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The impact of singing on pulmonary function and quality of life in patients with Muscular Dystrophy

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The impact of singing on pulmonary function and quality of life in patients with Muscular Dystrophy

This thesis is presented in partial fulfilment of the
Bachelor of Music (Honours)

Mia Simonette

Western Australian Academy Of Performing Arts (WAAPA)
Edith Cowan University
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ABSTRACT

Muscular dystrophy is a congenital disorder that results in progressive deterioration of muscle strength and function. The genetic disorder is caused by the absence of dystrophin protein which helps to keep muscle cells together, the absence of this protein causes muscles to become weak and fragile. Despite impairment of motor function and muscle strength, a major issue is the progressive impact on the respiratory muscles. Weak pulmonary function can lead to secondary issues such as atelectasis, decreased lung compliance, repeated infections, ineffective cough and ventilation-perfusion during sleep[1]. Respiratory failure is said to be the most common cause of death in patients with muscular dystrophy but there is evidence to prove breathing exercises can improve respiratory function in patients[2].

Dramatic change in pulmonary function has been proven through the use of correct breathing techniques to develop stronger respiratory muscles and positively impact quality of life in patients with pulmonary conditions[3]. There have been studies regarding respiratory training in patients with muscular dystrophy and other neuromuscular diseases but none that involve the use of pitch. Studies have also proven that singing and vocal exercises can strengthen respiratory muscles and overall pulmonary function. Singing also results in the release of endorphins, learning a new skill and the increase in social opportunities, all of which positively impact quality of life[4]. The use of singing to develop respiratory muscles and pulmonary function has never been investigated in patients with muscular dystrophy. This study will address the knowledge gap by analysing literature and survey questions written for this dissertation. After having personally seen progressive development in pulmonary function and quality of life whilst teaching two singing students over the course of six years and being involved in singing groups working with and supporting people with disability,

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[1] Medical SchoolElaine C Silva Darlene L Machado, Maria B D Resende, Celso R F Carvalho, Edmar Zanoteli, and Umbertina C, “Lung Function Monitoring in Patients with Duchenne Muscular Dystrophy on Steroid Therapy” (Medical School of the university of Sao Paulo, 2012), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3514262/.), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3514262/

[2] Marcos Rojo Rodrigues, “Effects of Yoga Breathing Exercises on Pulmonary Function in Patients with Duchenne Muscular Dystrophy: An Exploratory Analysis.” (2014), accessed 27 march 2019.), accessed 27 march 2019

[3] Aimee Kizziar, 2017, Pulmonary, critical care and sleep medicine, https://health.ucdavis.edu/internalmedicine/pulmonary/rehabilitation/index.html, https://health.ucdavis.edu/internalmedicine/pulmonary/rehabilitation/index.html., Pulmonary, critical care and sleep medicine, https://health.ucdavis.edu/internalmedicine/pulmonary/rehabilitation/index.html, https://health.ucdavis.edu/internalmedicine/pulmonary/rehabilitation/index.html

[4] Stephan Bongard Gunter Kreutz, Sonja Rohrmann,Volker Hodapp, Dorothee Grebe, "Effects of Choir Singing or Listening on Secretory Immunoglobulin a, Cortisol and Emotional State," (2003).

I strongly feel the need for research in the area. This research is reflective of personal experience in music and teaching.

ACKNOWLEDGEMENTS

I would like to thank my supervisor Dr Daniel Susnjar for his guidance and support throughout my honours year. I truly thank you for all the help and time you have given me during the writing process.

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To my mother Louise, father David, brother Luke, my grandparents Sidney, Beverly and Ian, my partner Tom and my extended family. Thank you for your on going support and help during my time at The West Australian Academy of Performing Arts. Thank you for never doubting me and for being so understanding especially during this final year.

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TABLE OF CONTENTS

TABLE OF FIGURES

INTRODUCTION

Muscular dystrophy is a congenital condition that results in progressive deterioration of muscle strength and function caused by the absence of dystrophin protein. This protein helps to keep muscle cells together, with out it muscles to become fragile and easily damaged. Despite impairment of motor function and muscle strength a major issue MD has on the progressive deterioration on the respiratory muscles leading to secondary issues such as atelectasis, decreased lung compliance, repeated infections, ineffective cough and ventilation-perfusion during sleep[5]. Respiratory muscle weakness[6] has been shown to have a high association with cardiovascular issues including myocardial infarction, cardiovascular death and possible strokes along with respiratory failure being an independent cause of death[7]. Respiratory failure is said to be the most common cause of death in patients with muscular dystrophy[8]. A restricted respiratory pattern in patients implicates risk for respiratory failure and death through patterns of maximal respiratory pressures[9] and forced expiratory volume[10]. There is evidence that breathing exercises can improve respiratory function in patients with muscular dystrophy[11].

Respiratory muscle training programs that focus on vital capacity of the lungs through deep breathing exercises are prescribed to patients. The programs are in place to prevent muscle deterioration as well as optimise blood flow distribution, reduce the sense of respiratory effort and impact overall fatigue. Typically patients are given personal respiratory training programs which are based on an underlying method that uses

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[5] Darlene L Machado.

[6] The definition of respiratory muscle weakness is the inability to generate adequate levels of pressure and volume in the respiratory cycle.

[7] Michael Sachs, “Performance of Maximal Inspiratory Pressure Tests and Mip Reference Equations for Four Ethinic Groups” (2013), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3616895/.), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3616895/

[8] Rodrigues.

[9] Maximal respiratory pressure is a measure of respiratory muscle strength which includes primarily the diaphragm.

[10] Darlene L Machado. L Machado

[11] Rodrigues.

three training principles: overload, specificity and reversibility. All of these steps involve breath work without pitch[12].

The absence of pitch is the only difference between the respiratory muscle training system and the technical aspects of breathing for singers. During a vocal lesson you will experience training that uses the same three principles as the respiratory muscle training system: overload[13], specificity[14] and reversibility[15],[16]. Ultimately RMT mirrors the ideas of prescribed respiratory training used on patients with conditions that affect pulmonary function. There has been no research regarding the similarities or studies that interchange the process for patients specifically with muscular dystrophy. The impact singing has on quality of life along with benefits to respiratory muscle strength and overall pulmonary health makes singing a viable option for pulmonary rehabilitation[17]. This study will be undertaken in order to highlight the benefits vocal training can have on patients as an enjoyable and rewarding way to exercise respiratory muscles by drawing on information from peer reviewed research and research specific survey questions.

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[12] Alison McConnell, Respiratory Muscle Training- Theory and Practice (Churchhill Livingstone, 2013).)

[13] Overload- To increase load or resistance on a muscle, creating greater stress than it is accustomed to, in order to increase fitness.

[14] Specificity- Individualising training so the focus is completing or developing a specific skill.

[15] Reversibility- The idea of detraining. Building up a skill, to which you will lose once finished training, only to rebuild that skill again during the next training session.

[16] Matthew Hoch Mary J Sandage, "Exercise Physiology:Perspective for Vocal Training," care of the professional voice (2017).

[17] Stephan Bongard Gunter Kreutz, Sonja Rohrmann,Volker Hodapp, Dorothee Grebe, "Effects of Choir Singing or Listening on Secretory Immunoglobulin a, Cortisol and Emotional State," (2003).

RATIONALE

This study aims to highlight singing as a viable rehabilitation method for patients with neuromuscular conditions affecting pulmonary function, in particular those with muscular dystrophy. The dissertation will analyse literature regarding The Respiratory Muscle Training program, a program currently used for patients with muscular dystrophy and other conditions that affect pulmonary function, and highlight the similarities it has with vocal training methods. The aims of this research paper include understanding the similarities between respiratory muscle training and singing practices whilst discovering the benefits vocal training has on pulmonary function and quality of life in patients with Muscular Dystrophy. By doing this research I hope to encourage singing as prescribed practice for patients as it not only positively affects the respiratory system but also increases quality of life through gaining a skill. I believe if patients can develop skills that have positive impact on their livelihood whilst practicing prescribed exercises there will be an overall increase in quality of life and regular respiratory muscle training will be encouraged. There have been no academic studies that look into the impact singing can have on muscular dystrophy, a disease where development of respiratory muscles is vital to overall health. Patients are prescribed exercises that over time become monotonous, this would not be the case if patients experienced achievement through the development of vocal skill and the

benefits singing has on the brain. By doing this research I aim to highlight the benefits of vocal practice

specifically for muscular dystrophy. Limitations to this research include the lack of clinically trialed case study. Eventually I would like to pursue further research implementing a vocal methodology within regular singing lessons for patients to trial progress.

