degree of stress or tension in the body had the capacity to trigger symptoms. The verdict on effectiveness of maximum expansion and maximum contraction exercises was inconclusive as adequate research was insufficient to characterize either as hurtful or harmful.

The collection of this information will be instrumental in designing a testing scenario for future study and iterations of this type of research in breathing exercises. From the summary of popular breathing exercises gathered, control exercises can be extracted from the relaxation category to observe lung function in a normal setting, while stress-inducing exercises, maximum expansion exercises, and maximum contraction exercises may be used to track a participant’s lung function over a period of time. The goal would be to produce hard evidence that certain breathing exercises should be struck from the regimen of breath training used by asthmatic wind instrumentalists.
ACKNOWLEDGEMENTS

The undertaking of a study such as this one could never have been possible without the vigilant guidance, percipient wisdom, and fervent encouragement afforded to me around the clock by Professor Timothy Conner, to whom I owe my greatest appreciation and heartfelt affection. I also extend a debt of gratitude to Dr. Ahmad El Khatib and Dr. Susan Benenati for their gracious willingness to collaborate and their insightful contributions to this study. I thank the members of my doctoral advisory committee, Dr. Aaron Tindall, Professor Gabriel Beavers, and Dr. D. Scott Stinson, for their counsel and alacrity in being intimately involved in this topic as well as Dr. Kimberly Sena-Moore for demystifying IRB protocol. I would also be remiss without acknowledgement of the advice, praise, late-night revisions, and unfettered endearment provided by Dr. Hsien Lee Lau, whose dedication and benevolence continue to inspire me every single day.
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CHAPTER 1: INTRODUCTION

Background

A fundamental component in the production of sound on a wind instrument is the ability to produce a strong and even inhalation and exhalation of the breath. Here I define a wind instrument as any aerophone—woodwind or brass—set into vibration by a column of air expelled from the lungs. Students of wind instruments often refine their breathing techniques in the same ways that they might develop an embouchure or handling of valves, keys, or slides through measured exercise and steadfast scrutiny. There are nearly as many schools of thought on breathing exercises as there are breathing pedagogues, but very few have addressed the unique approach required for teaching wind instrumentalists with asthma such as myself. Some of the leading regimens prescribed for developing desirable breathing habits can adversely exacerbate symptoms in asthmatics and can lead to confusion, frustration, and in some cases abandonment of instrumental study altogether.

The American Lung Association defines asthma as a chronic disorder of the airways that causes periodic inflammation, obstruction, and spasms of the airways.¹ For many suffering from the disorder, symptoms are mild between attacks and may include wheezing, chest tightness, coughing, and/or overall decreased respiratory functionality.

Symptoms are severely worsened during an asthma attack and may become fatal in instances of continued attacks. Any number of stimuli may trigger the onset of asthma symptoms or an attack including contact with an allergen or chemical irritant like tobacco or pollution, a respiratory infection, or physical incitement such as cold weather conditions or exercise of varying intensity.\(^2\) The lattermost stimulus references the type of activity involved in asthma symptoms experienced by wind instrumentalists while practicing their craft and is the most pertinent cause of symptoms to this study.

**Problem Statement**

Existing popular breathing exercise regimens such as *The Breathing Gym* developed by Sam Pilafian and Patrick Sheridan train wind instrumentalists to refine their breathing skills through physical conditioning, flow studies, and respiratory strength training.\(^3\) While the concepts behind these activities are indeed sound advice for brass and woodwind players alike, some of the suggested exercises are spurious in their attempt to create freely relaxed air passages for asthmatics. Similarly use of respiratory training devices such as incentive spirometers and *The Breather®*, meant to strengthen inspiratory and expiratory muscles independently, can actually exacerbate asthma symptoms despite their beneficial intentions. What is traditionally considered intuitive or standard practice in the field of breathing exercise for instrumentalists without respiratory disorders may in fact prove counterintuitive or harmful to their asthmatic counterparts.


Need for Study

The importance of this study lies not only in its implications for alleviating asthma conditions in students of wind instruments but also in its contribution to an otherwise underdeveloped area of research. This study on asthma as related to wind instrumental performance will provide a set of parameters on which further testing will be based. Results from further testing will yield the pertinent, evidence-based data to supplement the dearth of research in developing a pedagogy for asthmatic wind instrumentalists. Worth mentioning however is the abundance of research conducted in topics concerning asthma in athletes and effective practices thereof, which will serve as useful models when designing an investigative methodology for further study.

Purpose

The purpose of this study in asthma as related to wind instrumentalists is to identify the measurable factors and raise the questions necessary to formulate a pedagogy catered to asthmatic wind instrumentalists, classifying helpful and hurtful breathing practices. This information will allow students with asthma to understand their own breathing troubles and better manage them in a performance environment as well as provide educators with the pedagogical tools needed to address these issues in their students. The research questions directly related to the stated focus are as follows:
1. Which breathing exercises do wind instrumentalists with and without asthma practice to strengthen their lung functionality?
   a. Measure: Survey
   b. Answer: A summary of breathing exercises and breath training devices

2. What is the pathophysiology behind those breathing exercises that trigger asthma symptoms and those that limit triggers?

3. What can be learned from the developments in research on asthma and athletics and how can it assist wind performance in asthmatics?

**Personal Interest**

I was diagnosed with bronchial asthma in 1998 at the age of seven after experiencing my first asthma attack. My pulmonologist prescribed a daily regimen of albuterol nebulizer treatments, twice-a-day corticosteroid use, an albuterol rescue inhaler as needed throughout the day, and daily check-ins with a peak flow meter to monitor my breathing. My symptoms were well-managed by the time I entered middle school thanks to a reduced regimen of the abovementioned medications and avoidance of excessively strenuous physical activity, but my symptoms would only worsen from there as I began musical studies on the trombone in the sixth grade. Throughout my musical career and education I have been met with a gamut of hurdles ranging from the typical symptoms experienced by asthmatics to serious doubts of my ability to perform and make a living as a performer. Since I began breath training exercises to cope with my asthma in college, I have developed a deep personal interest in understanding how I can overcome my daily breathing struggles, how other asthmatic wind instrumentalists have dealt with their own
struggles, and how I can teach my asthmatic students to play a wind instrument successfully despite their conditions.

It is my sincere hope that this essay may also console the wounded self-esteem of the discouraged asthmatic wind instrumentalist seeking to become proficient on their instrument, develop better breathing habits, or pursue a career in musical performance. I have questioned my choice to study and master the trombone more times than I care to admit, and I vehemently affirm that this periodic lack of confidence and breach in optimism has served as an impetus for inquisition into breathing studies. I encourage the asthmatic reader inclined to feeling downtrodden not to idly sit by and allow respiratory hurdles to defeat them, but instead to face them with the curious mind necessary to formulate the appropriate questions for tackling such issues. I attribute much of my grit and will to persevere despite the odds to every voice, internal and external, which has ever propagated doubt in my abilities.
CHAPTER 2: REVIEW OF LITERATURE

Overview

While there exists a plentitude of speculation around asthma and wind instrument performance—often in the form of non-scientific, personal anecdotes in forums and articles across the web, in magazines, and in journals—veritable and definitive studies are in very short supply, especially regarding appropriate breathing exercises for asthmatics. Many of the articles one will find on asthma and wind instrument performance will claim that playing an instrument is an excellent way to “beat asthma.”4 Once again these are strictly personal accounts of unique successes with breathing disorders attributed to playing a wind instrument without scientific data, and more importantly it is the awareness of one’s control over their symptoms that typically leads to this success as the Asthma UK Centre for Applied Research reports:

The scientific evidence is unclear for now – studies can’t yet prove that [playing wind instruments] improves the way your lungs work or helps you breathe better. But lots of people with asthma say that singing or playing a musical instrument helps them to be more aware of their breathing…5

Breathing Pedagogy for Wind Instrumentalists

Since its conception in 2002, Sam Pilafian’s and Patrick Sheridan’s The Breathing Gym series has been hailed as a definitive application for singers and wind instrumentalists to increase lung capacity and endurance. Along with each book—transposed for various wind instruments—a DVD is included of audio/visual explanations and instructions for each exercise led by the creators. There is no mention of how or which of these exercises should be implemented in asthmatics save for a brief disclaimer at the beginning of the video warning those with breathing conditions to consult a doctor before use and to breathe through the nose while seated in the event of dizziness or lightheadedness. A selection of the exercises within this program may serve as variables for analysis in future testing and will be the subject of interviews with medical professionals.

Miami-based company Expand-A-Lung® touts its breath training program and inspiratory/expiratory training device modeled after exercises used in yoga and Tai Chi. In the testimonials included on the Expand-A-Lung® webpage, divers, elite athletes, musicians, and medical doctors reported increased lung strength and capacity as a result of using the device. While the webpage does not mention asthma, there are claims that its continued use assists in aiding adults with chronic obstructive pulmonary disorder (COPD) by immediately opening airways and targeting respiratory muscles. This device and others like it differ from incentive spirometers in their use of resistance monitors to

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6 *The Breathing Gym: Daily Workouts*, produced and directed by Andrew Beneze (Phoenix: Next Edge Video, 2008), DVD.
build intercostal strength as opposed to freer-flowing, non-resistance trainers. Because of this added resistance, the Expand-A-Lung® would be an excellent variable to include in both interview discussions and future testing.

Neil Howell incorporates non-resistance breath exercising in his “Mastering Breath Control: Breathing Exercises for Wind Instrumentalists”—a set of eight exercises that requires little more than one’s respiratory system in terms of materials. These flow studies are a series of increasingly advanced exercises in which one meters the breath in counts from one to eight on the inhale and four to twenty-eight counts on the exhale. There are suggested tempos for each exercise beginning with 50 beats per minute (BPM) and ending with 112 BPM in the eighth exercise. Howell also suggests the use of a breathing bag similar to that used by sufferers of panic attacks to control the volume of air inhaled and exhaled, though he does warn that prolonged use of the bag will result in lightheadedness because of high levels of exhaled carbon dioxide trapped in the bag and a lack of fresh oxygen intake.⁸

A “Singing” Approach to the Trombone and Other Brass by bass trombonist Charles Vernon of the Chicago Symphony Orchestra is a method book devoted to development of a concept of sound in brass instrumentalists with a heavy emphasis on proper breathing techniques. These studies are inspired by the teachings of renowned performers and pedagogues Arnold Jacobs and Edward Kleinhammer, both former members of the Chicago Symphony Orchestra with whom Vernon studied. Vernon suggests the use of a breathing tube fashioned from a small length of polyvinyl carbonate (PVC) pipe purchased from a hardware store to ensure a relaxed and open throat.

Attaching a plastic bag to the breathing tube regulates the volume of air inhaled. The breathing exercises included in this text are similar to those described in both The Breathing Gym and “Mastering Breath Control: Breathing Exercises for Wind Instrumentalists” with regard to metered inhalations and exhalations facilitated by metronome. These exercises differ however in their use of short rhythmic breaths which assist in expanding lung capacity.  

**Pathophysiology of Asthma**

Arthur Guyton and John E. Hall’s Guyton and Hall Textbook of Medical Physiology contains an informative chapter devoted to respiratory disorders and their pathophysiology. The subsection of this chapter on asthma will provide a substantial basis on which inferences correlating components of a breathing exercise and asthma symptoms may be founded. The textbook also provides invaluable explanations of the respiratory system’s physiology as it undergoes measurements for forced vital capacity (FVC) and forced expiratory volume per second (FEV₁). This chapter also compares measurements of normally-functioning respiratory systems with those experiencing airway obstruction and lung constriction.  

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Scientific Studies in Breathing Exercises

A key factor in developing awareness of the breath is practicing breathing exercises with an inquisitive mind, informing the breather of their level of control over their condition and the steps toward improving it. Cassandra Slader’s study on breathing exercises in “Double Blind Randomised Controlled Trial of Two Different Breathing Techniques in the Management of Asthma” is very similar in its subject matter to the topic I present here and could serve as a potential model for further testing. In her study fifty-seven participants were randomized to one of two breathing exercises (shallow nasal breathing and non-specific upper body exercises) and asked to execute the assigned exercise twice a day for thirty weeks with a pulmonary assessment after week twelve and twenty-eight. The results of these trials concluded that while no evidence favored one technique over the other, breathing exercises may indeed improve asthma symptoms in patients who use an inhaler.11

Tarun and Manjari Saxena’s study “The Effects of Various Breathing Exercises (Pranayama) in Patients with Bronchial Asthma of Mild to Moderate Severity” will be especially beneficial in a discussion of breathing pedagogy. This research focuses on ancient Indian breathing techniques called pranayama and the benefits they possess for improving asthma symptoms. Fifty cases of bronchial asthma were trained in breathing exercises and practiced over a period of twelve weeks with an initial and post-trial

measure of FEV$_1$ and peak expiratory flow (PEF). The researchers concluded that participant PEF and FEV$_1$ were improved by regular use of breathing exercises, especially expiratory exercises.$^{12}$

“Breathing Difficulties in Wind Instrument Players” by University of Maryland researcher Timothy B. Gilbert also attributes breath training and physical exercise as therapeutic programs that improve asthma symptoms, endurance, and general well-being in wind musicians. He cites the severity of impairment to wind instrumentalists that asthma poses even when similar conditions may appear trivial to non-musicians.$^{13}$


CHAPTER 3: METHODOLOGY

Overview

The purpose of this study in asthma as related to wind instrumentalists is to identify the measurable factors and raise the questions necessary to formulate a pedagogy catered to asthmatic wind instrumentalists, classifying helpful and hurtful breathing practices by way of addressing three research questions. First what can be learned from the wealth of research conducted in athletics with regard to breathing disorders and how can the results of those studies benefit similar research in wind performance? Second which breathing exercises do wind instrumentalists practice to strengthen their lung function? The sample for the survey was taken from willing participants—eighteen years of age and older—who played a wind instrument but did not necessarily have a breathing disorder. Lastly what is the pathophysiology behind those breathing exercises that trigger asthma symptoms and those that limit triggers?

