

University of Wales Trinity St. David

Module No: BMPF7013G

Title: Independent Study (30 Credits) May, 2024

Jane Stansfield

1911459

What is the impact of ageing on the voice of the amateur female symphonic choral singer?

Assignment Module 5

What is the impact of ageing on the female amateur symphonic choral singer?

Portfolio

Amateur female symphonic choral singers are part of a unique demographic who are expected to perform consistently with a high level of musicianship and vocal ability under the baton of world-class conductors and varied professional orchestras.

Singers are often required to commit to weekly rehearsals and demanding performance schedules throughout the year, with many individuals regularly performing with more than one ensemble. Annual auditions are often rigorous, with singers tested on a range of skills, including musicianship and performance ability (Brophy, 2005).

Whilst they are considered amateur musicians and, therefore, do not make a living from singing, they are expected to display similarly high levels of musicianship to the accompanying professional orchestras with whom they perform. This is vital to ensure ticket sales for large concerts, positive reviews, and subsequent profits for the organisations in question (Smith et al, 2019).

This, therefore, presents very different vocal demands to those of a social amateur choir member who simply sings for their own enjoyment, attending rehearsals when they are able, and the professional singer who relies on their voice to maintain a living.

Whilst standards may vary, many singers have received professional vocal training or musical training in other instruments but have either chosen to pursue careers in other sectors or have been unsuccessful in pursuing solo performance careers. Singing, therefore, becomes a lifestyle choice for this demographic, which can be argued is inherently linked to self-identity, fulfilling emotional needs, and musical engagement (Davidson et al., 2010).

From personal experience, many ageing female colleagues have sung with symphonic choral groups for a substantial part of their adult lives. These groups have become integral to their lifestyle, offering a social support network through their advancing years. Maintaining optimum vocal health and agility is absolutely fundamental to these singers, as failure to do so may lead to termination of the choral membership. As membership is intrinsically linked to lifestyle, termination can have a significant impact on mental well-being and future social intercourse.

Vocal integrity is, therefore, required to sustain both the organisation's performance standards and the social aspect that membership provides, highlighting the unique symbiosis of vocal ability and social intercourse associated with amateur symphonic choral singing.

As a singer in two symphonic choruses comprising a significant number of women over the age of fifty, I have become acutely aware of the stresses that the ageing voice places upon these singers and the lack of education, tailored intervention and support around this subject matter.

According to Titze (2000) and Behlau (2020), the female singing voice undergoes considerable physiological change during the ageing process, which can adversely affect vocal expression and performance quality. Therefore, it is imperative that singers are made aware of possible age-related changes to the voice to enable them to seek appropriate intervention where necessary.

Generic vocal intervention can be problematic as the diversity of vocal problems and the timeline in which they present for each individual can create difficulties in developing a standardised approach. Other lifestyle choices, genetics and comorbidities may also affect the voice (Munoz, 2013). This means that a one-size-fits-all approach to vocal training and health may fail to address the diverse and evolving needs of the female singer. As a result, individualised bespoke strategies may be required to address these challenges effectively.

This study, therefore, considers the implications of ageing on the female symphonic choral singer, exploring physiology, vocal health, and singer identity. From these findings, I will investigate current interventional strategies to ascertain if they are successfully meeting the singer's needs and address any areas requiring further investigation or change.

Rationale

Ageing is a natural evolutionary process that results in a linear decline in the function of the cardiovascular, respiratory, skeletal, and muscular systems after the third decade of life, impacting accuracy, speed, endurance, stability, strength, coordination, breathing capacity and nerve conduction velocity. This can subsequently affect the vocal apparatus, including laryngeal function, resonance, respiration, pitch, range, amplitude and ultimately, the quality of the singing voice (Eichorn, 2018, Ramig et al, 2001, Sataloff, 2000) These may be perceived as reduced volume, increased breathiness, a change in pitch, decreased endurance, increased vibrato and reduced vocal range (Eichorn, 2018).