RESEARCH QUESTIONS

This dissertation aims to discoverer similarities between respiratory training methods and vocal training practices in order to encourage further research and prove certain singing exercises to be a viable rehabilitation method for patients of muscular dystrophy. The scope of this research has potential for further study up to a PHD level.

METHODOLOGY

To support the hypothesis I will be conducting a literature review of peer reviewed research and a research specific survey. I will be highlighting the similarities between prescribed respiratory muscle training systems and the techniques used in a singing lesson. To compare the two practices the focus will be on literature discussing the Respiratory Muscle Training System, a program scientifically proven to work on pulmonary function in patients with neuromuscular conditions from Alison McConnell's book 'Respiratory Muscle Training-Theory and Practice'[18]. Along with analysing published vocal training methods to highlight the similarities specifically regarding breathing techniques and lesson structure based on Exercise Physiology article 'Perspective for Vocal Training and Exercise Science Principles'[19] and 'Vocal Warm Up: Implications For Singing Voice Pedagogy'[20] by Mary J Sandage and Matthew Hoch.

In addition this research paper will analyse anonymous, survey specific research questions I have written for patients with Muscular Dystrophy who have experienced singing to ask how/if that has influenced their life in anyway, along with medical professionals and/or family members who have either recommended singing as a rehabilitation method or have seen the effects it has on their patients/family members. The survey will be emailed to people who have been recommended or discovered during the research process.

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[18] Ibid.

[19] Matthew Hoch Mary J Sandage, "Exercise Physiology:Perspective for Vocal Training," care of the professional voice (2017).

[20] Matthew Hoch Mary J Sandage, "Exercise Physiology:Perspective for Vocal Training," care of the professional voice (2017).

CHAPTER 2: LITERATURE REVIEW

There has been research done in fields similar to this study's topic but not specifically regarding the effect singing or vocal practices can have on the pulmonary function and quality of life of patients with Muscular Dystrophy. In this literature review, previous research and existing knowledge in the field will be organised into subheadings that discuss each area of study listed under the following headings: pulmonary function of patients with muscular dystrophy, previous studies that use breath work or singing to assist neuromuscular conditions, the health benefits involved in singing, breathing techniques for vocal practice and knowledge regarding respiratory muscle training in neuromuscular diseases. A review and further discussion of literature by Alison McConnell, Mary J Sandage and Matthew Hoch will be included as a full understanding of their work is essential to the research.

2.1. HEALTH BENEFITS INVOLVED IN SINGING

There is a large knowledge base regarding the impact singing has on health and the many different facets to this. Adam Lewis Et al. conducted a analysis, titled 'Singing for Lung Health- a systematic review of the literature and consensus statement', which culminates six different studies focused on singing for lung health. The paper not only reviews data collected by the research but discusses methodologies used in singing for lung health practice which will be important when it comes to comparing preexisting methods of respiratory training[21]. The positive effects of singing on lung function is a common idea and therefore is featured in a lot of literature. The Lung Foundation Singing Group of Britain includes patients of chronic obstructive pulmonary disease as mentioned in a study by Sanjay Tanday, 'How the power of singing is heal thing patients to breathe again'. A 6 week course was assessed and progress was measured through interviews and surveys of patients, results stating participants improved physical components and there was a significant decrease in hospital anxiety and depression as well as proving singing to be an enjoyable way to learn proper breathing techniques[22]. A similar program was undertaken at the UC Davis Pulmonary Rehabilitation Centre

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[21] Phoene Cave Adam Lewis, Myra Stern, Lindsay Welch, "Singing for Lung Health- a Systematic Review of the Literature and Consensus Statement," Primary Care Respiratory Medicine (2016).

[22] Sanjay Tanday, "How the Power of Singing Is Helping Patients to Breathe Again," British Lung Foundation Singing Group (2016).)

lead by Dr. Aimee Kizziar of UC Davis Health. Interviews from patients and medical professionals from the centre show a positive experience using singing as a rehabilitation method and discusses the benefits singing can have on people with weak pulmonary function[23]. An earlier study by Gunter Kreutz et al. investigates the effect singing in a choir has on secretory immunoglobulin A, cortisol and emotional state. The results show singing leads to increases in positive effect in immunoglobulin A and reduces negative effect along with decreasing levels of cortisol and positively influencing emotional affect. This is essential to my research as it confirms singing has a positive influence on emotional state and the immune system, overall increasing quality of life[24].

2.2.. PREVIOUS STUDIES REGARDING SINGING OR BREATH WORK IN PATIENTS WITH CONDITIONS THAT EFFECT PULMONARY FUNCTION

Furthermore singing has been studied as a therapy for diseases that impact pulmonary function including chronic respiratory disease, in order to develop additional strategies to alleviate symptoms other than using pharmacological therapy. Victoria M Lord et al. performed a randomised controlled trial discovering that singing can improve quality of life measures and anxiety and is viewed as a very positive experience by patients, no adverse consequences of participants were observed[25]. In 2014 Marcos Rodrigues et al. used yoga breathing exercises to safely increase pulmonary function in patients with muscular dystrophy. The study showed successful results using hatha yoga breathing exercises and methods. Data collected in the study is relative to this dissertation as the similarities between breathing techniques in yoga and singing are uncanny and both contain ideas from the respiratory muscle training system[26]. A study was taken measuring the effects of singing on patients with cystic fibrosis through the impact on pulmonary function and quality of life. The results showed singing provides airway clearance and improves the quality of life in patients through

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[23] interview.

[24] Stephan Bongard Gunter Kreutz, Sonja Rohrmann,Volker Hodapp, Dorothee Grebe, "Effects of Choir Singing or Listening on Secretory Immunoglobulin a, Cortisol and Emotional State," (Kreutz

[25] Victoria M Lord, “Singing Teaching as a Therapy for Chronic Respiratory Disease- a Randomised Trial and Qualitative Evaluation” (2010).)

[26]Rodrigues.

an emphasis on breathing techniques during lessons[27]. A similar study was done questioning the impact singing and playing wind instruments can have on the quality of life and pulmonary function of patients with cystic fibrosis. Again the data read in favour of singing training but suggested further research could be done[28].

2.3. UNDERSTANDING PULMONARY FUNCTION IN MUSCULAR DYSTROPHY

An important study in terms of understanding pulmonary function in patients with muscular dystrophy was undertaken in 2015 by O.H Mayer and C. Rummey. The study characterised pulmonary function in patients with muscular dystrophy and assessed their lung function over time. The results found relative stabilisation from ages 10-18 years, and then a decrease at an older age. The study showed pulmonary function to decline 5% per year from ages 5 to 24. This data is important to the research as it shows the importance of respiratory muscle training in patients and highlights the severity of the impact muscular dystrophy has on pulmonary function[29]. Earlier studies by E.J Hapke determined abnormalities of pulmonary function in patients with Muscular Dystrophy compared to participants with standard lung function. This is important for the research as it outlines the severity of poor respiratory strength and measures this against a standard pulmonary function reading[30]. Journal article 'Introduction to muscular dystrophy' By John D Porter gives an in-depth introduction to muscular dystrophy and how it is genetically transferred including information discussing the regeneration of skeletal muscle. There are also a plethora of relatively up to date online resources that discuss the respiratory function in patients from position of educating patients or their families and friends about the disease.

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[27] Rachel Brager Goldenburg, "Singing and Cystic Fibrosis: A Collective Case Study on Effects of Privare Voice Lessons on the Pulmonary Function and Quality of Life of Adult Cystic Fibrosis" (2012), https://search-proquest-com.ezproxy.ecu.edu.au/pqdtglobal/docview/1760591361/fulltextPDF/F8DB03EAB17F4D72PQ/14?accountid=10675.), https://search-proquest-com.ezproxy.ecu.edu.au/pqdtglobal/docview/1760591361/fulltextPDF/F8DB03EAB17F4D72PQ/14?accountid=10675

[28] Lauren Anderson, "The Use of Singing and Playing Wind Instruments to Enhance Pulmonary Function and Quaility of Life in Children and Adolescents with Cystic Fibrosis" (Kansas, 2012), https://search-proquest-com.ezproxy.ecu.edu.au/pqdtglobal/docview/1288818949/CA6EE0AF1C154C4DPQ/4?accountid=10675.), https://search-proquest-com.ezproxy.ecu.edu.au/pqdtglobal/docview/1288818949/CA6EE0AF1C154C4DPQ/4?accountid=10675

[29] R.S Finkle O.H Mayer, C. Rummey, "Characterization of Pulmonary Function in Duchenne Muscular Dystrophy," (2015).