Research Question #1

To answer the third research question, I conducted research in the existing literature on the pathophysiology of asthma and its symptoms and invited expert opinion from pulmonologists to analyze the components of unique breathing exercises. Pathophysiology is a convergence of pathology, the study of abnormal functions observed during a disease or disorder, and physiology, the study of processes operating in
an organism. Understanding the pathophysiology of asthma did not necessarily offer advice in the treatment of symptoms, but rather explained the causes of those processes in the body that result in symptoms. The first step in developing a pedagogy for asthmatic wind instrumentalists was decoding the body’s response to components of breathing for wind playing and identifying ways to circumvent those troublesome aspects that trigger abnormal respiratory function.

In addition to secondary sources I compiled a series of transcribed interviews with medical professionals in the field, including Ahmad El Khatib, MD, a pulmonology fellow at Jackson Memorial Hospital at the University of Miami’s Miller School of Medicine. Our discussion was focused on the pathophysiology of the lower respiratory system affected by asthma and the most probable causes for exacerbation of symptoms. I demonstrated a set of breathing exercises for Dr. El Khatib as well and had him illustrate the processes involved during each in an effort to correlate symptoms with ineffective components of the exercise. Susan V. Benenati, MD is an allergist-immunologist in Coral Gables, Florida who has been in practice for more than twenty years, treating immune disorders including respiratory allergies and asthma. In an interview with her, I posed similar questions from my interview with Dr. El Khatib.

**Research Question #2**

In addressing the second research question, a survey following strict guidelines for research with human subjects (Appendix A & B) was disseminated via an online survey platform to students at the University of Miami’s Frost School of Music who

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majored in wind performance or who majored in a related musical discipline and whose principal instrument was a wind instrument. The survey asked participants to indicate all wind instruments on which they actively performed followed by an open-ended item in which they enumerated breathing practices they had learned. This list included exercises with which they were familiar and used regularly and any training devices with which they were familiar and used regularly. An optional open-ended item followed in which participants listed sources with which they were familiar for breathing exercise regimens and pedagogy that included books, articles, websites, videos, or electronic applications.

The results of this survey were compiled into a comprehensive summary of breathing exercises and training devices. The practices indicated within this summary were the subject of discussion with medical professionals in pulmonology regarding internal processes of the body and their capacity to induce asthma symptoms. This summary could also provide the variables for those practices applied in future study on efficacy towards maintaining, increasing, or decreasing lung functionality.

**Research Question #3**

The field of kinesiology and performance related subjects in athletics has long been further and earlier developed than the field of musical health, wellness, and psychology in terms of research devoted. As mentioned studies conducted in wind musicians with asthma and other breathing disorders are dwarfed in comparison to what has been discovered in sports medicine concerning the same topic. While this may come as a disappointment to the musicians reading this essay, this knowledge base can be of vital importance to understanding breathing issues experienced by wind instrumentalists.
In answering this first question, I used studies from various performance disciplines ranging from diving and skiing to yoga to make inferences about breathing issues in wind performance.

**Summary**

According to the Centers for Disease Control and Prevention, the number of Americans with asthma grew 28% from 2001 to 2011, and medical expenses for these individuals averages around $50.1 billion annually. In 2010 there were 3,404 deaths, 439,400 hospitalizations, and 1.8 million emergency department visits related to asthma.\(^{15}\) With a continual rise in cases of asthma among Americans, it is my hope that results of this research study will be of benefit to both students and teachers in developing a better understanding of breathing pedagogy for wind instrumentalists with asthma.

To develop a better understanding of breathing pedagogy for asthmatics, I have polled a population of wind instrumentalists to first identify the breathing exercises, breath training devices, and existing breathing pedagogies that are currently used with a level of frequency. Once I was able to summarize the breathing practices used among wind musicians, I interviewed Ahmad El Khatib, MD and Susan Benenati, MD to discuss the components of asthma pathophysiology that are affected by each reported breathing exercise. Along with these discussions I also conducted a review of research in the fields of kinesiology and respiratory disease to build an understanding of why some exercises are more problematic for asthmatic wind musicians than others and under which

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conditions do musicians and athletes alike experience the greatest likelihood for asthma flares. This research review also brought to light a few clinical studies of breathing exercise regimens that manifested successful improvements in FEV$_1$ and control of symptoms.
CHAPTER 4: RESULTS

Pilot Survey on Breathing Exercises and Breath Training Devices

I published a digital survey to collect data on types and frequencies of breathing exercises and breath training devices used by wind instrumentalists of varying ages and degrees of performer status. The survey (Appendix B) was launched through the Qualtrics XM platform and was disseminated by way of social media such as Facebook, delivery of an anonymous link to email addresses, and posting of a quick response (QR) code in classrooms and common areas at the Frost School of Music. While the survey was published on the University of Miami’s Coral Gables campus, distribution reached the surrounding South Florida communities and institutions and as far as Virginia Polytechnic Institute & State University (Virginia Tech) and West Virginia University.

The survey entitled “Breathing Exercises and Breath Training Devices” began with a series of simple demographic questions which would help to characterize the sample population but would in no way identify any single participant. Participants were asked to indicate the gender with which they identified more—male or female—and were additionally given the option to not respond to the question. A question followed in which participants would select their age from a menu of ages eighteen to ninety-nine with the obligatory choice to opt out of responding. Respondents were then asked to identify their level of musical performance from a bank of six degrees of ability: professional, graduate student, undergraduate student, beginning student, retired, or
hobbyist. A subsequent free-response question allowed participants to list the wind instruments on which they performed with the above-selected degree of performance ability. The final demographic question asked participants if they have a respiratory condition such as asthma or chronic obstructive pulmonary disease (COPD) to which they could respond either “yes,” “no,” or “prefer not to answer.” A “yes” response would then prompt an additional question about respiratory symptoms experienced while playing their wind instrument, including wheezing, shortness of breath, coughing, chest tightness or chest pain, and an option to enter any other symptom experienced not included in the list. These initial questions gave a statistical image of my sample by describing the gender and age distribution, the types and frequencies of principal instruments played and their relative degrees of ability, and what the average number of asthmatic respondents was in the population. The additional question about respiratory symptoms addressed which symptoms were most common in asthmatic respondents.

After the series of demographic inquiries, a sequence of free-response questions followed. The first asked participants to list the breathing exercises with which they were familiar and had in fact used regularly, followed by a second question that asked about breath training devices which were familiar to participants and used regularly. The purpose of these two questions was to develop a somewhat comprehensive summary of exercises and devices that could extend beyond those with which I am familiar as a trombonist. A final, optional question asked respondents to indicate any breathing exercise/breath training regimens or pedagogies with which they were familiar such as books, articles, websites, videos, or electronic applications. The purpose of this final question was again to create a collective summary of breathing exercises and breath
training devices from which to select exercises/devices for future study as well as to provide substantive topics for discussion with medical professionals to assess the components of exercises/devices that could be triggers for asthma flares.

**Response to Pilot Survey**

95 respondents participated in the pilot survey, of which 56 identified as male, 38 identified as female, and one chose not to answer. The distribution of men and women respondents was overall rather even but does not necessarily reflect the leading statistics on distributions of asthmatic men and women. Women have a 10.5% higher chance of developing asthma than men, and in 2016 asthmatic females accounted for 9.7% of the American population, compared to 6.9% for asthmatic males. For future studies a population reflecting this trend will be ideal with a slightly higher number of female participants.

The age range for the 95 respondents was from 18 years to 64 years with an average age of 28.87 years. The median age of participants was 24 years with a mode of 20 years (11 participants or 11.58% indicated an age of 20 years). This number does not represent the national averages by age group, however consideration must also be made for the type of participants who were recruited and the means by which the survey was disseminated—mostly college-aged adults recruited through social media and electronically-scanned QR code. Adjustments will have to be made in further trials to recruit a more diverse age range by means more readily accessible to all ages.

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The distribution of ability levels for participants reported that 32.26% were professional wind instrumentalists, 12.9% were graduate students, 40.86% were undergraduate students, 2.15% were retired, and 11.83% were hobbyists. No participants identified their performance ability as beginner. The large number of undergraduate students is correlated with and can be explained by the large number of responses for participants aged 18 to 22 years (41.05% of participants).

Keeping in mind that each participant was able to list one or more instruments on which they were proficient at the abovementioned ability level, 24 played oboe and/or English horn, 18 were trombonists, 11 played tuba, 10 played bassoon, 9 were trumpeters, 7 were flautists, 7 played French horn, 6 were saxophonists, 3 were clarinetists, 3 played euphonium, and 2 were bass trombonists. This information is very encouraging as every wind instrument family was represented by survey respondents. These results however are possibly the result of disseminating the survey amongst two popular Facebook groups for musicians: the page for the International Double Reed Society (oboes and bassoons) and a group for low brass instrumentalists (trombones and tubas).

25% of respondents identified as having a breathing disorder like asthma or COPD. This number is unexpectedly high when compared with CDC data that reported only 8.3% of Americans had asthma in 2009.\(^{18}\) The data may suggest there is some correlation between developing asthma and playing a wind instrument (see Deniz,

“Reduced Pulmonary Function in Wind Instrument Players”19), but that is beyond the scope of this study and will need further analysis. From the asthmatic sample 47.83% experienced shortness of breath while playing their respective instrument(s), 30.43% experienced coughing, 17.39% experienced chest tightness or chest pain, and 13.04% experienced wheezing. The respondents who chose the option to list additional symptoms most often reported stimulation of allergy symptoms experienced while playing their wind instrument.

The following questions hone the focus of the survey away from demographic data collection and center around the breathing exercises, breath training devices, and breathing pedagogy reported by individual respondents. The responses were by no surprise disparate in number of exercises listed and length of explanation, so to avoid a sesquipedalian discussion on varied responses, I will order breathing exercises into four unique categories: relaxation breathing exercises, stress-inducing breathing exercises, maximum expansion breathing exercises, and maximum contraction breathing exercises as seen in Appendix E.

The relaxation breathing exercises indicated by respondents were the most frequently reported out of all categories listed above. An exercise known as “The Classic” in The Breathing Gym,20 in which an inhalation lasts over a number of counts at a given tempo and is immediately exhaled over the same or different number of counts at that tempo, was the most frequently cited breathing exercise practiced by wind instrumentalists with 17 mentions (nearly 18% of respondents). Deep breathing

exercises, breathing exercises taught from the yogic tradition, and meditative breathing exercises or those which command greater attention to the breath were the second most frequently cited exercises at 11 mentions. 7 participants indicated that they did breathing exercises paired with movements or stretching, 5 indicated that they did flow studies—a variation on “The Classic” in which the hand is placed in front of the mouth as a monitor for even airflow—and 4 indicated that they performed a rhythmic variation on “The Classic” in which a breathing pattern based on a multiple-measure phrase or piece of music was emulated without the instrument.

Stress-inducing breathing exercises reported included an exercise in which the back of the hand was sealed over the mouth to create resistance during a forceful inhalation to capacity. Readers familiar with The Breathing Gym routine may know this exercise as “Champagne.” This exercise was the most popular among those that introduced a degree of tension in the body at 5 mentions, followed by 4 mentions of a variation on “The Classic” during which air is held in the lungs for a number of counts at a given tempo between the inhalation and exhalation. One participant indicated that they would attempt to hold a piece of paper in place on a wall solely by the force of their breath. Another indicated that they would rapidly inhale and exhale to maximum expansion and maximum contraction in The Breathing Gym exercise called “Power Breathing.” Another exercise from The Breathing Gym teachings entitled “Ee to Oh” was mentioned once by a participant. “Ee to Oh” refers to the shapes of the oral cavity when in its most closed or tense position—an “ee” syllable with teeth together, tongue arched, and smallest oral cavity—and when in its most open or relaxed position—an “oh”

22 Ibid.
syllable with teeth apart, tongue relaxed, and open oral cavity. A series of rapid inhalations and exhalations ensues during which time the musician slowly transforms the oral cavity from its most tense to its most relaxed position.\textsuperscript{23}

Exercises from the category pertaining to breathing exercises of maximum expansion were the least frequently reported. 6 participants mentioned an exercise in which the lungs are filled completely before repetitive sips of air are taken in to expand vital capacity. 2 participants also indicated that they practiced filling their lungs all the way to capacity before releasing on an exhale.

In the final classification of breathing exercises meant to strengthen accessory muscles of the respiratory system by way of maximum contraction of the lungs, 4 participants indicated an exercise isolating the abdominals, diaphragm, and intercostals in which a bottom-up approach is taken to inhalation. The abdominals (the lowest-placed respiratory muscles) are engaged before utilizing the diaphragm and finally the intercostal muscles on a slow inhalation. 3 participants indicated a technique for exhaling completely before pushing out all remaining air with a hiss sound until no more sound can be produced. A maneuver utilizing heavy panting facilitated by the diaphragm was mentioned by 2 respondents, and one mention of an exercise for breathing while lying on the floor was made. This last exercise is a way to isolate just the diaphragm in an effort to inhale while allowing gravity to aid on the exhalation.