Choral directors strive for vocal blend within the chorus, avoiding excessive vibrato often associated with the ageing voice. For many choral works, a purer, younger sound is often preferred to the overdarkened, richer sounds of the ageing voice; however, this can be dependent on chosen repertoire. A range of dynamic ability, adequate vocal range for the appropriate voice part, sustained endurance, and pitching and intonation proficiency, however, are always required.

It is clear then that age-related decline in these areas can significantly impact the choral singer's vocal health, performance ability, artistic identity and subsequent lifestyle (Sataloff, 2020).

According to the 2021 Census, the ageing population of England and Wales is increasing, with over 11 million people (18.6% of the total population) aged 65 years or older, compared with 16.4% in 2011. National Records of Scotland also project that by mid-2043, 22.9% of the population will be of pensionable age, compared to 19.0% in mid-2018. (2021 Government Policy). This trend is also reflected in many choirs throughout the UK, which often comprise many singers above the age of 50 years old (Howard, 2014). Analysis of current data reveals that a proportion of these singers will present with voice changes arising from age-related physiological and hormonal changes. However, the exact figures are unknown (Wicklund et al., 2012). Considering these trends and the advancements in health care, many female choral singers will sing well beyond middle age. It is, therefore, crucial to equip these women with the correct tools to enable them to continue to perform at the required standard through their advancing years.

From personal experience, many singers remain largely ill-informed about the implications and symptoms of age-related change until they encounter problems, often assuming these changes are related to poor technique (D'Haeseleer et al., 2014, Packham, 2013, Sundberg, 2019). This lack of education and awareness can lead to a delay in seeking appropriate intervention and care, which may result in unnecessary vocal decline.

Whilst many studies regarding the impact of ageing on the professional singer are widely available and a large number of social subscribing initiatives for social singers exist, research into this particular niche demographic remains largely underdeveloped.

In view of the perceived lack of awareness and educational support available to the amateur symphonic choral singer, the negative impact that ageing can have on the voice and the relevance of sustaining optimum vocal health to enable the singer to continue in the lifestyle of a symphonic choral singer, the rationale of the study is therefore to explore the suitability of current interventional practices to ensure that the ageing symphonic choral singer retains optimum vocal health to meet the requirement standards of the chorus in which they sing.

Objectives of the Study

The study aims to examine the impact of ageing on the female voice, exploring the effects of advancing age on the musculoskeletal, respiratory and neurological systems and the subsequent impact on vocal health and artistic identity. Psychological and emotional implications will also be considered. From this data, I will consider the suitability and efficacy of current management strategies in sustaining vocal health and artistic longevity. These findings will form the basis of

future research and implementation of strategies to raise awareness of age-related vocal change in symphonic choral singers.

Planned Study					
Consider topics and learning objectives	February-March 2024				
Source and Read Relevant Literature	February-March 2024				
Write Literature Review		March -April 2024			
Write Critical Reflection		March-April 2024			
Submit Draft Assignment			22nd April, 2024		
Final Ammendments				25th April-2nd May 2024	
Submit Final Assignment					3rd May, 2024

Methods and Research Design

This study uses a thematic interpretivist approach to explore the impact of ageing on the female symphonic choral singer and the efficacy of current interventions.

Due to the subject matter and the broad nature of the research title, I will draw upon primary-sourced medical literature and grey literature from the field of vocal pedagogy, employing a mixed-method approach that combines quantitative and qualitative data to consider the physiological implications of the ageing process on the respiratory, musculoskeletal, and neurological systems and the voice. According to Creswell et al. (2018), this combined approach offers an effective way to triangulate data, cross-validate findings, and strengthen the overall study.

It will follow a thematic approach, identifying recurring themes associated with the impact of age-related change on the female singing voice, endeavouring to find repeated patterns of meaning (Braun et al, 2006).

Meta-analysis will be used to synthesise the data, as, according to Cooper (2017), it allows for a more objective synthesis of research findings and can provide a more precise estimate of the effect of a particular intervention than any individual study alone.

From an epistemological perspective, the study will align with the interpretivist movement due to the use of thematic analysis to understand patterns within qualitative medical literature.