[30] 1972M.D. E.J Hapke, J.C. Meek, M.D., and J. Jacobs, M.D., "Pulmonary Function in Progressive Muscular Dystrophy," 61, no. 1 (1972).)

2.4. RESPIRATORY MUSCLE TRAINING FOR NEUROMUSCULAR CONDITIONS

Respiratory muscle training has been documented in academic research for many years with contrasting results. An early example of RMT principles are documented in Dennis McCool, Et al. article titled 'Inspiratory Muscle Training in the Patient with Neuromuscular Disease' from the journal Physical Therapy. In the article many different respiratory muscle training protocols are proven successful in patients with neuromuscular diseases. Successful outcomes from all the different methods examined encourages the idea that there are multiple ways to implement RMT and that there is market for new programs based on a similar structure[31]. There have been many older case studies (1985-1994)[32];[33];[34];[35];[36];[37] regarding respiratory training in neuromuscular diseases but resulted in contrasting findings. This seems be due to control groups containing varying conditions, the type of training used and dated methods. It is not until the early 2000's until we begin to see clearer outcomes from respiratory training programs in specifically muscular dystrophy patients[38],[39],[40].

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[31] George E Tzelepis F Dennis McCool, "Inspiratory Muscle Training in the Patient with Neuromuscular Disease," Physical Therapy 75, no. 11 (1995).

[32] 1985A.F. DiMarco, Kelling, J.S., "The Effects of Inspiratory Resistive Muscle Training on Respiratory Muscle Function in Patients with Muscular Dystrophy," Muscle Nerve (1985).)

[33] 1986A.J. Martin, Stern, L., Yeates, J, "Respiratory Muscle Training in Duchenne Muscular Dystrophy," Dev. Med. Child. Neurol. (1986).)

[34] 1988P.E. Smith, Coakley, J.H., Edwards, R.H, "Respiratory Muscle Training in Duchenne Muscular Dystrophy," Muscle Nerve 11 (1988).)

[35] 19R. Stern, Martin, A.J., Jones, N, "Training Inspiratory Resistsnce in Duchenne Dystrophy Using Adapted Computer Games," Child Neurol, no. 31 (1989).)

[36] D. Bar-Yishay Vilozni, E., Gur, I, "Computerized Respiratory Muscle Training in Children with Duchenne Muscular Dystrophy," Neuromuscular disorder 4 (1994).

[37] 19T. Wanke, Toifl, K., Merkle, M., "Inspiratory Muscle Training in Patients with Duchenne Muscular Dystrophy," Chest, no. 105 (1994).)

[38] 20W. Koessler, Wanke, T. Winkler, G., "2 Years' Experience with Inspiratory Muscle Training in Patients with Neuromuscular Disorders," Chest 120 (2001).)

[39] 20G. Winkler, Zifko, U., Nader, A., "Dose-Dependent Effects of Inspiratory Muscle Training in Neuromuscular Diseases," Muscle Nerve (2000).)

[40] 20N. Topin, Matecki, S., Le Bris, S., "Dose-Dependent Effect of Individualized Respiratory Muscle Training in Children with Duchenne Muscular Dystrophy," Neuromuscular disorder 12 (2002).)

The results from these studies prove to be dose-dependent and test specific, for example, in the work of Koessler et al[41], where strength focused exercises are used, respiratory muscle strength is increased in participants. Similarly, in research of Topic et al[42], endurance based training was involved therefore endurance improved in the patients. Ideally a program of similar nature to the study by Winkler et al[43], would be used in further research regarding respiratory training in muscular dystrophy as it not only focuses on strength but also endurance. The dual conditioning response had positive impact on both properties resulting in increased respiratory muscle strength and maintenance of lung function.

2.5. ALISON MCCONNELL- RESPIRATORY MUSCLE TRAINING THEORY AND PRACTICE

One of the most vital resources to this research is the literature written by Professor of Applied Physiology, Alison McConnell[44], titled 'Respiratory Muscle Training-Theory and Practice'. The book has in-depth information regarding the respiratory system, respiratory muscle training methods used in clinical service and condition specific research regarding the impact this program has on patients. The method outlines important training principles in order for rehabilitation to take place. This structure will provide a basis for the methodology used in this dissertation therefore is vital in the overall scheme of research[45]. During this section I will discuss topics mentioned in McConnell's writing and analyse information that relates to the research questions. A full understanding of McConnell's work is essential to this research dissertation.

Chapter One of Alison McConnell's[46] book provides an understanding of the Anatomy and Physiology of the respiratory system, describing the principle structures and function. I will be discussing the sections most important to this research including respiratory pump muscles. Respiratory pump muscles are formed around the lungs and attach to the ribcage in order to generate breathing action by expanding and compressing. These muscles are broken into two groups; inspiratory muscles and expiratory muscles (See figure 1).

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[41] Koessler.

[42] Topin.

[43] Winkler.

[44] McConnell.

[45] Ibid.

[46] Ibid.

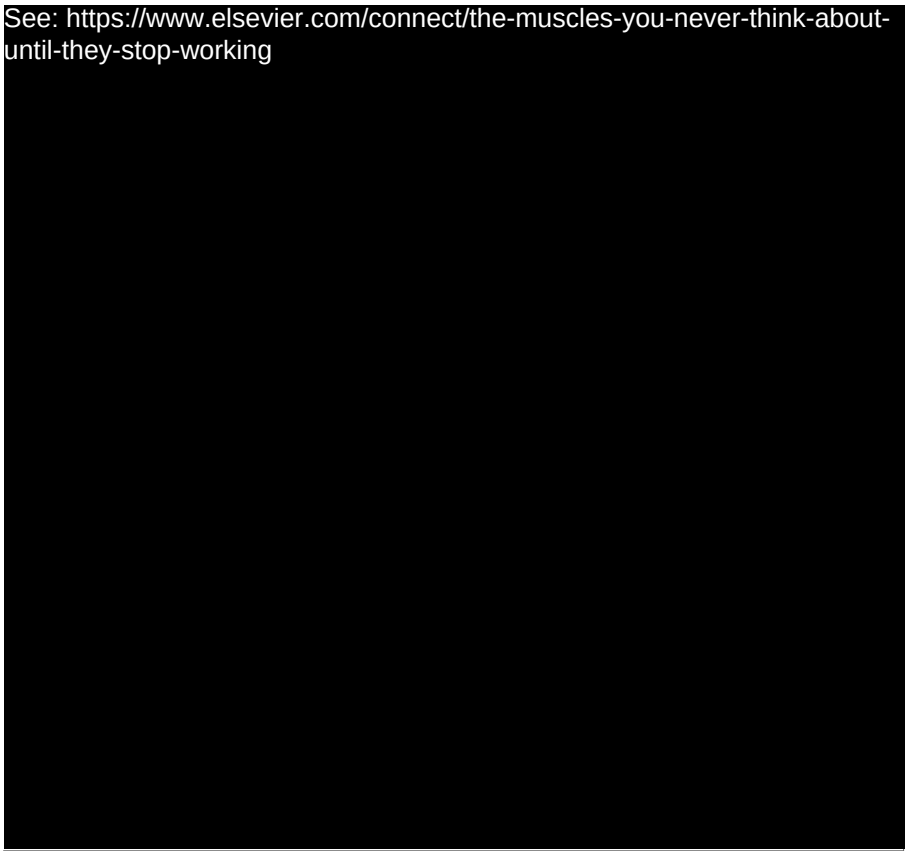

Figure 1[47]: Diagram of respiratory muscles; inspiratory muscles and expiratory muscles.

Inspiratory Muscles include the Sternocleidomastoid, Scalene, Intercostal muscles and primarily the diaphragm, all of which contract in order to let air into the lungs. The diaphragm attaches to the lower ribs and the lumbar vertebrae and moves up and down, increasing and decreasing the volume of the thoracic cavity[48] due to inflation and deflation of the lungs. Expiratory muscles include intercostal muscles, abdominal muscles, rectus abdominis, external oblique, internal oblique and the Transversus abdominis. When these muscles contract the pressure forces the diaphragm upwards into the thoracic cavity resulting in expiration. The abdominal muscles involved in breathing not only have important functions regarding posture and movement but also are vital in the act of either coughing or singing as well as optimising the position of the diaphragm to optimise breathing[49].