A number of breathing devices were indicated for the question on those used by wind instrumentalists (Appendix E), including 20 mentions (21.05\% of respondents) of various incentive spirometers like the Breath Builder and Voldyne 5000. Use of a breathing tube made from either rubber or PVC was indicated by 5 participants, while 3

\textsuperscript{23} Sam Pilafian and Patrick Sheridan, \textit{The Breathing Gym}, (Meza, AZ: Focus on Music, 2009).
mentions were made of using the mouthpiece for the instrument to work on breathing habits. 3 participants also indicated that they used a balloon for resistance to exhalation, and similarly 2 mentions were made of using a breathing bag like those manufactured by CMVI Ltd. for that same purpose. 2 respondents used their peak flow meters to track their peak expiratory flow (PEF) progress, and 2 respondents performed breathing exercises with straws to replicate the resistance experienced on their instruments. One mention was made of using the “Breathe” application for their Apple Watch to meditate on their breath.

The final question, though optional, asked participants to list the resources from which they had performed breathing exercise regimens in the past (Appendix E). The overwhelming response was for the exercises developed by Sam Pilafian and Patrick Sheridan in The Breathing Gym series; nearly half of respondents were familiar with this routine (41 mentions). The next most popular pedagogy at 5 mentions was for the teachings of Arnold Jacobs and writings based on his approach like Brian Frederiksen’s Arnold Jacobs: Song and Wind and Kristian Steenstrup’s Teaching Brass. A popular breath training routine used by drum corps programs around the country called “The System” was mentioned twice. 2 participants indicated application to their wind instruments of breath training techniques used by vocalists. 2 participants also made mention of yogic traditions and breathing meditations. The remainder of responses were a smattering of familiarities with Alexander technique, body mapping, and the teachings of pedagogues like Edward Kleinhammer, Jan Kagarice, Doug Hill, Stephen Caplan, et al.
CHAPTER 5: DISCUSSION

Respiratory Physiology

To begin any discussion on the pathophysiology of a disease or disorder, one must first understand the conditions under which processes of the body function normally. Since the scope of this research only includes the functions of the human body insomuch as its capacity to play a wind instrument, a particular focus will be placed on the respiratory system and its physiology.

One of the principle functions of the lungs is to absorb oxygen (O$_2$) from the air we breathe, which is composed of nitrogen (N), oxygen (O$_2$), argon (Ar), carbon dioxide (CO$_2$), and other trace gases. Consequently when we exhale we release waste gas CO$_2$, and this process continues every time the breathing cycle is completed in a vital function called gas exchange. Oxygen-rich air flows in through either the mouth or nose, which warms and moistens the air like a humidifier so as not to irritate the lungs. The moistened air travels down the trachea or windpipe and branches off into either lung through the left or right bronchus. These primary bronchi branch off into bronchial tributaries know as secondary and tertiary bronchi, which too branch into thousands of smaller bronchial tributaries know as bronchioles.\textsuperscript{24}

The entire bronchial system is visually analogous to an inverted tree where the trachea is the trunk and the bronchioles are the smallest twigs and stems as seen in Figure 5.1. In the visual analogy of the inverted tree, the leaves connected to each twig are the alveoli or collections of tiny air sacs, which rapidly exchange gasses as described above. Bronchioles give rise to alveoli by way of terminals connected to alveolar ducts and send oxygen through capillaries surrounding the alveoli to the various arteries and veins of the body and ultimately the heart.

The rapid exchange of CO₂ for O₂ does not occur however without help from the respiratory muscular system located in the thoracic or chest cavity. Two such muscles are largely responsible for inhalation and exhalation: the diaphragm and intercostal muscles. The diaphragm is located below the lungs and separates the chest and

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25 Figure 5.1, Bronchi, Bronchial Tree, and Alveoli, figure by National Cancer Institute, “Bronchi, Bronchial Tree, and Lungs,” accessed February 12, 2019, https://training.seer.cancer.gov/anatomy/respiratory/passages/bronchi.html.
abdominal cavities. This muscle contracts by pressing downward to increase the size of the chest cavity, which in turn opens the lungs, sucking air in through the nose and mouth. The same principle by which air enters a bellows applies here, where the lungs are the concertinaed chamber and the diaphragm is the handle which may be pushed and pulled to expand and contract the chamber. The intercostal muscles located between the ribs also expand and contract the size of the chest cavity by pulling the ribcage both upward and outward. Visualize the way in which your chest moves up and out while inhaling as a result of this maneuver. The opposite is true for the exhale, in which case the diaphragm relaxes and pushes back up while the intercostal muscles between the ribs bring the ribcage back downward and inward to reduce the space inside the thoracic cavity.27

Some other muscles may be involved depending on the rate of breathing and condition of the respiratory system. The abdominal muscles assist in expanding and contracting the cavity when a resting breath rate is insufficient, such as during and after rigorous physical exercise or while playing a wind instrument. The location of the diaphragm between the thoracic and abdominal cavities allows the abdominal muscle to control the movement of the diaphragm up and down when the respiratory needs of the body surpass the capabilities of the diaphragm and intercostal muscles alone. Muscles in the neck and around the collarbone may also assist in breathing when the aforementioned muscles do not work well or are impaired by lung disease.28

One may have assumed that the lungs were simple bags or sacs that filled and deflated like balloons with respiration, but the truth is lungs are dense webs of bronchial

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28 Ibid.
passageways that fill many thousands of small balloon-like sacs. While the above processes seem quite involved in terms of execution, very little is required to initiate the act of breathing—the respiratory control center at the base of the brain sends constant signals through the spine to pertinent muscles involved in the process to ensure ongoing contraction and relaxation of those muscles. Testament to this involuntary process, the reader has executed all of the maneuvers discussed above many times over without being aware before reaching the end of this paragraph.

**Pathophysiology of Asthma**

Because there are many ways in which the respiratory system can become inflamed, there are several pathophysiological explanations for conditions that occur in an asthmatic patient. To characterize these conditions, let us first delineate two types of asthmatics: the atopic and non-atopic asthmatic. Atopy is the genetic predisposition toward heightened immune response and the development of asthma, allergies, and eczema. Atopic asthmatics typically demonstrate symptoms such as wheezing at a young age and are often born from an atopic parent. The occurrence of atopy may also be explained by poor atmospheric conditions and smoking during pregnancy. A non-atopic asthmatic is a patient who has developed asthma in adulthood, typically from experiencing a number of viral respiratory infections throughout his or her life.

On the cellular level, when an atopic individual is introduced to an antigen like dust, mold spores, or pet dander, excessive levels of antibodies called *Immunoglobulin E*...
(IgE)\textsuperscript{30} are released from \textit{B lymphocytes} in the interstitium—the fluid-filled space between the skin and organs or between the skin and muscles that constitutes approximately one-fifth of a human’s body weight. \textit{Lymphocytes} are a sub-classification of white blood cells that constitute the immune system, including \textit{T lymphocytes} (those that kill pathogen-infected cells in the body) and \textit{B lymphocytes} (those that neutralize foreign bacteria and viruses).\textsuperscript{31} When \textit{B lymphocytes} produce the antibody IgE, it attaches to inflamed cells to signal the release of inflammatory mediators. Separate areas of the body react differently to inflammatory mediators, and in the case of the airways this means bronchoconstriction and further respiratory inflammation.

Another cause for bronchoconstriction is due to the release of histamine from mast cells, which also causes excessive mucous production in the airways. When an individual comes into contact with an allergen for the first time, IgE antibodies targeted to that specific allergen attach to mast cells. Upon subsequent contact with the specific allergen, the primed mast cells are able to detect the foreign substance and release histamines and other mediating agents into the body. Among histamine’s effects on the body are redness, warmth, and edema or swelling as well as attraction of other inflammation mediators to the site of histamine release. Perhaps the clearest and most apparent example of histamine release is seen at the site of a mosquito bite shortly after contact. The mosquito saliva is detected as a foreign substance and mast cells gather to release histamine, which in turn creates a raised, red wheal. Antihistamines which may be taken orally fight allergic reactions like swelling and itching, but regrettably do very

little to fight bronchoconstriction. Histamines are only one chemical compound among many (including B lymphocytes) that cause constriction of the airways during inflammatory states, so the antihistamine has no effect on any other mediating chemicals.32

Several factors may be responsible for the abnormal narrowing of a patient’s airways characteristic of asthma, including epithelial damage. Epithelium is the term used in medicine for the outermost surface of an organ, for instance the epidermis is the outermost surface of the skin. In pulmonology the respiratory epithelium refers to the layer of cells lining the airways, providing a protective barrier against infection. The respiratory epithelium is lined from the nose to the alveoli with cilia or hair-like structures that are responsible for transporting mucous up the airways to capture particulate matter.33 When these cells are damaged, they can peel away leaving the airways vulnerable to infection and hyper-responsiveness. The respiratory epithelium also harbors chemical mediators for inflammatory response, so in the absence of these enzymes penetration by allergens is at increased risk.34

Over-production of mucous in the airways is also a common cause in asthmatics for reduced function of the airways. Mucous hypersecretion occurs when mucosal glands hypertrophy or multiply and expand. The increased levels of secretion occlude the airways and can form mucous plugs. Hypersecretion does not cause the airways to constrict but rather blocks the normal movement of air.35

32 Calman Prussin and Dean D. Metcalfe, “IgE, Mast Cells, Basophils, Eosinophils,” The Journal of Allergy and Clinical Immunology (February 2010): 73-80.
35 Ibid.
Edema is swelling in areas of the body caused by microvascular leaks of fluid into nearby tissue. Regarding respiratory edema, small blood vessels or capillaries in the walls of the airway dilate and leak fluid, causing the tissue to swell. This leakage can lead to excessive secretions and may impact the facility with which epithelial cilia are able to remove the secretions. All of these factors play a role in the narrowing of airways.36

Bronchospasms or bronchial spasms are attributable to the abovementioned release of histamines by mast cells upon contact with foreign particles. This type of spasm is characterized by sharp contractions of the smooth muscle surrounding bronchioles that create airway constriction as seen in Figure 5.2. Use of beta blockers pose a theoretical risk of bronchospasms during respiratory stress in asthmatics and is of particular relevance to those musicians who use the drug as a relief from performance anxiety.37

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37 Alex Marsh et al., "Housing Deprivation and Health: A Longitudinal Analysis," Housing Studies 15, no. 3 (September 2017): 411.
Remodeling of airways refers to the process by which smooth muscle hardens and becomes stiff. In cases of poorly controlled asthma, patients are at particular risk for changes in structural tissue and may experience irreparable damage to these muscle fibers. Over time smooth muscle becomes infected and mucinous glands that produce secretions hypertrophy. This expansion of mass in the airways increases the thickness of the muscle wall and occludes the lumen or the space inside the bronchiole through which air travels. Only use of an inhaled corticosteroid can temporarily calm inflammation and open these passages again, and frequent inattention to this matter or neglect to use appropriate medication will retrain and remodel this structural tissue.

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Similar to the permanent restructuring of bronchiole muscles in airway remodeling, a patient may develop a “barrel chest” due to levels of air trapped in the lungs. Typically an asthmatic will have a harder time exhaling than they do with inhaling because of bronchiolar collapse occurring on expiration, which compresses the bronchioles. This compression coupled with likely higher levels of thick, mucinous excretions lead to severe respiratory obstruction. A “hunger for air” or dyspnea develops as a result of “dead” or unused air trapped in the lungs, and over time the intercostal muscles of the ribcage restructure to accommodate the expansion of the chest cavity, forming a “barrel chest.”

The Effects of Popular Breathing Exercises on Lung Function

I met with two experts in the field of pulmonology local to Miami, Florida to learn more about the pathophysiology of asthma when treated with various popular breathing exercises. Ahmad El Khatib, MD is a fellow at Jackson Memorial Hospital who has received certification in Internal Medicine and is board-certified in Pulmonology. My conversation with Dr. El Khatib centered around the effect on the respiratory system of popular breathing exercises. His responses to my interview prompt (Appendix C) elucidated the inner function of the lungs when subject to a regimen of particular breathing exercises and breath training devices. In a similar interview with Susan V. Benenati, MD, we discussed the physiology of normal or non-asthmatic lungs and contrasted the pathophysiology of abnormal or asthmatic lungs when performing

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breathing exercises popular in the pedagogical canon (Appendix D). Dr. Benenati is board-certified in Internal Medicine and Allergy and Immunology, internship and residency-trained in Internal Medicine and fellowship-trained in Allergy and Immunology at Johns Hopkins University, and has practiced privately for twenty-eight years.