The interpretivist movement assumes that patterns within qualitative medical literature are subjectively constructed through interpretation and interaction. It seeks to uncover how various authors, patients, or medical professionals interpret and convey their experiences and understandings. Thematic analysis will be used to identify these patterns, exploring the nuanced and context-specific meanings within the qualitative data. The movement also acknowledges the researcher's interpretation as central to the process, interpreting the data and constructing meaning from the identified themes. This will enable me to ascertain if the vocal requirements of the symphonic choral singer are affected by the ageing process and what interventions are suitable to address these age-related changes identified by emerging, recurrent themes in the literature.

The research will be conducted ethically and transparently, paying particular attention to data quality and validity and acknowledging appropriate sources (Bryman, 2016)

The literature search will be conducted using academic databases such as PubMed, Google Scholar, and Scopus. The search will include keywords and terms such as "ageing and voice," "female choral singers," "symphonic choir," "vocal ageing," "psychological impact of ageing on singers," "physiological changes in ageing singers," and "thematic analysis in vocal studies." This will enable me to establish the key vocal requirements of the female amateur symphonic choral singer. By identifying these requirements, I intend to ascertain which may be affected by age-related vocal change and what can be done to mitigate these changes.

The selected studies will include peer-reviewed articles, books, and dissertations focusing on the physiological and psychological impacts of ageing on female symphonic choral singers, incorporating pivotal historical literature and more recent studies to ensure continued relevance.

Due to the size of the study and the extensive literature available on the physiological and psychological implications of the ageing process, data citation analysis will be used to identify the most appropriate articles on age-related change (McCain, 1990), and data searches refined to display articles from 2000 onwards to keep the research current (D'haeseleer, 2012, Hamdan 2017, Moseley 2020). However, in doing so, I want to ensure that pivotal historical articles on the subject matter are not missed, as these can provide valuable insight into the evolution of the subject matter. Citation analysis tools like Google Scholar Metrics and Scopus Citation Tracker will also be employed to determine the impact and relevance of the articles. Articles that exclusively feature male or non-choral singers and those unrelated to ageing will also be excluded where appropriate.

Research regarding the ageing female voice is constantly evolving, with several academics making significant contributions to our current understanding. Titze (2000), LeBorgne (2014), Abibtol (2006), Sataloff (2000), Hallberg (1996), Callaghan (2000), Ploger (2010), and Searce (2016) emerge as key contributors. Their work has improved our understanding of the ageing female voice and what factors may contribute to these changes, informing current best practices in voice therapy and rehabilitation for ageing women. These authors all provide useful insight into the factors that may contribute to age-related vocal change, highlighting areas of research that require further investigation and areas suitable for intervention.

Many of the age-related changes to the musculoskeletal, respiratory, and neurological systems can result in similar vocal problems. Thematic analysis will encourage the most significant themes related to vocal change to emerge, allowing the data to be presented in a more coherent narrative, providing a comprehensive overview of the subject matter, and subsequently forming the basis of the Literature Review. By identifying these vocal changes, the efficacy of current strategies to manage these problems can then be considered. This will form the basis of my final dissertation regarding interventional strategies for the ageing symphonic choral singer.

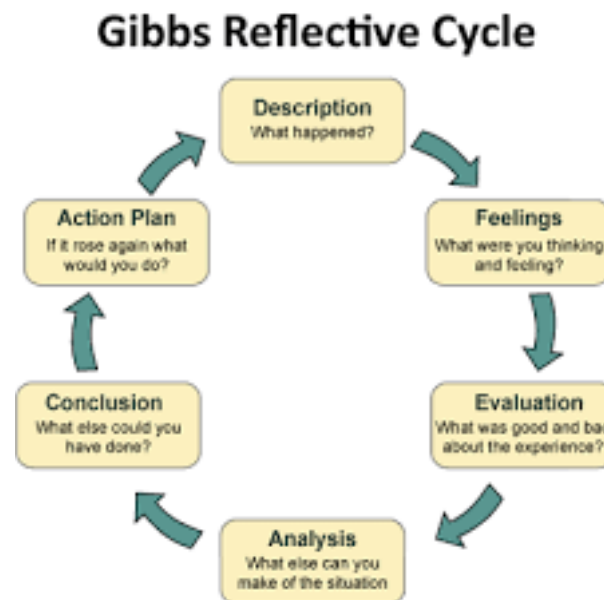
Various data collection tools will be employed, including purposeful sampling to identify information-rich cases (Cresswell et al., 2011) and citation mining of articles written by the key contributors to broaden the literature. This will enable me to gain a deeper understanding of the subject matter, identify gaps in existing knowledge, and highlight areas where further research is required.