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[47] Ibid.

[48] Thoracic cavity- Otherwise known as the chest cavity, a chamber of vertebrates protected by the ribcage, muscle and fascia.

[49] Ibid.

When looking at the importance of muscle movement and its regularity in the act of breathing it is understandable why respiratory failure and other issues are the most common causes of fatality in neuromuscular conditions including muscular dystrophy[50]. The elastic properties of the Lung are altered in patients with muscular dystrophy as the condition affects all skeletal muscles (see Figure 2).

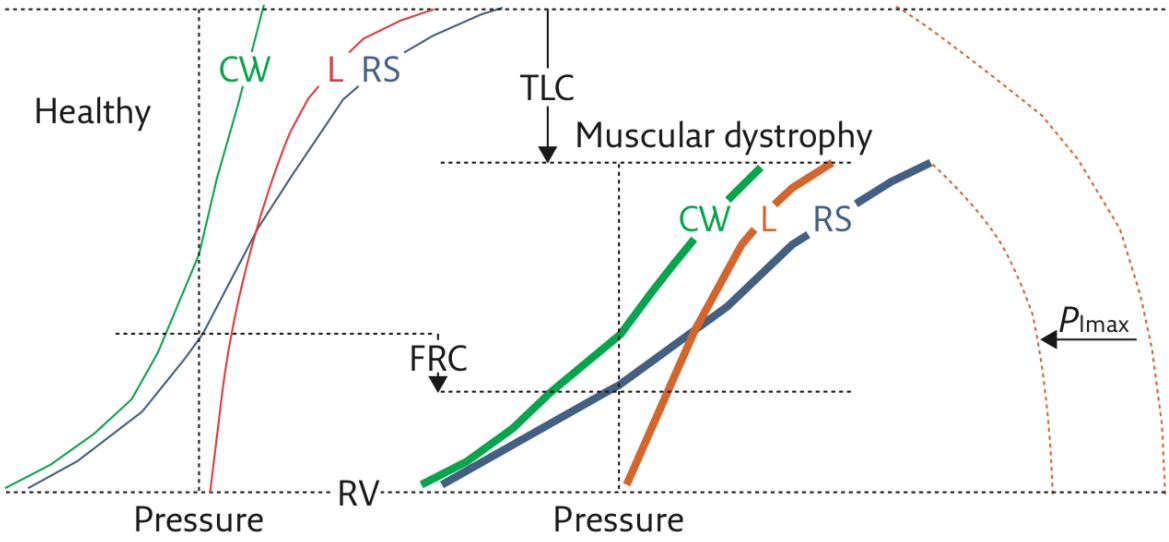

Figure 2[51]: This diagram represents the pressure volume curves of contrasting respiratory systems; healthy and Muscular Dystrophy. The pressure volume curves of the respiratory system (RS), the chest wall (CW) and lung (L). The maximal inspiratory pressure (Pimax) is measured in Muscular Dystrophy along with reduced total lung capacity (TLC), residual volume (RV) and functional residual capacity (FRC).

A variety of factors contribute to the reduced total lung capacity, compliance of the chest wall, lungs and respiratory system including muscle atrophy and osteoporosis both due to inactivity[52]. With the combination of weak respiratory muscles and a less compliant chest wall and lungs, patients deal with a progressive imbal-

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[50] Rodrigues.

[51] Aliverti A Lo Mauro A, "Breathe," Physiology of respiratory disturbances in muscular dystrophies 12 (2016).

[52] "Breathe," Physiology of respiratory disturbances in muscular dystrophies 12 (

ance between the pressure and capacity resulting in fatigued[53] respiratory muscles[54]. The restrictive pulmonary dysfunction leads to shallow, fast breathing patterns, therefore more regular breaths are necessary due to the small amount of air being let into the lungs. The extra breaths taken can result in muscle fatigue, this along with respiratory muscle weakness, creates an imbalance in the demand/capacity relationship[55]. The writing of Alison McConnell states, according to feedback, exercising respiratory muscles is making an important contribution to improving fatigue and the perception of effort when breathing[56].

Chapter Four discusses the disease specific impact respiratory muscle training has on patients and summarises previous studies measuring the results. Alison discusses, the effect exercising respiratory muscles has depends on the severity and progression of the disease, the slower the disease progresses the more effective training will be[57]. Muscular dystrophy is a progressive muscular condition, which in accordance to McConnell's writing means respiratory training is likely to be successful, the extent of this depends on the severity of the deterioration. During this chapter McConnell summarises various studies where respiratory training is used in trials for patients with forms of muscular dystrophy. The data provided preliminary support for the use of RMT in patients with muscular dystrophies, specifically inspiratory resistance training which results in many benefits including improvements to lung function or sustaining current lung function if downhill progression is occurring rapidly [58].

Chapter Five contains an overview of the generic principles involved in muscle training and how they can be applied to respiratory training. The chapter also provides evidence that respiratory muscles respond well to the ‘overload’, ‘specificity’ and ‘reversibility’ methods[59].

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[53] The definition of fatigued respiratory muscles is the inability to sustain a given pressure in response to a constant load.

[54] Ibid.

[55] McConnell.

[56] Ibid.

[57] Ibid.

[58] Ibid.

[59] Ibid.

Overload is a process that requires muscles to work for longer, at a higher intensity and/or more frequently than they are commonly used to in order to obtain training response[60]. Generally two main forms of overload are used;

1. External loads at the mouth (intensity)
2. Increased breathing volume and flow rate for extended durations (Intensity and duration)

It is recommended that this kind of training takes place at least three times per week. Studies have shown significant change in muscle function after 3 weeks of frequent training[61]. McConnell writes, the changes of strength that occur during the first 2 weeks of training are a result of the neutral adaptation process[62], making contribution to the immediate short term improvements[63]. In respiratory studies by Downey et al[64], improvements in diaphragm thickness were between 8 and 12% after 4 weeks of inspiratory muscle training as well as there being improvements in maximal inspiratory pressure.

Specificity is the principle of individualising training so the focus is on completing or developing a specific skill. This principle encourages an increase in strength and/or endurance through combinations of these main forms of specificity both of which are interrelated[65];

1. Load specificity
2. Flow specificity

Respiratory muscles seem to respond to strength training stimuli[66] and endurance training stimuli[67].

Reversibility is the idea of detraining. Building up a skill, to which you will lose once finished training, only to rebuild that skill again during the next training session. Two main elements of reversibility are;

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[60] Ibid.

[61] Ibid.

[62] Neutral adaptation process- Improving the coordinated activation of synergistic muscles.

[63] Stern.

[64] 2007A.E. Downey, Chenoweth, L.M., Townsend, D.K, Effects of Inspiratory Muscle Training on Exercise Responses in Normoxia and Hypoxia, vol. 156 (2007).)

[65] McConnell.

[66] Strength training stimuli- High intensity and short duration

[67] Endurance training stimuli- low intensity and long duration

1. Detraining

2. Maintenance

McConnell's book supports the notion that general training principles of overload, specificity and reversibility apply as much to the training of respiratory muscles as they do to other muscles of the body[68]. Literature by Mary J. Sandage and Matthew Hoch titled Exercise Physiology: Perspective for Vocal Training and Exercise Science Principles and the Vocal Warm Up- Implications for Singing Voice Pedagogy address these principles in the context of a vocal training lesson[69].

2.6. RESPIRATORY MUSCLE TRAINING IN VOCAL PRACTICE

RESEARCH BY MARY J. SANDAGE AND MATTHEW HOCH

Another two vital sources of literature for this research are articles by Mary J. Sandage and Matthew Hoch titled 'Exercise Physiology: Perspective for Vocal Training'[70] and 'Exercise Science Principles and the Vocal Warm Up- Implications for Singing Voice Pedagogy'[71]. The sources discuss the use of respiratory training methods in the context of a vocal lesson, involving the same principles mentioned in Alison McConnell's book[72]: overload, specificity and reversibility as well as delving deeper into the practice aspects of these principles will be discussed.