For the purposes of an efficient interview, I categorized the list of popular breathing exercises compiled from the results of the survey into four groups dependent on their intended results. Relaxed breathing exercises are those which rely on as little muscle involvement as possible and promote the free travel of air in and out of the lungs. Relaxed exercises include breathing in for four to sixteen counts and breathing out for four to sixteen counts or any similar breathing meditation. Stress-inducing breathing exercises introduce degrees of muscle involvement typically in an effort to strengthen respiratory muscles by way of resistance. Stress-inducing exercises include rapidly breathing in and out while changing the oral cavity from a “she” syllable (closed teeth, arched tongue, and constricted throat) to a “ha” or “ho” syllable (teeth further apart, relaxed tongue, and opened throat). Another exercise that induces stress or tension involves creating suction against the back of your hand with the mouth and fighting to inhale to capacity in a matter of counts. Stress-inducing breathing exercises can be further classified into the final two categories based on the respiratory muscles they train: maximal expansion breathing exercises and maximal contraction breathing exercises. Maximal expansion breathing exercises seek to expand one’s lung capacity. Maximal expansion exercises include those which require the participant to inhale to capacity then “sip” in bursts of air repetitively before exhaling completely. Maximal contraction
breathing exercises work a participant’s intercostal muscles and diaphragm by exhaling completely before forcing air out further until nothing remains in the lungs. Maximal contraction exercises include a full inhalation followed by a forced exhalation on the syllable “HA” and then a “ssss” noise as one fights to squeeze out all remaining air until empty.

Benenati began our interview with an overview of the physiology of normally functioning lungs. Bronchioles are surrounded by muscle on the outside and lined on the inside with the same tissue that lines the nose and esophagus. Under normal circumstance when you inhale, the musculature surrounding the airways stretch the bronchioles to increase lung volume, and when you exhale the muscles relax and the bronchioles resume a resting position, decreasing lung volume and pushing out air. In an asthmatic the first pathophysiological process initiated when an asthma flare begins is the twitching of the musculature surrounding the bronchioles. The twitching causes the bronchioles to constrict sharply in a process known as bronchospasming. Bronchospasms irritate the lining of the bronchiole and cause inflammation, and as the twitching progresses the airway becomes smaller and smaller as swelling worsens. Swelling and irritation of the bronchial lining encourages the spasm of the muscles, “so you end up with this interplay of muscle spasms and airway lining swelling that keep each other going,” says Benenati.41

This being said an asthmatic has a much lower threshold for response to provocations of the respiratory system than their non-asthmatic counterparts and develop bronchospasms far easier. Participating in certain breathing exercises may only affect the non-asthmatic mildly, but an asthmatic who is exhibiting this immune response may

41 Susan Benenati, interviewed by Steven Eckert, digital recording, Miami, March 5, 2019.
potentially get worse due to undue exacerbation. Even asthmatics whose airways are operating at or around baseline will experience these symptoms to a much lesser degree than those with uncontrolled asthma.

Asthma is a spectrum of physiologic processes that happen in the lungs, and depending on where you are in [the spectrum of severity] at a given moment, these exercises may be helpful or hurtful. The changes that occur with asthma…may affect whether or not these exercises may be either helpful or hurtful in a particular moment in time. They help you at baseline, but if you’re flaring at all, you may find them difficult to do or actually induce worsening symptoms temporarily.42

El Khatib’s thoughts on relaxed breathing exercises started with a basic explanation of asthma’s underlying inflammatory state. When there is ongoing respiratory inflammation, there are plenty of factors of the immune system playing a role at the cellular level. Antibodies for unique antigens are present in the body in varying degrees across individual patients and are responsible for inflammation. So a breathing exercise with the intended purpose of opening up airways and removing unnecessary muscle involvement will likely have nothing to do with the release of immunoglobulins and leukotrienes.

Relaxed breathing exercises, though used frequently by musicians practicing airflow studies, are principally designed for rehabilitating weak or failing respiratory systems and “are geared more towards learning to breathe again,” says El Khatib.

When you do these exercises, you’re going to learn to breathe again the way you should. That would give a lesser sensation of shortness of breath in general, and I think that is where you would possibly perform better as a musician—when you’re optimizing your breathing.43

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42 Susan Benenati, interviewed by Steven Eckert, digital recording, Miami, March 5, 2019.
43 Ahmad El Khatib, interviewed by Steven Eckert, digital recording, Miami, February 23, 2019.
So it appears that relaxed breathing exercises are actually ideal for the asthmatic wind instrumentalist in terms of least inflammatory response and pathophysiological effect on the respiratory system.

Tension-inducing breathing exercises on the other hand have a very different pathophysiological effect according to El Khatib. He answered by first describing the rationale for types of treatment in asthmatic patients. When asthma symptoms are exacerbated in a patient, often times the best method of treatment is not an inhaler but a nebulizer treatment.

The airways of the patient experiencing acute exacerbation are very actively and acutely inflamed. If you give them any form of the metered-dose inhalers that they take, there are minute, finite particles flying around in them. Those particles, even those that are going to potentially help you, will irritate the airway and may cause further symptoms and issues with your breathing.\(^{44}\)

If an asthmatic is already experiencing respiratory inflammation, then avoidance of any and all potential irritants is imperative for treatment. The issue appears to not only involve particulate irritants but also any movement which may be cause for further inflammation.

So when you talk about these potentially tension-causing exercises of the airway, I would say that if your airways are inflamed and you are inducing that form of tension on the airways, then...it can probably cause further issues with breathing or worsening of symptoms. If it’s just slower, unforced breathing, deep breathing, or yoga breathing, that is probably a better way of improving symptoms and possibly functionality and performance.\(^{45}\)

Benenati identified a list of known triggers of bronchospasm, including dry air, cold air, irritants, allergens, and infection. Rapid breathing dries out the airways, stimulating asthma.

\(^{44}\) Ahmad El Khatib, interviewed by Steven Eckert, digital recording, Miami, February 23, 2019.
\(^{45}\) Ibid.
Those [exercises] that might have to do with rapid breathing in and out, that might actually dry out the mucosa, especially those that are done at cold temperatures, may actually stimulate bronchospasm. If you are flaring, it will make it worse. If you’re at a well baseline...you may not tolerate that rapid breathing concept compared to someone whose lungs are completely normal.\(^{46}\)

She warned that exercises involving rapid breathing while changing the oral cavity from closed to open (called “Ee to Oh” in The Breathing Gym\(^{47}\)) will not be helpful for a symptomatic asthmatic, especially if the exercise involves deep inhalations. This will prove to only further provoke someone who is flaring. Rapid breathing or panting exercises may be very helpful in a normal lung, but they can be quite provocative depending on an asthmatic’s placement on the spectrum of severity.

El Khatib’s beliefs on the ability to increase capacity with maximum expansion breathing exercises were inconclusive as there are no extensive studies into the topic in medical research and the few studies in breathing exercises available make contradictory claims. He offers a possible explanation for the dearth of medical research on the topic:

\[\text{[Breathing exercises] used to be very big before all these inhalers came out. During the 1960’s, 70’s, and 80’s is when all of these exercises were first published. And it used to be big back then, but they didn’t have much more to do for the patient...there was little understanding. So they said maybe let’s do these different maneuvers of breathing, maybe they’ll improve. But then inhalers came out, and they stopped doing [breathing exercises]. And now it looks like [physicians are] coming back to them.}^{48}\]

El Khatib did postulate that asthmatic wind instrumentalists who report improvement in lung function correlated with practicing maximum expansion techniques are most likely performing better because of a placebo effect. We know that placebo can be very powerful in eliciting a desired response, and it is very probable that fighting

\(^{46}\) Susan Benenati, interviewed by Steven Eckert, digital recording, Miami, March 5, 2019.
\(^{47}\) The Breathing Gym: Daily Workouts, produced and directed by Andrew Beneze (Phoenix: Next Edge Video, 2008) DVD.
\(^{48}\) Ahmad El Khatib, interviewed by Steven Eckert, digital recording, Miami, February 23, 2019.
perceived sensations of shortness of breath yields greater lung function. Without sensations of shortness of breath, one breathes easier and better; and when one breathes easier, it is possible to perform better.

Benenati argues that maximum expansion exercises cannot hurt the respiratory system unless inflammation is present. However even in the event that a patient is in a flare state with regard to their asthma, the worst that could happen after participating in an exercise such as this would be that the exercise is unproductive or there is an inability to perform the exercise to standard.

What often happens when you’re heading towards a flare or in a flare is that you can actually get airways closing or swelling shut in the most dependent parts of the lungs in what we call air trapping. Air trapping is where your whole lung volume is no longer accessible until you relax that spasm and relax that swelling. Then in those very farthest reaches where the air should go all the way out, there’s air trapping behind spasm and swelling. Once you treat that and once the asthma flare goes away, the far reaches of the lungs are more accessible than they were before.49

If someone is experiencing air trapping, expansion exercises are in effect useless because there is essentially reduced access to the parts of the airways attempting to be inflated. Air hunger can also be a sign of air trapping. In cases like this a patient will feel as if they cannot fully expand the lungs because spasm and inflammation have closed off a swollen area so that it is no longer exchanging gasses in and out.

That exercise in someone with COPD, where air trapping is almost a constant thing…may not be performed to the same state as when their lungs are in a healthier state or compared to someone without asthma…If you can’t perform that, maybe there’s something going on in your lung dynamics that might warrant some exploration into asthma or COPD, in the case of someone who’s been a long-term smoker.50

49 Susan Benenati, interviewed by Steven Eckert, digital recording, Miami, March 5, 2019.
50 Ibid.
With regard to maximum contraction breathing exercises or those intended to strengthen respiratory muscles, I asked El Khatib if exercises such as these could actually strengthen targeted muscles. He was doubtful because again there was no substantial evidence upon which to rely that probed the area of breathing exercises and their validity as muscle trainers. He did however come across a couple exercises in his research which isolates the muscles of the respiratory system.

One of these breathing exercises [is] where you lie down flat, supine on your back, and you breathe…That way you’re relying more on your diaphragm than anything else. Another exercise they teach to those folks with asthma is to breathe from the abdomen and rely less on the accessory muscles of breathing, whether you’re using intercostals or the neck muscles as well…That in turn gives you an idea of how strong these muscles are and how you can take a breath in and exhale. 51

For patients with COPD or those who are smokers, the issues are different from asthma in that the lung tissue breaks down, and there is literally less muscle and tissue to open up. In this way muscle strengthening “may actually help in your breathing,” says Benenati. 52 In asthma however exercises affecting the accessory muscles of the respiratory system are not quite as detrimental so long as the twitchiness or capacity for a spasm is not made worse. If someone practicing maximum contraction breathing exercises or exercises involving the diaphragm and intercostal muscles experiences symptoms such as chest tightness or wheezing as a result, it may be a sign that their symptoms are not fully controlled.

An effective method for gauging the strength of respiratory muscles is of course the FEV1 test or forced expiratory volume in one second, but the issues with a test such as this are the inherent, confounding variables. Improvements in an FEV1 test may be

51 Ahmad El Khatib, interviewed by Steven Eckert, digital recording, Miami, February 23, 2019.
52 Susan Benenati, interviewed by Steven Eckert, digital recording, Miami, March 5, 2019.
indeed attributable to muscle strength but just as well may be a result of the inflammatory state of the airway—how inflamed, obstructed, or narrow it is. El Khatib says, “It’s going to come down to a combination of both [breath exercises and inflammatory state].” Unfortunately the research does not exist at the time of this essay, but in medical research there is always the option to use similar studies as models. “When you don’t have enough research in the world of medicine, you can always look at another similar area and try to extrapolate that information to your area of interest,” says El Khatib.

According to El Khatib, an example from which we can extrapolate information is one involving Aboriginal patients with asthma. In a study by Robert Eley and Don Gorman in Australia, it was estimated that roughly 15% of Australian Aboriginal people had asthma, but management of the condition was reportedly very poor. In an effort to bolster asthma management as well as increase awareness of a culturally-significant instrument, Aboriginal, school-aged boys underwent six months of once-weekly music lessons on the didgeridoo. Respiratory function was significantly increased in the children as a result, and the subjects themselves even reported noticeable improvements in their lung health.

We found out the patients who do some exercise with didgeridoo (maybe a half hour or hour a day) strengthen that area, and there are improvements in their symptoms. So you need to look at [use of inhaled medication] in addition to supplementation with these breathing exercises. That would give you the ultimate optimization of your performance whether you are a musician or athlete or anything along these lines.

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53 Ahmad El Khatib, interviewed by Steven Eckert, digital recording, Miami, February 23, 2019.
54 Ibid.
56 Ahmad El Khatib, interviewed by Steven Eckert, digital recording, Miami, February 23, 2019.
Review of Studies in Kinesiology

The science behind sports and physical activity has developed strongly since around 1885, when the American Association for the Advancement of Physical Education (AAAPE) was established to institutionalize the study of bodily movement or kinesiology. Sports proponents began recognizing the positive health benefits of gymnastics, calisthenics, and physical training on the body as well as the close relation that sports have with medicine and the biological sciences. It is no wonder that the scientific studies in sports medicine and kinesiology have progressed to such a level today as a revered discipline in the medical world, so why have studies in musical health and wellness lagged behind so markedly? It could be said that the musician is nothing more than an athlete competing in an art-sport, where physical fitness related to the mechanics of the body and acute attention to bodily movement are essential to peak performance. Until the compendium of kinesiological-musical studies is further developed, musicians and physicians must glean what they can from academic literature on sports medicine to apply to a musical setting.