The overload principle in relation to vocal training can be in regards to the dynamic of the voice and/or the demand of your voice during performance/prior to performance. High intensity vocal performance can be a form of vocal overload as the intensity increases, the ability to sustain vocal control over a long period of

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[68] Ibid.

[69] Mary J Sandage. J Sandage

[70] Ibid.

[71] Matthew Hoch Mary J Sandage, "Exercise Science Principles and the Vocal Warm Up: Implications for Singing Voice Pedagogy," (2017).

[72] McConnell.

[73] Matthew Hoch Mary J Sandage, "Exercise Science Principles and the Vocal Warm Up: Implications for Singing Voice Pedagogy," (J Sandage, "Exercise Science Principles and the Vocal Warm Up: Implications for Singing Voice Pedagogy.

time decreases. Increasing the volume to either a spoken or sung voice can be viewed as overload[73]. Muscles must be worked beyond average practice in order for muscle to develop or maintain strength[74].

Specificity in the context of singing practice will allow you to improve in areas you specifically focus practice on. This principle is also described as the SAID principle, 'Specific adaptations to imposed demand'[75]. The SAID principle works in direct correlation to the task you have chosen to improve as muscle is trained via specific motor units and muscle fibres to specifically do that task[76].

The reversibility principle in regards to singing is the idea of detraining skills and relearning them within a short space of time in order to better the skill and obtain muscle memory. It is not recommended that these skills are left untrained for more than four weeks as the muscle mechanisms will be down regulated[77]. Skill needs to be maintained by using 70% of the maximum ability regarding skeletal muscle and the cardiorespiratory system otherwise after a few weeks the body may reverse strength and endurance gains[78]. The act of reversibility is done between training sessions and cannot be directly linked to a specific vocal warm up exercise.

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[74] Ibid.

[75] Mary J Sandage, "Exercise Physiology:Perspective for Vocal Training." J Sandage, "Exercise Physiology:Perspective for Vocal Training.

[76] Ibid.

[77] Ibid.

[78] Ibid.

CHAPTER 3: DR INGO TITZE'S 'FIVE BEST VOCAL WARM-UP EXERCISES'

This chapter will include a discussion exploring warm up exercises by Dr Ingo Titze written to involve the previously mentioned techniques: overload, specificity and reversibility. Applying sources and my own knowledge the chapter will discuss how these techniques relate to singing practice and the application of respiratory muscle training techniques. Using Dr Ingo Titze's 'Best Five Vocal Warm-Up Exercises'[79] I will create more specific vocal exercises as an example for someone wanting further direction.

Titze's 'Best Five Vocal Warm-Up Exercises'[80] are mentioned in Mary J. Sandage et al. work, to be the most effective technique regarding muscle training and coordination. These five classes of exercise were chosen as they have strong physiologic justification and variations of the themes were found prevalent in vocal training environments[81]. The exercises are presented in a format that is open to interpretation and is done in this way to prevent boredom amongst students. In the table below are the 'Best Five Vocal Warm-Up Exercises' including the vocal benefits[82] as it is presented in Dr Ingo Titze's research. Using the information provided by Titze and the research regarding overload, reversibility and specificity I have categorised the exercises into the principles involved and supported these decisions with evidence form the above research.

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[79] Dr Ingo Titze, Journal of Singing 57 (2001).)

[80] Ibid.

[81] Ibid.

[82] Ibid.

Exercise	Vocal Benefit	Principle Utilised
1- Lip trill, tongue trill, humming or phonation into narrow tubes (straw or straw in water) on glides, scales or arpeggios over a wide pitch range	-Results in respiratory muscles rapidly getting into full action. Minimises upward force on vocal folds because of positive oral pressure. -Spreads the vocal folds to vibrate their edges only. -Lowers phonation threshold pressure by providing an inertia acoustic load. -Stretches vocal folds to maximum length.	As mentioned in Mary J Sandage et al. research, overload involves the muscles use to be used at a level higher than standard practice. This exercise rapidly activates the respiratory muscles not only engaging them in order for development to occur but to create a strong basis for further vocal practice and muscle development.
2- Two-octave pitch glides first down only, then up and down on high vowels (‘i’ or ‘u’). Targeting a transition from low chest to high pure falsetto and finally a mixed voice.	Also gives maximal stretch to vocal folds (first ligament, then muscle). -Provides maximum dichotomy between TA (Transverse abdominal muscle; a muscle layer of the front and side of the abdominal wall) and CT (Cricothyroid; elongates the vocal folds and allows pitch change) Muscles, then requires unity between them.	As mentioned in Mary J Sandage et al. research, overload occurs when a muscle is being worked above its average use. Two octave pitch glides not only target the muscles related to the vocal folds but also the front and side muscles of the abdominal wall at their most contrasting states. Forcing the muscles to be at their most tense point and find this natural in order to achieve the exercise. This exercise is positively engaging respiratory muscles to an extreme that wouldn’t be achieved in everyday life especially if there is lack of physical exercise and movement. Specificity is being achieved in this exercise as the singer is gaining the ability to use their TA and CT muscles at the same time and the more this is practiced the easier the skill will be to accomplish.

3- Forward tongue roll and extension using vowel sequence (‘a’ to ‘i’) on scales.	-Creates independence between the phonatory and articulatory structures. -Loosens tongue and jaw. -Helps keep vertical larynx position stable during articulation.	Specificity is regarded by Mary J Sandage et al. to allow improvement in areas specifically focused on. This exercise focuses on the loosening of jaw and tongue and creating independence between the phonatory and articulatory structure resulting in a vertical and stable larynx position. These areas will improve by accurately doing the exercise.
4- Messa di voce (sustaining a single pitch and varying the dynamic), proceeding from a partially occluded tract to high vowels (‘i’ , ‘u’) then to low vowels (‘ae’, ‘a’, ‘o’)	-Engages the layers of the vocal fold tissue gradually in vibration, medial to lateral. -Helps singer match tension in muscle to tension in ligament. Tests symmetry of crescendo verses decrescendo control under continually decreasing lung volume. -Makes intrinsic muscles of the larynx work in coordination with changing lung pressure.	As mentioned in Mary J Sandage et al. research, varying dynamic volume of a held note can be viewed as overload. In order to sustain a held note and vary the air pressure there has to be a a certain level of muscle strength. The more these muscles are worked beyond average practice the more likely they are to become stronger or maintain a level of strength. In order for the overload principle to work the singer must continuously increase the difficulty of the exercise. Specificity can also be applied to this exercise. In doing this exercise the singer is specifically working on breath control and respiratory muscles including the diaphragm to result in seamless or easy dynamic shifts and the ability to hold a note for a period of time.

5- Staccato (short detached note) on arpeggios (broken chord)	-Elicits clean and rapid voice onset, establishing a dominant mode of vibration of the vocal folds. -Trains adductor/abductor of the intercostal muscles and diaphragm muscles simultaneously with tensor muscles of the larynx during pitch change.	As mentioned in Mary J Sandage et al. research, overload occurs when muscles are trained at a level that is more difficult than standard everyday practice. This exercise trains the adductor and abductor of the intercostal muscles and diaphragm muscles as well as muscles of the larynx as it pushes muscles to be used at an extreme superior to a spoken or rested voice. Having positive benefits to the respiratory system and ability to accurately voice pitches. Specificity is involved as the exercise focuses on gaining accuracy when singing detached pitches as intervals larger than a minor or major 2nd. It also involves a dominant mode of vibration whilst applying the rapid voice onset.

The above table shows the use of respiratory muscle training principles and exercises within standard vocal training practice using pitch. These exercises are proven to actively improve vocal strength and technique as well as have a positive effect on respiratory muscles and breathing technique as they are specifically geared towards muscle training and co-ordination[83]. Each vocal warmup mentioned above in Dr Titze's 'Best Five Vocal Warm-Up Exercises' involves a description of the exercise without notation presenting specific instructions. Below I have included the five vocal warmups notated for further understanding.

[83] Mary J Sandage, "Exercise Science Principles and the Vocal Warm Up: Implications for Singing Voice Pedagogy." J Sandage, "Exercise Science Principles and the Vocal Warm Up: Implications for Singing Voice Pedagogy.

Exercise 1. Lip trill, tongue trill, humming or phonation into narrow tubes (straw or straw in water) on glides, scales or arpeggios over a wide pitch range. Lip and tongue trills, humming and phonation into a straw can be interchanged over the below note choices throughout the vocal range. The below exercises can be done at any tempo.

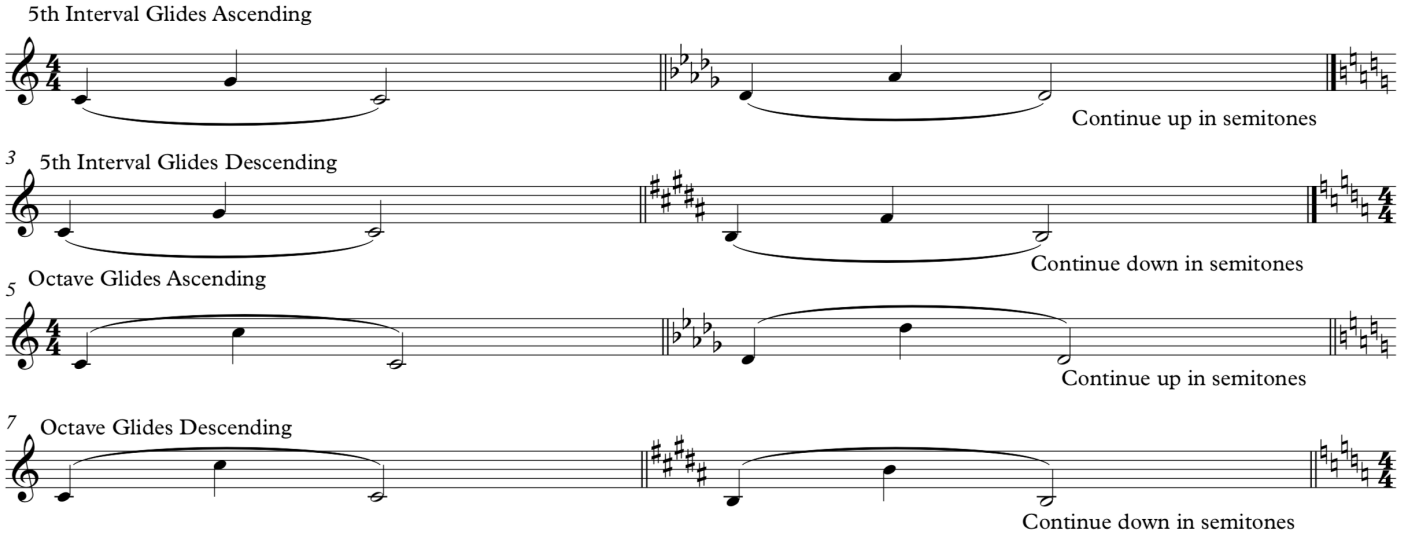

Figure 3. Exercise 1a. 5th interval and octave glides ascending and descending in semitones.

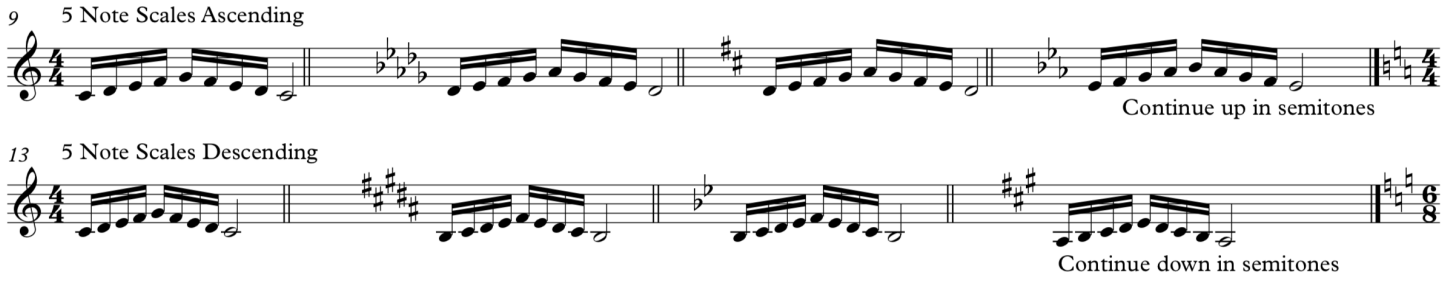

Figure 4. Exercise 1b. 5 note scales ascending and descending in semitones.

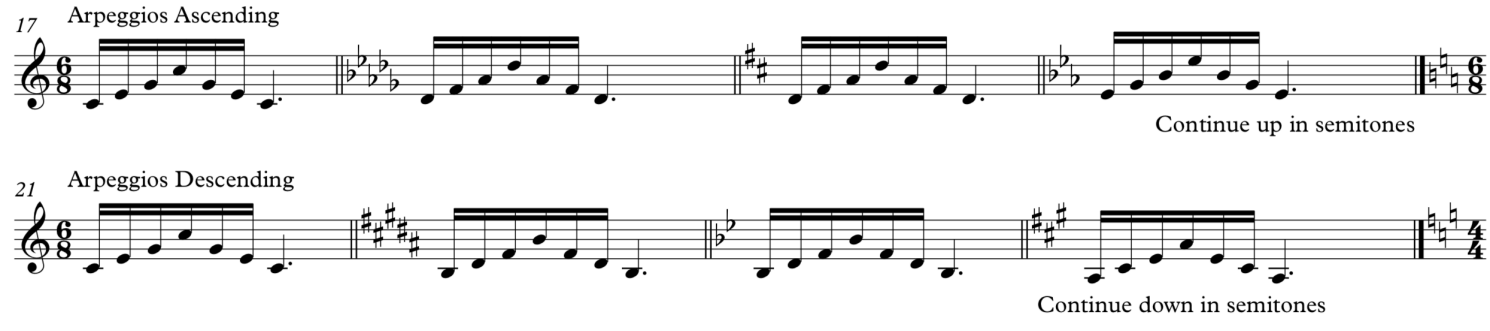

Figure 5. Exercise 1c. Arpeggios ascending and descending in semitones.

Exercise 2. Two-octave pitch glides first down only, then up and down on high vowels (‘i’ or ‘u’). Targeting a transition from low chest to high pure falsetto and finally a mixed voice. High vowels ‘i’ and ‘u’ are interchangeable over the below notated pitch glides. ‘Figure 6. Exercise 2a.’ can be repeated until the voice feels warm enough to continue onto Figure 7. Exercise 2b.’ The below exercises can be done at any tempo.

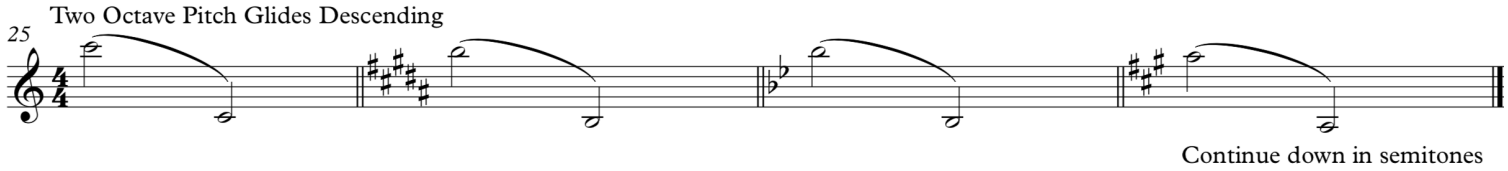

Figure 6. Exercise 2a. Two octave pitch glides descending in semitones. Sung using high vowels ('i' or ‘u’).

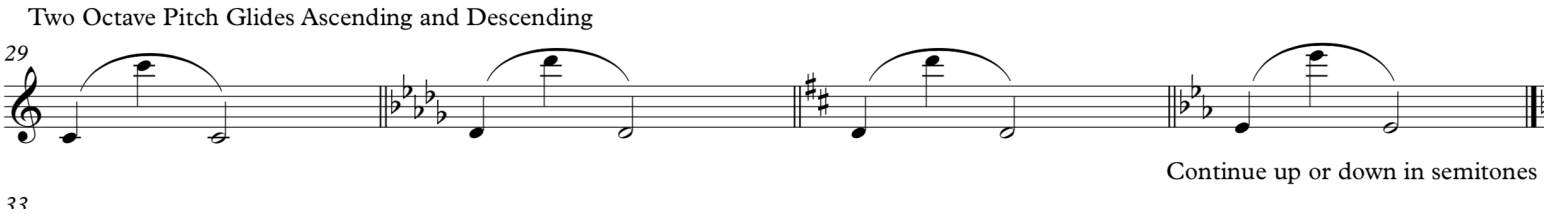

Figure 7. Exercise 2b. Two octave pitch glides ascending and descending in semitones. Sung using high vowels ('i' or ‘u').