In 1968 swimming was officially recognized by authors in the United States as a viable breathing exercise for asthmatic children in combination with traditional therapies because the rationing of air and systematic breathing necessary to swim are great tools for retraining deficiencies in asthmatic breathing. In a Hungarian study published in 2016, Ende László states that regular swimming training in children as a therapy for bronchial asthma has been in practice since 1981 and that young asthmatics have seen great

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increases in their respiratory health. Use of medications like inhaled corticosteroids dropped significantly, severity of the disease lessened, and physical fitness was observed to be at a higher level than children without asthma. László also points out that asthma is most frequent in elite athletes of endurance sports like cross-country skiing, swimming, and long-distance running because the competitors inspire two hundred liters of air on average per minute. This much air intake is sure to inflame airways if ambient conditions are cold and/or dry and pollutants and allergens in the air are higher.58

A 2016 meta-analysis in *Physical Therapy in Sport* of respiratory muscle training in athletes and non-athletes proved the benefits of specific exercises in strengthening the accessory muscles of breathing. Twenty studies were included in the meta-analysis and involved rowers, runners, cyclists, triathletes, and swimmers as well as non-athletic control populations. These studies used several exercises to measure respiratory benefits. One type of exercise used was isocapnic hypernea training in which participants would inflate and deflate a breathing bag at a set metronomic tempo. The tempo was increased by one or two beats per minute (BPM) from an initial thirty BPM over the course of testing, while the volume of the breathing bag was increased incrementally by one or two tenths of a liter over the course of testing. Another exercise used commonly among the studies was threshold load training in which spring-loaded resistance was adjusted on a breath training device to optimize use of respiratory muscles.

in breathing. Devices used in the meta-analysis were the PowerLung™, POWERbreathe®, SpiroTiger®, RT2 training devices like the DeVilbiss RT-Trainer, flow resistance devices, and custom devices.\(^{59}\)

A similar meta-analysis in *Physical Therapy in Sport* from 2018 compared twenty-five studies of inspiratory muscle training in soccer players, basketball players, swimmers, triathletes, cyclists, rowers, runners, rugby players, ice hockey players, and tennis players. By using inspiratory muscle training devices over the period testing, muscle strength improved in every study regardless of the type of athlete involved. Increases in diaphragm thickness and muscle strength, improvements in incremental aerobics, improvements in time-trial performance, improvements in pulmonary function and endurance, and reductions in fatigue were among the benefits reported by studies.\(^{60}\)

A team of scientists from Denver, Colorado developed a series of biphase inspiratory breathing techniques and implemented them with a sample population of sixty-one athletes ranging from high school junior varsity ability to collegiate and professional ability. The breathing techniques are biphase because they consist of a resistance phase followed by a non-resistance phase. Three techniques are described in the article all revolving around the concept of differential inspiratory resistance or high resistance followed by low resistance. The first was the Tongue Variant wherein participants created high resistance by breathing in through the nose. The Tooth Variant created resistance by inhaling through teeth placed firmly over the bottom lip, and the Lip

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Variant witnessed participants creating high resistance by breathing through pursed lips. Each technique was followed immediately by low resistance inspiration through the wide-open mouth. The purpose of the article was to present a breathing strategy that can be used during high-intensity exercise to prevent exercise-induced laryngeal obstruction. In a retrospective survey 66% of participants reported clinical effectiveness of breathing techniques when applied during their sport of choice.\textsuperscript{61}

A study by Yochai Adir and Alfred A. Bove published in the *European Respiratory Review* describes the recommended approach to recreational diving with a self-contained underwater breathing apparatus (SCUBA) for the asthmatic diver. While diving the barometric pressure on the body increases by 1 bar for every 10 meters of seawater descended from a 1.013 bar atmospheric pressure at sea level. An underwater breathing apparatus accommodates changing atmospheric pressure with a pressure regulator, however if ascending or descending too quickly—rapidly changing their intrapulmonary pressure in relation to surrounding ambient pressure—a diver will experience pulmonary barotrauma (PBT) which may cause an abnormal presence of air in the membranous partition between the lungs (pneumomediastinum), a collapsed lung (pneumothorax), or worst of all an arterial gas embolism occluding blood flow. For the asthmatic diver additional risks include bronchoconstriction caused by breathing cold, dry air throughout the dive or by excessive exertion. While diving associations from the UK Sport Diving Medical Committee to the Thoracic Society of Australia and New Zealand unilaterally advise against recreational diving in asthmatics who have experienced an attack in the past two to five years, the study does outline some effective

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strategies for divers with breathing conditions. Adir and Bove conclude that judicious selection of diving locals with attention to temperatures and currents is a key factor in avoiding risks associated with diving for asthmatics as well as adhering to specific diving depth-time limits.\(^\text{62}\)

While yoga is not generally considered to be a vigorous physical activity, its implications for bodily movement make it a candidate for discussion in a kinesiological context. Ramesh Manocha authored an article on sahaja yoga meditation and its effects on asthmatic meditators. Sahaja (meaning “effortless”) yoga meditation is focused around arriving at a state of thoughtless awareness or mental silence in which the mediator is fully conscious but free of unnecessary mental activity. Twenty-one subjects were randomized to the yoga group, while twenty-six were randomized to a control group. All subjects took 1500\(\mu\)g of beclometasone (Qvar\(^\circledR\) inhaled corticosteroid) a day, but the yoga group supplemented their medication with the relaxation practices. Improvement in airway hyperresponsiveness was greater in the yoga group than the control group after two months of intervention. Manocha attributes these results to the alteration of breathing patterns in meditators, where shortening velocity (or the speed at which muscle changes length during contraction) of smooth muscle in the bronchioles is decreased and airway narrowing is reduced.\(^\text{63}\)

A similar study testing the effects of yogic breathing exercises or pranayama on patients with bronchial asthma was published in International Journal of Yoga in 2009. Twenty-five subjects each were randomized to either a pranayama group or control


\(^{63}\) Ramesh Manocha et al., “Sahaja Yoga in the Management of Moderate to Severe Asthma: A Randomized Controlled Trial,” Thorax 57 (February 2002): 110-115.
group. In the *pranayama* group, subjects were taught five yogic breathing exercises. These included deep breathing, *sasankasana* breathing (holding the wrists behind the back and leaning backward on the inhalation and forward to the floor on the exhalation), *anuloma viloma* breathing (breathing through alternate nostrils), *brahmari* chanting (inhaling through nose and exhaling while buzzing the lips), and *omkara* breathing (deep oral inhalation followed by forced, high-pitch exhalation on the syllable “OOOO” until no further exhalation is possible). The first three techniques listed above were to normalize breathing while the last two worked to strengthen expiration. After twelve weeks there was significant improvement in symptoms and lung function in the subjects of the *pranayama* group. The authors attribute this improvement to the strength developed through forceful expiratory exercises like *omkara*, forcing otherwise closed airways—endemic in asthmatics—to open on exhalation. Additionally the expiration of trapped air was a factor in improved lung function; during normal *omkara* meditators exhale for ten to fifteen seconds, but the study altered this breathing technique to extend until failure to exhale was reached, minimizing trapped air.\textsuperscript{64}

### Pathophysiology of Exercise-Induced Asthma

An important component to consider of the symptoms experienced by athletes with chronic asthma is the pathophysiology of asthma brought on by the exercise itself. Exercise-induced asthma is more accurately characterized as exercise-induced bronchoconstriction because the exercise causes narrowing of airways or

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bronchoconstriction but is not a root cause of asthma,\textsuperscript{65} therefore its pathophysiology is slightly different and warrants discussion in this study. This information is pertinent for extrapolation and application to a study in asthma in musicians as both music and sport are forms of strenuous performance that may precipitate the onset of debilitating breathing symptoms. Bouts of exercise-induced asthma are known to exhibit the same symptoms as inflammatory or chronic asthma with the addition of greater-than-normal fatigue and in turn poorer performance.\textsuperscript{66}

Asthmatics typically fall into one of three categories: having both chronic asthma and exercise-induced asthma, having chronic asthma but no exercise-induced asthma, or having exercise-induced asthma but no chronic asthma. The majority of asthmatics fall into the first category, and while roughly seventeen million Americans (6.16\% of total population) reported having chronic asthma in a 1998 study, 90\% of those Americans also reported having exercise-induced asthma. About 10\% did not experience bronchoconstriction triggered by vigorous exercise despite having chronic asthma. Compare this with a 28\% prevalence in non-elite, middle and high school athletes evaluated in a 1992 study by Ned T. Rupp and his team of researchers from the Medical


Collectively from similar studies with elite athletes—those competing successfully at an international level—exercise-induced asthma is more prevalent than non-elite athletes and the general population.68

Olympic Gold Medalist in swimming Tom Dolan, Pittsburgh Steelers All-Pro Running Back Jerome Bettis, and Atlanta Hawks All-Pro Forward Dominique Wilkins are among the gleaming examples of elite athletes with successful sports careers despite their exercise-induced asthma. Dolan remarks:

Every day I’m in the pool, I know I’m getting more out of it than if I were able to breathe normally…It definitely increases my tolerance for pain and forces me to endure a little more than anyone else.69

In fact the threshold for pain alongside increased physical and mental resilience in elite athletes is often viewed as a normal component of their training and perhaps pushes them to perform at higher-than-average levels. Gold Medalist in swimming Amy Van Dyken also has exercise-induced asthma and serves as an advocate for understanding and effectively managing the disease in athletes, reinforcing the message that breathing conditions should not prevent athletes from rising to their true potential.70

Having discussed the prevalence of exercise-induced asthma among athletes and the general population, a discussion on the inner processes of the body during exercise-induced asthma is now in order. The most important triggers of asthma instigated by exercise are all ambient factors such as the temperature of the air inhaled, the humidity of

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inhaled air, and the presence of chemical irritants in an environment. As previously mentioned the nose (and to a lesser degree, the mouth) acts as a humidifier of inhaled air so as not to irritate the airways (Figure 5.3). Particularly cold air and dry air are among the most frequent causes for both chronic and exercise-induced asthma, however these risk factors are further elevated in several outdoor sporting venues. The cold, dry air experienced at higher altitudes is an inherent risk for skiers, snowboarders, hockey players, ice skaters, and other winter sport athletes. Runners and cyclists may also experience airway inflammation due to panting and oral inspiration even in the most humid conditions because of the intensely drying nature of those types of breathing. Chemical irritants are especially at hand in indoor swimming and hockey environments where carbon monoxide, sulfur dioxide, nitrogen dioxide, calcium hypochlorite, and sodium hypochlorite are trapped in a confined space. Inhaling chemical irritants necessitates the release of histamine as described above, causing severe airway tightening and labored breathing.71

Cool air and dry air also contribute to water loss and dehydration of the airways in a process called the osmotic effect. The osmotic effects on cells in the respiratory system lead to bronchial narrowing, dry cough, and overproduction of mucous. When the airway surface loses water, water from adjacent epithelial cells moves out in response to altered osmolarity or the change in concentration of a solution. The body tries to replenish airway surface liquid to shrunken cells in an effort to create a water source for humidifying air. Additionally when cells regain volume upon water absorption, a

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biochemical event occurs similar to those which occur before release of mediators like histamine and leukotrienes as seen in Figure 5.4. Heightened levels of these mediators lead to the bronchoconstriction and cough.\textsuperscript{73}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{osmotic_effect}
\caption{Osmotic Effect and Loss of Airway Surface Liquid.\textsuperscript{74}}
\end{figure}

Non-asthmatics are not immune to the osmotic effect as any loss of airway surface liquid will initiate the process of water replenishment. This explains why even healthy individuals who have never reported having asthma symptoms may experience bronchoconstriction, cough, and overproduction of mucus after participating in vigorous activity in cold, dry conditions. There are more inflammatory cells present in the asthmatic airway, and for this reason the asthmatic experiences hyperresponsiveness to


\textsuperscript{74} Figure 5.4, Osmotic Effect and Loss of Airway Surface Liquid, figure by Jeremy D. Bufford and Robert F. Lamanske, “Exercise-Induced Asthma – Science Direct,” accessed March 9, 2019, https://www.sciencedirect.com/science/article/pii/B9780323042895100402.
cold, dry inhaled air. Production of bronchodilating mediators (chemicals which relax constricted airways) released in the body may become impaired in both healthy and asthmatic patients when dehydration continually injures the epithelial surface.75

**Implications for Further Study**

In my interview with Dr. Ahmad El Khatib, he described an impromptu testing scenario for measuring the effectiveness of popular breathing exercises on asthmatic wind instrumentalists as a means to prove how facile such a test would be for future study. He lamented that he was unable to locate any research that could either confirm or deny the efficacy of breath training devices despite how easy it would be to collect such data.

[Gather] a group of asthma patients, give them the regular treatment that they need, and give them incentive spirometry and peak flow measurements to see what the number is going to be. Have them use the incentive spirometer, let them blow for peak expiratory flow, and see what the measurement is. I couldn’t find anything like that with actual numbers that can say it is getting better or not…And the use of some of these expiratory devices can assist.76

After recording baseline lung function measurements, randomized groups of asthmatic wind instrumentalists would be matched for age, gender, weight, and experience with breathing exercises and administered several a number of trials with a certain breathing exercise. Between trials lung function measurements would be recorded to track components of functionality such as heart rate, vital capacity, forced expiratory volume

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76 Ahmad El Khatib, interviewed by Steven Eckert, digital recording, Miami, February 23, 2019.
per second (FEV₁), and peak expiratory flow (PEF). A comparison of measurements from baseline to post-test would indicate trends in diminishing or improving lung function as a result of performing popular breathing exercises.