Exercise 3. Forward tongue roll and extension using vowel sequence (‘a’ to ‘i’) on scales. Forward tongue rolls and the vowel sequence can be interchanged over the below scale. The scale below can be sung at any tempo, descending or ascending in semitones.

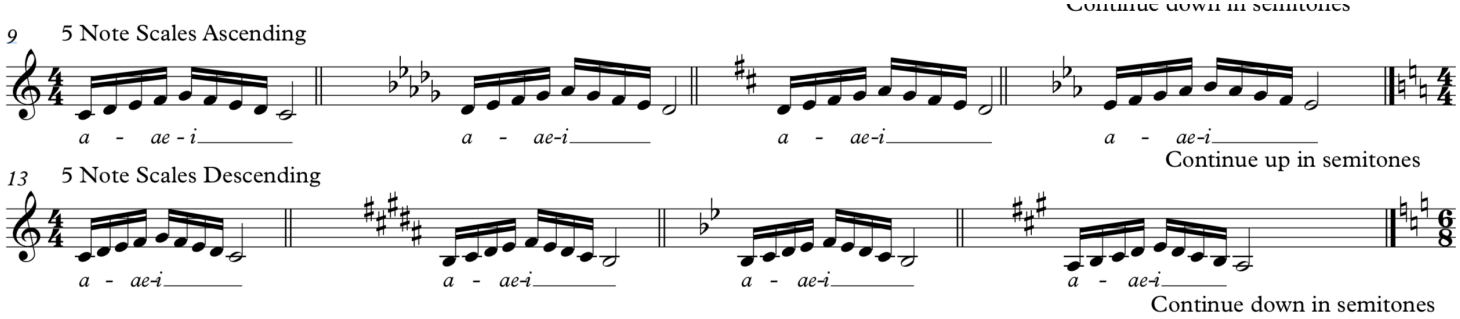

Figure 8. Exercise 3a. 5 note ascending and descending scales to be sung at any tempo using forward tongue rolls or vowel combination ‘a’ to ‘i’.

Exercise 4. Messa di voce (sustaining a single pitch and varying the dynamic), proceeding from a partially occluded tract to high vowels (‘i’ , ‘u’) then to low vowels (‘ae’, ‘a’, ‘o’). The below stave shows dynamic variation available for this exercise over one held note with changing vowel sounds (high to low vowels). This note can be held for any length but should maintain breath quality.

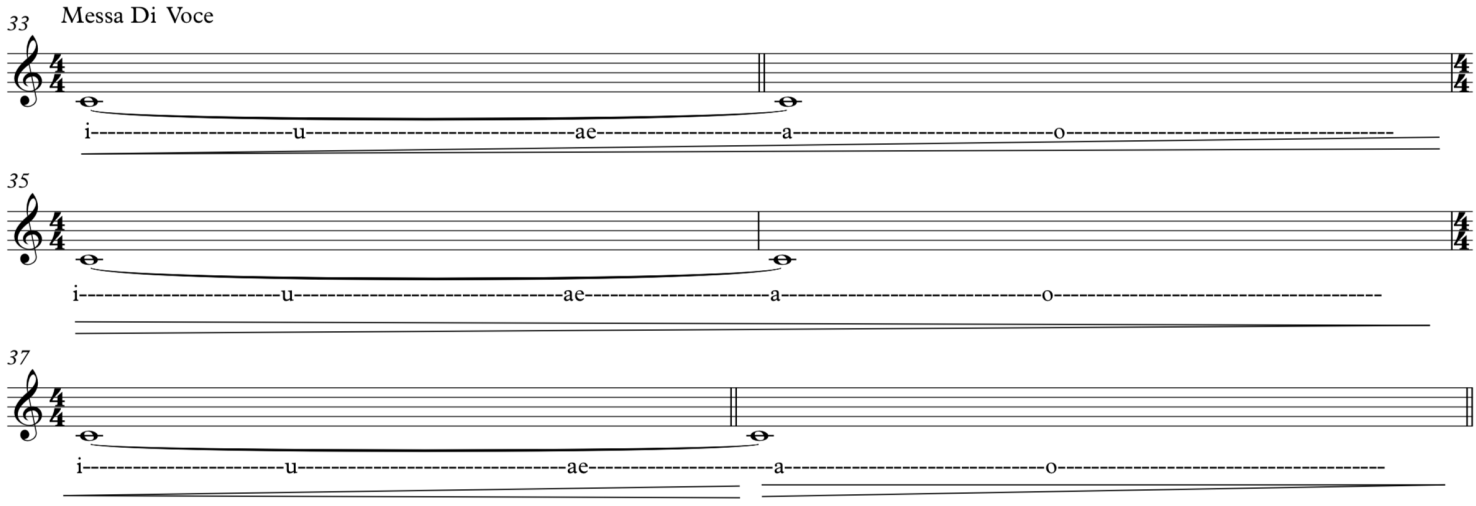

Figure 9. Exercise 4. Messa Di Voce. Long notes with dynamic and vowel variation. The exercise can be performed on many notes of the singers vocal range and the note can be held for any amount of time.

Exercise 5. Staccato (short detached note) on arpeggios (broken chord). The arpeggios notated below are to be sung short and detached over any vowel suited eg. ‘i’ or ‘a’.

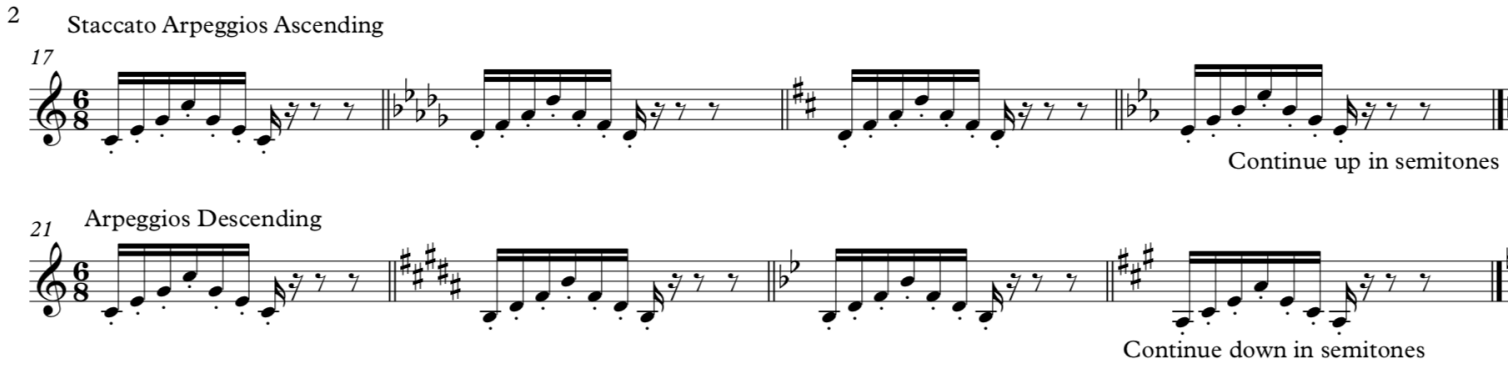

Figure 10. Exercise 5. Ascending and descending arpeggios to be sung short and detached on vowels including ‘a’ and ‘i’.

CHAPTER 4: SURVEY QUESTIONS AND DISCUSSION OF RESULTS

This chapter discusses the responses from a short six question anonymous email survey formulated for this dissertation to ascertain the impact singing has on muscular dystrophy. The survey responses came from a selection of 15 participants who included, patients of MD, parents of children with MD and medical professionals who work with MD patients. In order to respect the privacy of anonymous survey I have chosen not to include the complete responses of each interviewee.

In constructing the survey questions I aimed to query the participants relationship with muscular dystrophy and whether or not they had experienced singing or the respiratory training method. In order to reach an understanding regarding the impact singing has on muscular dystrophy these questions were essential. The questions were answerable in long or short form and include an open section for the participant to include any information that may not have been already addressed.

Ethics clearance was received before undertaking the following survey.

The six survey questions were:

1. What is your relationship with muscular dystrophy and how has it affected your life?
2. Have you (or someone you know) had any experience with singing? If so, have you seen it to have any affect on health or quality of life?
3. Have you ever been advised with regards to, respiratory muscle training systems, and do you have any experiences in the area, if so what is your response to them?
4. What is your view on using singing as a potential respiratory muscle development program?
5. Is there anything else you would like to add?
6. Are you under the age of 18?

Regarding the first question: (What is your relationship with muscular dystrophy and how has it affected your life?) participants disclosed their personal and professional relationship with the condition. Survey participants ranged from Physiotherapists, Occupational therapists, parents of children with muscular dystrophy and Patients with MD. Patients with muscular dystrophy and parents of patients consistently discussed the impact the disease has on their/their child's independency and the progressive deterioration of muscle strength. One participant also mentioned the impact on lung capacity. In their case reduced to less than 30% of standard lung function. All participants with the disease mentioned confinement to a wheelchair. Medical professionals responded with their job title and in which area they work with patients of muscular dystrophies.

Question two: (Have you (or someone you know) had any experience with singing? If so, have you seen it to have any affect on health or quality of life?) received responses that involve the improvement singing has on quality of life and maintaining lung function and respiratory health. Patients with MD all responded to this question with belief that regular singing was a key part of maintaining good lung health resulting in the avoidance of colds and chest infections. Two patients claimed regular singing had assisted in the fact they have never had a chest infection or needed hospitalisation. All MD patients also mentioned the impact singing had on their quality of life through the development of self confidence, introduction to new social environments and a sense of achievement. One participant stated: "Singing became an outlet for me-something to bring me joy, develop my self confidence, and provide a sense of achievement and belonging-something that was especially important during my teenage years as my condition progressed." Parents of patients with MD also agreed singing has a positive impact on lung health and quality of life. One response stated that the more their child sang the bigger improvement to their breathing resulting in getting less colds, less build up of congestion and better sleep. As patients with Muscular Dystrophy are mostly confined to a wheelchair, parents mentioned singing and breathing exercises are a way to assist in blood flow similar to what you would experience doing physical exercise. Medical professionals highlighted the positive impact singing has on the quality of life of some of their patients as well as the improvement of lung function and

good lung health. One medical professional said: “A few of my clients participate in singing and choir on a regular basis. These clients have very few respiratory infections.”

Question three: (Have you ever been advised with regards to, respiratory muscle training systems, and do you have any experiences in the area, if so what is your response to them?) resulted in varying answers but overall participants supported the idea of singing as respiratory training whether it has or has not been recommended to them. Patients with Muscular Dystrophy all answered this survey question with a no. None of the patients participating in this survey had ever been recommended respiratory muscle training programs or had them made available to them. Parents of patients with MD also claim they were never advised of any respiratory training systems, and singing and/or breathing training was something they found on their own without realising the benefits it would have on their child/children. One parent responded with: “I am definitely a lover of this [singing] training. I feel every parent of a child with a muscle condition, disease or weakness should be made aware of it.” Medical professionals responded that they were aware of the benefits of singing and respiratory muscle training. One medical professional said breath stacking was recommended for boys with Duchenne Muscular Dystrophy once they are wheelchair bound in order to maintain lung function. Another medical professional responded: “I am aware that singing is known to assist with strengthening respiratory muscles which will be beneficial to people with muscular dystrophy who have difficulty with breath control, coughing or bringing up secretions.”

Question four: (What is your view on using singing as a potential respiratory muscle development program?) all survey participants responded positively towards singing as a rehabilitation method. All patients with muscular dystrophy involved in the survey claimed that singing was beneficial to their health and wellbeing. One participant responded with: “I do believe that singing regularly helped to preserve and slow the degeneration/loss of lung function. Being able to maintain or slow the progression is significant in itself, so I see this as a huge long term health benefit and would strongly encourage other people in similar situations to consider doing the same.” Parents of patients with MD also responded positively to the idea of singing as a respiratory muscle development program. One parent wrote: “I feel it would greatly benefit a lot of patients with respiratory problems and muscle weakness. The results we have had just be taking up singing and going to vocal lessons, just because we liked music, has made such a difference.” Parents also claimed

they would like to see singing used in pulmonary testing environments to make it more enjoyable to children in such an intimidating environment. Professionals in the field all responded with a positive view towards singing as a respiratory muscle development program as it encourages correct breathing techniques and breath control which could be beneficial to respiratory muscle maintenance. One medical professional wrote: "It would be hugely beneficial to implement a singing program to aid with strengthening respiratory muscle development. This program could be used daily with clients to assist with moving secretions within the lungs as weakened respiratory muscles can create difficulty coughing."

Question five: (Is there anything else you would like to add?) received varied levels of contribution from survey participants. Patients with muscular dystrophy responded with insight to personal experience; living with muscular dystrophy and the impact singing can make on day to day life. One survey participant wrote: "Over the years, as my condition progressed it became harder to take a deep breath—I think regular singing has pushed me to really stretch to get the absolute maximum out of the limited capacity I do have—which I am sure flows onto my normal breathing during the day and sleep at night." Parents of children with muscular dystrophy mentioned the impact singing has on their children's quality of life and lung health. One participant wrote: "Our spinal doctor has said if we consider any form of spinal surgery [to assist severe scoliosis], your lungs and body have to maintain as healthy as possible [sic]. The doctor recommended my kids keep singing as it's about quality of life and living each day with a smile and singing certainly does that." Medical professionals who completed this survey did not have anything to write in response to this question.

Question six was included to determine if the survey participant is under the age of 18, therefore having to complete a parental consent form.

RESEARCH OUTCOMES

The similarities between respiratory muscle training programs and singing exercises prove the positive impact singing has when used as a pulmonary function rehabilitation method for patients with muscular dystrophy. This study identified the similarities between 'The Respiratory Muscle Training System' by Alison McConnell and the research of Mary J Sandage and Matthew Hoch, highlighting use of training methods; 'overload','specificity', and 'reversibility' used in both practices. Respiratory muscles of patients with muscular dystrophy and other neuromuscular conditions are said to respond well to these training principles.

The training principles: 'overload', 'specificity' and 'reversibility' benefit muscle training though strengthening muscles, developing specific skills, increasing endurance and rebuilding skills through detraining. This training method is used in respiratory muscle training for patients with muscular dystrophy as well as in vocal warm up exercises for singing. This investigation found vocal warm up exercises developed by Dr Ingo Titze, "Five Best Vocal Warm-Up Exercises', written to involve the previously mentioned training principles but using pitch specifically to benefit vocal strength and technique, and further discussed the benefits of practicing them. Within the five exercises vocal strength and technique are improved as well as positively impacting respiratory muscles and breathing technique as the exercises are specifically geared towards muscle training and co-ordination. Muscle training and co-ordination along with breathing technique are vital in the rehabilitation of pulmonary function in patients with MD therefore the use of these exercises and other singing techniques are a beneficial training process.

The study also analysed an email survey sent to patients with muscular dystrophy, parents of patients and medical professionals in the area. Significant findings were all survey participants agreed pulmonary health and quality of life were improved in patients with muscular dystrophy when singing practise and training is involved. Not only did participants mention the impact singing has on quality of life through the release of endorphins, creating social environments and a sense of achievement but also improvement on lung capacity, health and function resulting in less colds and respiratory infections. One participant stated singing had preserved and slowed with degeneration/loss of lung function. All participants understood the benefits of singing for respiratory muscle training but none had ever been advised to use singing training for rehabilitation.

CHAPTER 5: CONCLUSION

This study strongly indicates the positive impact singing has on pulmonary function through a literature review and an analysis of survey questions. In doing so, the research has uncovered many similarities between successful training methods and has supplied a way in which patients with muscular dystrophy can effectively use the training through five exercises. However this dissertation has far from exhausted research possibilities in the field. Different paths of inquiry are available for further study by other researchers who may potentially be from a medical background. Further research could include case studies implementing the vocal training method and measuring the impact on pulmonary function throughout the training period or an extended vocal training system that increases in difficulty.

This dissertation aspires to highlight singing and vocal warm ups as a potential rehabilitation method for patients with muscular dystrophies or other neuromuscular conditions. The suggested warm up exercises are accessible to all abilities, no matter what level of vocal training the participant has, the vocal exercises will still effectively target respiratory muscle training. In conclusion, this study creates discussion about the use of pitch in respiratory muscle training for patients with muscular dystrophy and will hopefully encourage the use of singing as a rehabilitation method pulmonary function along with more research in the field.

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