Using the summary of breathing exercises and breath training devices reported by participants in the pilot survey as a bank for possible exercises in a test setting, “The Classic” would be an excellent control exercise because of its likelihood to avoid triggering symptoms. This exercise and all of those classified as relaxation breathing exercises were predicted to have the least detrimental effect on asthmatics, and since the aspiration of this study is to categorically identify helpful exercises from hurtful ones, exercises like “The Classic” would be a prime benchmark to which comparisons could be made with more dubious breathing exercises. Based on the conversations I had with experts in pulmonology, any of the breathing exercises from the remaining three categories (stress-inducing breathing exercises, maximum expansion breathing exercises, and maximum contraction breathing exercises) that involve rapid breathing or panting could be implemented in a test setting to demonstrate a potentially detrimental effect to lung functionality. The end goal will of course be to cobble together helpful breathing techniques to create a new pedagogy for asthmatic wind instrumentalists as there exists no such paradigm in education as of the writing of this essay.

With regard to the review of studies in kinesiology, a few key findings can be extrapolated to further development of asthmatic wind pedagogy. Perhaps simply playing a wind instrument is one way in which asthmatics can improve their lung function as demonstrated by regular swim instruction in asthmatic children in László’s study. He found that the rationing of air and retraining of the breath that occurred in
youth swimmers helped with their symptoms, so transitivity it may be assumed that playing a wind instrument alone is enough to retrain the respiratory system in asthmatics. The two meta-analyses from *Physical Therapy in Sport* both proved that use of resistance inspiratory training devices led to improvements in lung function and warded off symptoms of exercise-induced asthma like fatigue and poor performance as well may be the case in asthmatic musicians. The report from Denver scientists demonstrated that external devices are not a requirement to strengthen respiratory muscles and that all one truly needs to work these muscles is the body itself. The two studies in yogic traditions applied to pulmonary function signify meditation and meditative breathing exercises as powerful tools for improved lung function when coupled with traditional medications like inhaled corticosteroids. Finally the in-depth look into the pathophysiology of exercise-induced asthma cautions against a few environmental factors to consider when an asthmatic plays a wind instrument. To avoid the greatest risk of triggering symptoms, it is advised that asthmatics perform where the air is temperate, mildly humid, and free from allergens, chemical irritants, and pollutants. In other words take steps to reduce triggers in performance by ensuring a space is not too cold and dry and that venues are free of common antigens like smoke, mold spores, dust, and animal dander.

**Conclusion**

One element of my research was to extrapolate from the existing research in kinesiology and asthma the implications for asthma in music performance, more specifically asthma in wind instrumentalists. It appears that a certain set of environmental conditions must be achieved for best results in both athletics and musical
performance for the asthmatic whether the disease in question is chronic or exercise-induced. Principally the performance venue must be well-humidified and must be maintained at a warm temperature to avoid triggering asthma symptoms like wheezing or chest tightness. Dressing in layers or in full concert attire is not means enough to prevent flare-ups as the matter of body temperature is inconsequential. The air inhaled should be neither too dry nor too cold. Secondly any measure should be taken to reduce the level of chemical irritants and allergens in the atmosphere of a performance space. Chemical irritants will most likely be less common in the concert halls, practice rooms, and studios of traditional musical environs unless heavy-duty cleaners are used in these spaces. However allergens such as mold spores and dust abound in older, infrequently maintained venues such as churches and historical landmarks and pose a particular threat to the health and safety of asthmatic performers.

I also ventured to gather data on the breathing exercises most popular among wind instrumentalists and received a diverse array of responses from participants of a pilot survey. While most respondents (46.3%) reported utilizing exercises within the relaxation breathing exercise category, a number of respondents (12.6%) also reported partaking in stress-inducing breathing exercises. While participants of the pilot survey were not limited to only those with a respiratory disease, this may perhaps illustrate the unfamiliarity asthmatic wind instrumentalists have with breathing exercises that may prove harmful to their conditions. The breathing exercises listed in the summary from Appendix E may be used as variables in future study in which vital response to exercises are recorded in asthmatic wind instrumentalists.
My final research question involved discussions with physicians and experts in pulmonology on the pathophysiology of respiratory illness and how components of popular breathing exercises may contribute to the onset of an asthmatic response. Ahmad El Khatib, MD confirmed that relaxation breathing exercises were indeed a beneficial practice for asthmatic patients but warned against those that induce tension or stress in patients who were already exhibiting asthmatic symptoms. His thoughts on maximum expansion techniques were inconclusive as there were no data for these types of exercise and their influence on an asthmatic response, though he did believe maximum contraction exercises such as those which utilize diaphragmatic breathing could be of particular import to asthmatic patients. Susan Benenati, MD advised against breathing exercises utilizing panting and rapid breathing as these techniques cool and dry the airways, creating a scenario conducive to triggering asthma symptoms. Neither physician found any evidence to suggest that a breathing device could induce asthma symptoms or an attack.
BIBLIOGRAPHY


Deniz, Omer, Sema Savci, Ergun Tozkoparan, Deniz I. Ince, Muharrem Ucar, and Faruk Ciftci. “Reduced Pulmonary Function in Wind Instrument Players.” *Archives of Medical Research* 37, no. 4 (Amsterdam: Elsevier, 2006).


Figure 5.1. Bronchi, Bronchial Tree, and Alveoli. Figure by National Cancer Institute, “Bronchi, Bronchial Tree, and Lungs.” Accessed February 12, 2019. https://training.seer.cancer.gov/anatomy/respiratory/passages/bronchi.html.


APPENDIX A
April 3, 2019

Aaron Tindall
305-284-1519
atindall@miami.edu

Dear Dr. Aaron Tindall:

On 4/3/2019, the IRB reviewed the following submission:

<table>
<thead>
<tr>
<th>Type of Review:</th>
<th>Initial Study</th>
</tr>
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<tbody>
<tr>
<td>Title of Study:</td>
<td>Winded: Creating a Set of Parameters to Assess the Effectiveness of Popular Breathing Exercises in Asthmatic Wind Instrumentalists</td>
</tr>
<tr>
<td>Investigator:</td>
<td>Aaron Tindall</td>
</tr>
<tr>
<td>IRB ID:</td>
<td>20190212</td>
</tr>
<tr>
<td>Funding:</td>
<td>None</td>
</tr>
</tbody>
</table>
| Documents Reviewed: | • Social Media Recruitment Prompt  
|                  | • Recruitment Advertisement  
|                  | • Informed Consent  
|                  | • Protocol for IRB Approval  
|                  | • Survey |

The IRB approved the study on 4/3/2019.

Attached are stamped approved consent documents. Use copies of these documents to document consent.

NOTE: Translations of IRB approved study documents, including informed consent documents, into languages other than English must be submitted to HSRO for approval prior to use.

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system.
Should you have any questions, please contact: Vivienne Carrasco, Sr. IRB Regulatory Analyst, (phone: 305-243-6713; email: vcarrasco@med.miami.edu)

Sincerely,

[This is a representation of an electronic record that was signed electronically and this page is the manifestation of the electronic signature]

Charles S. Carver, Ph.D.
Chair, Social and Behavioral Sciences IRB
Appendix B
BREATHING EXERCISES AND BREATH TRAINING DEVICES
SURVEY

********************************************************************

PARTICIPANT AGREEMENT:
I have read the information in this consent form and agree to participate in this study. I have had the chance to ask any questions I have about this study, and they have been answered for me. I am entitled to a copy of this form after it has been read and electronically signed by printing a PDF of this document.

Print informed consent here:
https://umiami.qualtrics.com/CP/File.php?F=F_d0iCBMRrAKcLoTb

☐ By checking this box, I consent to participate in this survey and submit my electronic signature
☐ I do not consent

With which gender do you identify yourself more? (Choose one)

☐ Male
☐ Female
☐ Prefer not to answer

What is your age? _____

☐ Prefer not to answer
How would you describe your level of musical performance? (Choose one)

☐ Professional
☐ Graduate Student
☐ Undergraduate Student
☐ Beginning Student
☐ Retired
☐ Hobbyist

Which wind instrument(s) do you play with the above level of musical performance?

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

Do you have a respiratory disorder (asthma, COPD, etc.)? (Choose one)

☐ Yes
☐ No
☐ Prefer not to answer

If you answered “Yes” to the above question, which respiratory symptoms do you experience while playing your wind instrument? (Choose all that apply)

☐ Wheezing
☐ Shortness of breath
☐ Other:

☐ Coughing
☐ Chest tightness/pain
Please indicate any BREATHING EXERCISES with which you are familiar and use on a regular basis. If pertinent, provide brief explanation.

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Please indicate any BREATH TRAINING DEVICES with which you are familiar and use on a regular basis. If pertinent, provide brief explanation.

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__________________________________________________________________________________
(OPTIONAL) Please indicate any BREATHING EXERCISE REGIMENS or PEDAGOGY with which you are familiar. This may include books, articles, websites, videos, or electronic applications.

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APPENDIX C
APPENDIX C
INTERVIEW TRANSCRIPT
AHMAD EL KHATIB, MD
ON-SITE INTERVIEW
Saturday, February 23, 2019,
8:50AM
Miami, Florida

Steven Eckert: My research is focused on the effectiveness of breathing exercises and use of breath training devices in musicians of wind instruments (i.e., flute, saxophone, trumpet) with asthma or a related respiratory disorder. For the purposes of this interview, I would like to understand the pathophysiology of the respiratory system when subject to certain types of breathing exercises or devices which may be effective for non-asthmatics but could actually exacerbate symptoms in those with asthma or COPD. In each of the following questions I will ask about the effect on the respiratory system; try to speak from a pathophysiological perspective or through the lens of what is actually happening inside the body. With that being said, how do simple, relaxed breathing exercises affect an asthmatic’s respiratory system? Simple, relaxed breathing exercises could be breathing in for four to sixteen counts and breathing out for four to sixteen counts while maintaining a free and open airway or any similar breathing meditation.

Ahmad El Khatib: In general when we talk about asthma, we need to have a general understanding of what the disease is. It’s very complex, but if you want to simplify it down as much as possible, it is a disease of inflammation of the lungs. There are many different phenotypes when we talk about asthma. We know much more about it now than we did in 1960 or 1970, and that has made us understand better what happens but at the same time it showed us that we knew so little about it before. So when you talk about the disease itself and the pathophysiology, then you need to have a general understanding of the underlying inflammatory state of every single patient, and it’s not always the same—that’s key. When you have ongoing inflammation, you have a lot of different factors of your immune system that are playing a role. Whether it’s on the cellular level, whether it’s on the molecular level, you’re talking immunoglobulins and leukotrienes. And those are what’s key, and are basically either making the disease active or not or what the activity is. That area is going to tell how bad the disease is right now and possibly in the future for that particular person. So when we talk about these breathing exercises, you have to ask yourself, “Are they affecting [you on the molecular level] or not?”

Whether it’s the slow breathing where you have to relax or the yoga breathing, etc., what it comes down to with these breathing exercises is that they are geared more towards learning to breathe again. Because asthmatics tend to hyperventilate or breathe fast, that is a problem. You kind of forget how to breathe, and why does that happen? The sensation of shortness of breath. When you’re short of breath, you try to “get more
air,” so you sometimes breathe fast, faster than you should be doing. And that’s when you throw off your inspiratory-expiratory time, which should in general have more or less fixed intervals. When you do these exercises, you’re going to learn to breathe again the way you should. That would give a lesser sensation of shortness of breath in general, and I think that is where you would possibly perform better as a musician—when you’re optimizing your breathing. Now whether that affects the inflammatory level of the cells we discussed earlier and those molecular markers, I’m not really sure. I don’t think so.

SE: Some breathing exercises encourage a degree of tension in the mouth and/or throat. For instance, rapidly breathing in and out while changing the oral cavity from a “she” syllable (closed teeth, arched tongue, and constricted throat) to a “ha” or “ho” syllable (teeth further apart, relaxed tongue, and opened throat). Another tension exercise involves creating suction against the back of your hand with the mouth and fighting to inhale to capacity in a matter of counts. How do breathing exercises that encourage tension affect an asthmatic’s respiratory system?

AEK: When you talk about irritation to the airways of asthmatics, it will come down to how bad are your airways inflamed right now. For example, when you’re having an acute exacerbation of your asthma, one of the things we look for and try not to do is give them the actual inhaler. We prefer nebulizations as treatment. Why? The airways of the patient experiencing acute exacerbation are very actively and acutely inflamed. If you give them any form of the metered-dose inhalers that they take, there are minute, finite particles flying around in them. Those particles, even those that are going to potentially help you, will irritate the airway and may cause further symptoms and issues with your breathing. And that’s why we prefer to do more nebulized treatments than anything else. [We like to use] the systemic intravenous steroids, for example, more than just those inhaled at that point. So when you talk about these potentially tension-causing exercises of the airway, I would say that if your airways are inflamed and you are inducing that form of tension on the airways, then yes it can probably cause further issues with breathing or worsening of symptoms. If it’s just slower, unforced breathing, deep breathing, or yoga breathing, that is probably a better way of improving symptoms and possibly functionality and performance.

SE: You say that regardless of whether it’s a relaxation-focused exercise or one that might introduce some degree of tension, it really does not have an effect on the cellular level.

AEK: I think so. It’s more geared to relief from anxiety and the shortness of breath. The sensation of shortness of breath is amazing. There are many things that can cause you to be short of breath. It’s just how you deal with it and how you try to adjust it. You do these exercises that teach patients how to prolong their expiratory phase, decreasing the respiratory rate in general from breathing too fast to breathing slower, and in turn you will be able to exhale longer. And that can help you feel better and less short of breath.

SE: Typically in an asthmatic, the issue tends to be with expiration. Inspiration is not as affected.
**AEK:** Correct. Asthma is an obstructive lung disease geared by the inflammation that we talked about earlier. A little bit of background on that: in general, when we talk about lung disease, there are two big families of those diseases. There is an obstructive lung disease and a restrictive lung disease. You can have both at the same time, I’m not saying that they can’t coexist. It’s just that asthma on its own is the obstructive lung disease. And that means when you’re trying to exhale, you have difficulty with getting all that air back out again. So yes, it’s the expiratory portion of breathing that is most affected by asthma.

**SE:** Other breathing exercises seek to expand one’s lung capacity. One exercise requires the participant to inhale to capacity then “sip” in bursts of air repetitively before exhaling completely. How do exercises geared towards expanding lung capacity in this way affect an asthmatic’s respiratory system?

**AEK:** This is where I don’t think there’s enough research on this topic, and that’s what a lot of these [articles] mention. There’s unfortunately a lot of contradictory information. Some of these articles say that breathing exercises can improve lung function. A lot of them say that they don’t do much. In theory when you tell me that you perform better, that’s probably geared more towards a placebo effect. It’s probably because you are actually breathing easier or breathing better that you can actually perform better.

In terms of improvement with actual, objective data and the metrics that we look at for pulmonary function testing, the data here is contradictory. Some would say, “Yes, there is improvement in your functional vital capacity or your FEV1 or total lung capacity.” Some say that there is no difference. Even the review articles on the meta-analyses mention a lot about the quality of life, a lot about the use of inhaler, and they looked at function tests as well. I think they had twelve or thirteen articles included in that meta-analysis. Six of them mention that there is some improvement of your lung function, but it doesn’t look like the rest did. They weren’t able to statistically give us good information about it because they said there is a lot of heterogeneity in the information. Every study was way different than the other one—how many patients they had enrolled, what kind of breathing exercises they were doing, the duration of treatment—so if you want to statistically put down the numbers, it won’t really be doable. So that was a disappointment for me, I wanted some type of information, just a number. But they couldn’t incorporate that.

Again some of the smaller studies said that they actually saw improvement. The main issue with this article [Saxena, Pranayama] is that the number of patients is only fifty. We always like to see more people. There is a lot of contradiction here. The verdict is not out there yet to say, “yes” or “no.” I think because there have been a lot of advancements pharmacologically, the disconnect happened. What I read and what I learned about this topic is that it used to be very big before all these inhalers came out. During the 1960’s, 70’s, and 80’s is when all of these exercises were first published. And it used to be big back then, but they didn’t have much more to do for the patient back then. There was little understanding. So they said maybe let’s do these different maneuvers of breathing, maybe they’ll improve. But then inhalers came out, and they stopped doing [breathing exercises]. And now it looks like they’re coming back to them.
SE: Conversely others work their intercostal muscles and diaphragm by exhaling completely before forcing air out further until nothing remains in the lungs. Can we actually strengthen muscles like the diaphragm and intercostal muscles in this manner? And what are the effects of these muscle workouts on an asthmatic’s respiratory system?

AEK: Excellent question, but the very short answer is: we don’t know. I found zero research on that topic to be honest with you. I did find one of these breathing exercises where you lie down flat, supine on your back, and you breathe. And that way you’re relying more on your diaphragm than anything else. Another exercise they teach to those folks with asthma is to breathe from the abdomen and rely less on the accessory muscles of breathing, whether you’re using intercostals or the neck muscles as well. Does that really work? Objectively and as far as numbers we can measure, I don’t know. It’s easily doable because in part of the pulmonary function test, you measure the maximum inspiratory force and maximum expiratory force. And that in turn gives you an idea of how strong these muscles are and how you can take a breath in and exhale. The problem with looking only at regular function tests like vital capacity is that it can be related to muscle strength of your breathing but it also has to do with the airway itself and how inflamed it is, how obstructed it is, and how narrow it is. So for example, the FEV₁, which is how much you can exhale in one second, is going to differ a lot whether your airways are obstructed or open. And that’s exactly what we see in asthmatic patients. You do it before you give the bronchodilator, you do it after you give the bronchodilator, and there’s a significant response. So unfortunately there’s more than just the muscle factor as a variable in how much you can exhale or how strongly and easily you can exhale. It’s going to come down to a combination of both. In theory, I think it should be doable. Unfortunately there’s not much research that I came across. But here’s the thing: when you don’t have enough research in the world of medicine, you can always look at another similar area and try to extrapolate that information to your area of interest. I can tell you in patients with COPD, let’s say, or smokers with bad COPD, we really gear their management in a way to incorporate something we call pulmonary rehab. Pulmonary rehab basically is rehab geared towards your breathing in combination with your exercise in the past, and we try to improve both at the same time. It enhances muscle function, it improves skeletal muscle function, and how well you can perform on a capacity level function. So if you want to take that and extrapolate that into how strongly you breathe or maybe getting an incentive spirometer and work on that as well, in theory I think it should work. Another example I can think of is when we talk about obstructive sleep apnea, for example. There are a lot of exercises and maneuvers, for example playing the didgeridoo. And to understand that a little more, when you talk about obstructive sleep apnea, it’s the musculature of the soft tissue at the back of the throat that starts to “sag” and collapse and cause breathing issues in your sleep. We found out the patients who do some exercise with didgeridoo (maybe a half hour or hour a day), strengthen that area and there are improvements in their symptoms.

The primary thing again is going back to the inflammation that occurs in the airway—that is the mainstay of the disease of asthma. That is where all the treatment is mainly geared to target more than anything else. You don’t only hear about how much you can exhale, though obviously you want your patients to feel well and function properly and be able to perform better. If you don’t treat asthma as a condition, the
inflammation progresses to a degree that remolds the airways, and that is potentially irreversible in the end, very detrimental to the patient. And that’s where all the information has been geared to—calming down that inflammation. That’s why inhaled corticosteroids will in my opinion be a mainstay of therapy for a very, very long time unless something new comes about after that. So you need to look at that in addition to supplementation with these breathing exercises. That would give you the ultimate optimization of your performance whether you are a musician or athlete or anything along these lines.

SE: Just to go back to this idea of remodeling, you’re talking about the hardening or stiffening of smooth muscles surrounding the bronchioles.

AEK: When you talk about the inflammation that occurs in these airways, there are different components pathologically and pathophysiologically which are playing a role. One: the smooth muscles are for sure getting infected. Two: the mucinous glands that produce all the secretions have hypertrophied and there are more of them. And the overall thickness of the wall increases, thus occluding the lumen of the inside. That’s where the problem comes in. And when you take the inhaled corticosteroid, it’s going to act locally on these airways, calming down the inflammation and hopefully keeping them quiescent as long as possible. And thus the lumen would open even more. The inhaled bronchodilator that you take as a rescue inhaler acutely acts on these muscles to try to open the airway up. It doesn’t calm the inflammation, though.

SE: Could we replace use of a bronchodilator with a certain set of breathing exercises if it’s not so much about the inflammation and more about opening airways?

AEK: I think they should be used together, hand-in-hand. I don’t think the inhaled steroid is replaceable by anything because it’s just pharmacology. You need the inflammatory state to calm down a little bit, and the steroid is the only way to do that; at least one of the ways, but it’s the best way we have right now. When it comes to the short-acting bronchodilator, concurrent use with some breathing exercises is probably better than breathing exercises alone.

SE: Musicians also use external devices to help train the breath. Some will opt to purchase manufactured devices like incentive spirometers or inspiratory/expiratory muscle trainers while others have fashioned their own devices from lengths of PVC pipe or rubber hose. What are the effects on an asthmatic’s respiratory system when using such devices to train the breath, especially when degrees of resistance are added?

AEK: I think subjectively that you do feel better for sure when you do these maneuvers and exercises. I would have loved to see some data about that, but I couldn’t find any articles. But it would be very simple to do. Have a group of asthma patients, give them the regular treatment that they need, and give them incentive spirometry and peak flow measurements to see what the number is going to be. Have them use the incentive spirometer, let them blow for peak expiratory flow, and see what the measurement is. I couldn’t find anything like that with actual numbers that can say it is getting better or not.
But again some of the articles here say there is some improvement with these breathing exercises. And the use of some of these expiratory devices can assist.

SE: Many asthmatics must use their inhaler in tandem with breathing exercises when symptoms are triggered. Is using an inhaler during breathing exercise just a requisite step for an asthmatic to achieve intended results? Or should use of the inhaler alert an asthmatic that an exercise is harmful to their growth?

AEK: Excellent question! Like you said, it’s going to be geared towards every single patient differently. It all stems back to the fact that in the world of asthma, it’s not just one disease, there are a lot of phenotypes. And a lot of cells in your inflammatory system and immunology are acting, but we don’t know if you’re going to have this particular set of cells that are going to play a role in making the disease worse or if you are going to have another one. We’re not really sure. And that’s why every single patient may be different than the other one. Is it going to replace taking the inhaler? I don’t know. It’s difficult to tell. Definitely you may feel worse with some of these breathing exercises, but the whole point is to maximize and optimize your breathing and performance. And taking the inhaler first is definitely going to improve your lung function.

That being said, there’s a lot of data from the articles that I have here. The folks that did the breathing exercises didn’t need to use the rescue inhaler as much anymore, they didn’t get to be short of breath. But then again, I’m not sure if they were “performing” at a level of a musician or an athlete. They didn’t mention things like that, but there seems to be not only a trend but some evidence that seems to be statistically significant as well that these patients don’t necessarily have to use their rescue inhaler as much anymore. The way we actually follow up with patients in our clinic when we see asthmatics is by asking a set of questions, one of which is, “How many times do you use your inhaler a day?” Not only during the day but during the night as well. This is one of the things we’ll look at to judge and make a decision whether this patient is having his symptoms and asthma controlled or not. I’m sure you’re familiar with the ACT [(asthma control test)] score as well, which is where you calculate a questionnaire given to the patient (zero to five) for every [question]. And they say how well their asthma symptoms are controlled, how many times they’re wheezing, what is their use of the rescue inhaler, how do they feel about their control of their symptoms and asthma. And we’ll look at that and say, “Okay, this person has good control of their systems. Let’s try to cut back now on their inhaled steroid or other bronchodilator a little bit and see how they do.” So maybe that is also a contradictory factor in the fact that you’re not using your rescue inhaler as much anymore. Maybe the asthma is more quiescent now; maybe it’s more controlled. I don’t think we can know if it’s exactly this or that—if it’s the breathing exercises or your disease is just not as bad now. Just in the past decade or so, we’re learning more and more about asthma and what it is. We come across patients that are so difficult to treat. I mean, it’s asthma; you’re diagnosed and the methacholine challenge is confirmed and everything, but they’re super difficult to treat. Why? Again it’s going to stem down to what the inflammatory state of that person is. It’s a different set of markers in the blood and leukotrienes and a different type of pathway of cells that are involved in causing asthma in that particular patient which doesn’t necessarily respond to steroids. So it’s a lot more complex than we knew before. And I think that may be where the main
issue is: to say whether it is the breathing exercises or controlling the symptoms. But we know for sure that the inflammation needs to be taken care of by the inhaled steroid. Again I can tell you for sure from what I’ve seen and your own personal experience, that if you use the breathing exercises, you don’t need to use your rescue inhaler as much and that’s always a good sign.
Steven Eckert: My research is focused on the effectiveness of breathing exercises and use of breath training devices in musicians of wind instruments (i.e., flute, saxophone, trumpet) with asthma or a related respiratory disorder. For the purposes of this interview, I would like to understand the pathophysiology of the respiratory system when subject to certain types of breathing exercises or devices which may be effective for non-asthmatics but could actually exacerbate symptoms in those with asthma or COPD. In each of the following questions I will ask about the effect on the respiratory system; try to speak from a pathophysiological perspective or through the lens of what is actually happening inside the body. With that being said, how do simple, relaxed breathing exercises affect an asthmatic’s respiratory system? Simple, relaxed breathing exercises could be breathing in for four to sixteen counts and breathing out for four to sixteen counts while maintaining a free and open airway or any similar breathing meditation.

Susan Benenati: A useful scenario would be to set the stage for exactly what goes on pathophysiologically in asthma, and give you a sense of when and where these might be more applicable. Fortunately or unfortunately for the asthmatic, asthma is not a fixed moment in time. The changes that occur with asthma—there may be baseline abnormalities that might not bother you at a particular moment, but under certain circumstances where there are triggers present or your asthma flares—may affect whether or not these exercises may be either helpful or hurtful in a particular moment in time. Asthma is a spectrum of physiologic processes that happen in the lungs, and depending on where you are in that spectrum at a given moment, these exercises may be helpful or hurtful. They help you at baseline, but if you’re flaring at all, you may find them difficult to do or actually induce worsening symptoms temporarily.

The concept is that under normal circumstances the airways—we’re talking about the breathing tubes, themselves—are tubes that are surrounded by muscle. The whole process is a combination of a lined tube—the tube is lined by the same tissues that line your nose and that you’re very familiar with under allergy and other inflammatory circumstances can get inflamed and swollen, but the outside of the tube is muscle. Under normal circumstances, those muscles, when you inhale, help to increase your lung volume by stretching out those bronchioles. And when you exhale, they come back to a resting position. When asthma occurs (again on a whole spectrum of severity) the first thing that happens when you first start to get tight is the muscles themselves start to get
twitchy and may spasm. So the first sign that things are just a little tight is spasm of the muscles. As the spectrum of asthma severity gets worse, the linings of the airways get more inflamed. And the more inflamed and swollen they are (of course the smaller the airway, the smaller the amount of air you’re going to pass) there’s kind of a cellular communication between inflamed linings and muscles. And those muscles get twitchier, so you end up with this interplay of muscle spasms and airway lining swelling that keep each other going.

So the reason I’m setting that stage is even people that have asthma and even when they’re doing well, their interplay is a lot twitchier so to speak than normal lungs. If you do provocative things to asthmatic lungs even when they’re well, their threshold for responding to those provocative things may be much lower. And in fact that’s often how we will diagnose people who we’re not sure if they’re asthmatic or not; by literally kind of doing provocative things and seeing at what level they respond to them. Because normal lungs will respond up here, but asthmatic lungs will respond at a much lower provocation. In that setting, there are some things that cross over into what may be some of these exercises, and we can go through them one-by-one and talk about which ones may or may not be affected. Someone in a baseline asthma situation may be affected mildly, someone who’s flaring may actually potentially get worse doing those because that may exacerbate that interplay and make those twitchy muscles more twitchy.

This is what’s going on in the bronchioles. That’s different than what’s going on in the intercostals and the diaphragm, etc. So as we go through your different exercises, we can kind of say, “This is likely or not likely to be affected by someone at baseline in asthma or if they’re flaring in asthma.” If they’re doing well and they’re well-controlled, this part isn’t so important. If they’re on the border, this part may play into whether or not they can complete those exercises or whether those exercises may actually temporarily make their asthma even worse.

I might group things in categories as those that are predominantly intercostal or diaphragmatic—when your asthma is flaring, those exercises are not a bad idea to help build those strengths. In COPD, especially in musicians who have smoked and maybe go on to have COPD, the problem is different from asthma in that the lung tissue breaks down so you literally have less muscle, less tissue to open up. Everything kind of coalesces, so whatever you are able to do with the muscles of the diaphragm (and I think the intercostals) may actually help in your breathing, whereas in asthma that’s not as important. Those things that affect intercostals and diaphragms shouldn’t hurt asthma, per se. Those things that will potentially affect the twitchiness of the muscle or affect the thresholds at which asthma may get worse are going to be the things that may need to be cautioned against or avoided when you’re in an asthmatic flare. They might even tell you, if you’re doing them and things aren’t going well, that maybe you’re not at a good baseline and you should be paying attention to your asthma.

There are some known things that will be triggers of spasm of the muscles here or bronchospasm as we call it. Dry air, cold air, irritants, etc., and of course allergens and infection and all of those things are known to exacerbate asthma. So rapid breathing, which will dry out the airways, is a known stimulant to asthma. There are pulmonary function tests and asthma tests that are built around rapid breathing to see what can you tolerate in terms of rapid breathing. That same concept of a threshold of an asthmatic even when they’re well is going to be at a lower threshold of what they can tolerate with
rapid breathing than a normal lung. Those that might have to do with rapid breathing in and out, that might actually dry out the mucosa, especially those that are done at cold temperatures, may actually stimulate bronchospasm. If you are flaring, it will make it worse. If you’re at a well baseline (an asthmatic even when well), may not tolerate that rapid breathing concept compared to someone whose lungs are completely normal.

SE: Some breathing exercises encourage a degree of tension in the mouth and/or throat. For instance, rapidly breathing in and out while changing the oral cavity from a “she” syllable (closed teeth, arched tongue, and constricted throat) to a “ha” or “ho” syllable (teeth further apart, relaxed tongue, and opened throat). Another tension exercise involves creating suction against the back of your hand with the mouth and fighting to inhale to capacity in a matter of counts. How do breathing exercises that encourage tension affect an asthmatic’s respiratory system?

SB [Regarding the exercise of changing the oral cavity described above]: If the intention is to include as deep a breath with each one of those inhalations and really involve the lung dynamics in those, then I would expect that to be something that might be provocative in someone less so at baseline, more so in a flare. That may exacerbate the twitchiness of the airways. So something like that would not be helpful in an asthmatic. It might actually be provocative—less provocative at a baseline that isn’t normal—and the understanding is that most asthmatics by definition even at baseline aren’t normal, that their threshold for reactivity is going to be much lower than a normal lung. That exercise may be very helpful in a normal lung, but not tolerated and in fact provocative depending on where an asthmatic is on their spectrum of severity.

SB [Regarding the exercise involving suction against the hand described above]: You’re using more accessory muscles. You will see accessory muscle use as a very important sign of someone who’s having significant respiratory distress. So when you are calling on those muscles, that’s a sign of significant respiratory distress. If the question is “Is there an advantage to strengthening those muscles?” we teach people with severe COPD how to purse-breathe, how to utilize those muscles when they can. But the flipside is: if someone’s utilizing those, it means that they’re already too far gone. But in an asthmatic patient who is somewhat controlled, those types of maneuvers wouldn’t be as detrimental.

SE: Other breathing exercises seek to expand one’s lung capacity. One exercise requires the participant to inhale to capacity then “sip” in bursts of air repetitively before exhaling completely. How do exercises geared towards expanding lung capacity in this way affect an asthmatic’s respiratory system?

SB: If the question is, “Is this a provocative situation in an asthmatic versus will this help someone with asthma perform better?” I don’t know. It couldn’t hurt unless you’re already in a flare. The only potential I would recognize there is that you may not be able to perform it well. It’s not that it would make it worse, but you’re not going to be able to perform it as well when you’re in a flare because what often happens when you’re heading towards a flare or in a flare is that you can actually get airways closing or
swelling shut in the most dependent parts of the lungs in what we call air trapping. Air trapping is where your whole lung volume is no longer accessible until you relax that spasm and relax that swelling. Then in those very farthest reaches where the air should go all the way out, there’s air trapping behind spasm and swelling on the farthest reaches of the lungs. Once you treat that and once the asthma flare goes away, the far reaches of the lungs are more accessible than they were before. When there is air trapping going on—sometimes that can happen in low-level asthma that’s just there simmering for a long time or at some stages of an asthma flare—you may have a very different experience when you are trying to do [expansion exercises] when you’ve got air trapping going on and you really don’t have access essentially to some parts of the airways you’re seeking to inflate.

Air hunger can be a sign or a symptom of air trapping in that you feel like you can’t fully expand because in fact you can’t. You have trapped air. Again this spasm and inflammation has effectively closed off or trapped air behind a swollen area so that it’s no longer exchanging in and out. It’s kind of trapped there.

That exercise in someone with COPD, where air trapping is almost a constant thing, or in someone with asthma as a characteristic of where they are at that moment (and that can change), may not be performed to the same state as when their lungs are in a healthier state or compared to someone without asthma. The flipside of that may be: if you cannot perform that normally, it might be a little red flag saying, “Uh oh, something’s impending.” If you can’t perform that, maybe there’s something going on in your lung dynamics that might warrant some exploration into asthma or COPD, in the case of someone who’s been a long-term smoker.

**SE:** In a patient with trapped air over several years, a barrel chest may develop because of muscular accommodation in the ribcage. Is that correct?

**SB:** That’s more common in people with COPD than with pure asthma because air trapping is usually a lot more transient, a lot less permanent in asthma than in COPD.

**SE:** Musicians also use external devices to help train the breath. Some will opt to purchase manufactured devices like incentive spirometers or inspiratory/expiratory muscle trainers while others have fashioned their own devices from lengths of PVC pipe or rubber hose. What are the effects on an asthmatic’s respiratory system when using such devices to train the breath, especially when degrees of resistance are added?

**SB:** I would expect that those that create resistance, when you’re well, might help to train the muscles and strengthen the muscles. If you’re not perfectly well, those may actually exacerbate some of the asthma symptoms or may be hurtful in that setting. If those muscles spasm or if those muscles around your bronchioles are twitchy and you’re working them really hard, it would be similar to exercise that, when an asthmatic is not in a normal state, can take you from no symptoms into symptomatic just by stressing the muscles around the bronchioles. Those that create the resistance may not be an advisable thing for an asthmatic unless they are under really good control.

All of this conversation can be summed up as: an asthmatic can be under good control and should be able to do the things they need to do if they’re under good control,
often with medication and by controlling their triggers and things like that. An asthmatic under control, on the appropriate medications, may be able to do some of those things. Will they benefit from them? Listen to your body. If doing those exercises seems to induce any asthmatic symptoms, it’s not advisable to be doing those. I would put devices like the resistance inspiratory-expiratory trainer in the category of “could be a potential issue for an asthmatic,” either to be able to perform or exacerbate a borderline or flaring asthma situation.

Are those helpful in getting an asthmatic to be able to improve their lung function or perform? I don’t know. I would be interested in knowing if there is any healthful effect in doing these types of things that either create tension or work the muscles either externally or around the bronchioles. When you’re under good control can you improve your lung function? I think the overall sense is that if they’re done when you’re not flaring and you listen to your body and do them to tolerance, there can certainly be a helpful effect over baseline. That’s what pulmonary rehab is all about. COPD patients have a series of exercises and rehabilitation regimens to try to optimize what they’ve got.

SE: When we talk about a patient’s control of their asthma, how do we measure control?

SB: There are definitely scoring systems that ask question to which the answers reflect things that are likely to be effected depending on your degree of control. There are a number of well-validated questionnaire tools that essentially design the questions to get at parameters that reflect control. So how often you have symptoms, how often you’re woken at night, how often you use your inhaler are all reflective of the level of control that you have. Some of those questionnaires also include your spirometry numbers and where they are as a percentage. There definitely are validated question systems that as you answer the questions, you score a number. And that number, depending on the range of the numbers, can give you a sense of whether you’re well-controlled or not. And the value of them is often not just in the moment of taking those validated questionnaire tools but also over time. You can use those tools to see where you are in the moment, but if you’re doing them over the course of months, you can get a sense of whether you are stable or unstable over time. So yes, there are tools and well-validated questionnaire tools that seem subjective, but the subjective questions are based on pulmonary parameters and parameters of control that are going to influence the results or the content of that question.

SE: Many asthmatics must use their inhaler in tandem with breathing exercises when symptoms are triggered. Is using an inhaler during breathing exercise just a requisite step for an asthmatic to achieve intended results? Or should use of the inhaler alert an asthmatic that an exercise is harmful to their growth?

SB: The concept would be the same in an athlete. If you pre-treat with an inhaler before you perform (or do a breathing exercise before your soccer game) is that harmful or is that helpful? If you are going to do it and you are having trouble, then pre-treating is a requisite before you can continue. If you don’t use the inhaler before an exercise like that, you may not be able to continue without it. If use of the inhaler makes you ask
yourself if you should continue it, I think the answer would likely be: listen to your body, use the inhaler. And in spite of the inhaler, if you’re still having trouble, by all means please listen to your body and don’t proceed further. If there is data that any of these exercises improves your capacity and you are able to do them with the help of the inhaler, then by all means use the inhaler. But if in doing so even with the inhaler, you are having trouble, you should not push through it if the inhaler doesn’t fully relieve your ability to perform.

If you find an exercise gives cause for the use of an inhaler, that is a red flag. And there are two parts to that. Should you continue? Well, you can take the inhaler and see if you are able to continue. If you are able to continue comfortably and you listen to your body, go ahead and continue. But if you’re not already aware that there is an asthma issue going on, that’s a red flag to tell you, “This is not normal.” If you’re not already on adequate controller medication, that should be your alert that something is going on and you are not adequately controlled. In all of those validated tools and as we have done in our day-to-day practice, use of inhalers is a barometer for control. The point is not don’t use your inhaler unless you absolutely have to, it’s use your inhaler when you need to. But use that as your barometer for control, and if there is a consistency to using the inhaler—if you are using it two times in a day or two days in a week—it implies that you are not in good control and additional intervention is necessary to get you in better control. This is a red flag that you may not be in good control, especially if it’s at a consistent rate.
APPENDIX E
# SUMMARY OF POPULAR BREATHING EXERCISES, DEVICES, AND PEDAGOGIES

<table>
<thead>
<tr>
<th>Popular Breathing Exercise</th>
<th>No. of Respondent Mentions*</th>
<th>% of Respondent Mentions*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relaxation Breathing Exercises</strong></td>
<td></td>
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<tr>
<td>“The Classic”</td>
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<tr>
<td>Deep Breathing, Yoga Breathing, and Meditative Breathing</td>
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<tr>
<td>Breathing with Movement or Stretching</td>
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<tr>
<td>Flow Studies</td>
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<tr>
<td>Rhythmic Breathing</td>
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<tr>
<td><strong>Stress-Inducing Breathing Exercises</strong></td>
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<td></td>
</tr>
<tr>
<td>“Champagne”</td>
<td>5</td>
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</tr>
<tr>
<td>Suspended Breathing</td>
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<td>“Ee to Oh”</td>
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<td>Paper on Wall</td>
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<tr>
<td>“Power Breathing”</td>
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<td><strong>Maximum Expansion Breathing Exercises</strong></td>
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<td>Sipping beyond Capacity</td>
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<td>Full Capacity and Release</td>
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<td><strong>Maximum Contraction Breathing Exercises</strong></td>
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<td>Bottom-Up Breathing</td>
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<td>Exhale and Hiss</td>
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<td>Diaphragmatic Panting</td>
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<td><strong>Popular Breathing Training Devices</strong></td>
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<td>Incentive Spirometer</td>
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<td>Mouthpiece</td>
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<td>Peak Flow Meter</td>
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<td>Straw</td>
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<td>Popular Breathing Pedagogies/Pedagogues/Regimens</td>
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<td>% of Respondent Mentions*</td>
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*Numbers and percentages taken from 95 total respondents