In drawing conclusions on the appropriateness of current intervention and management strategies, I am aware that my perspective might introduce an element of bias. Having personally seen the effects of age-related vocal change in several close friends and choral members and the lack of diagnosis and cohesive support that was offered to them during this time, I was aware that this might influence the conclusions I drew on the suitability of intervention for this niche demographic. Analytical bias will be, therefore, be addressed by acknowledging and challenging personal assumptions, carefully considering the impact of age-related vocal change and whether the impact of these changes may be significant enough to warrant significant coverage in mainstream literature. This will ensure objective and unbiased conclusions (Pannucci, 2010).

Critical Reflection

To investigate how ageing affects the female choral singer, I used Gibbs Reflective Cycle (1988) to create a structured framework for deepening my understanding of the topic and guide future practice.

Gibbs' Reflective Cycle (1988) comprises six stages: Description, Feelings, Evaluation, Analysis, Conclusion, and Action Plan. It encourages a holistic approach to reflection, facilitates exploration of emotional responses, critically evaluates literature, and formulates actionable insights.



As the research question relates to medical research and vocal pedagogy, I felt this model was the most suitable for reflecting on my learning experience, enabling me to expand my knowledge of the ageing process and the impact of physical and psychological decline on vocal health, explore current strategies for vocal care and maintenance, and develop informed approaches to consider in future research, to support these singers during their advancing years.

The purpose of the initial part of the Literature Review was to determine the vocal requirements of the female symphonic choral singer. This highlighted a high standard of vocal ability, encompassing, a clear, resonant tone with good intonation and control, an appropriate vocal range for the voice part, an ability to blend with other singers in the section and the ensemble as a whole, and stamina and endurance to sustain long rehearsals and performances (Abrahams et al, 2018). Rhythm and pitch accuracy, musical interpretation and expression, sight-reading skills, clarity in diction and pronunciation, conductor awareness and the capacity to sing harmony parts are equally vital skills (Dunkley, 2017).

This was important as age-related change affecting any one of these areas may be significant in determining longevity in the chorus.

The unique position of the symphonic choral singer was also highlighted, demonstrating the close link between singing, mental health and lifestyle opportunities. The relationship between social intercourse, mental health and vocal agility is one of the key areas to emerge for consideration in intervention and is something that I hadn't perhaps considered as significant before the analysis of the Literature Review.

Age-related changes to the singing voice can profoundly impact the emotional experience of the female singer, affecting self-perception and artistic identity (Pabon et al, 2018). Navigating this loss whilst preserving a sense of continuity in artistic expression can be challenging for many ageing singers. Therefore, for these singers, emotional support is just as important as vocal support. This is an area that I intend to develop in future research, as the size of the study did not allow for in-depth analysis and exploration of the most suitable interventional strategies.

The literature review then examined the impact of ageing on the body, identifying changes to the musculoskeletal system, including loss of muscle mass and strength, joint degeneration and stiffness, muscle fibrosis and change to elasticity, bone density loss, and postural change. Respiratory changes presented as reduced respiratory muscle strength, loss of chest wall compliance, decreased lung elasticity, altered breathing patterns and increased airway resistance. Neurological implications include neural change and motor function (Collins et al, 2010, Cruz et al, 2019, Doty, 2013, Karamanidou et al, 2019).

There was an overwhelming amount of literature available on the ageing process, which I found hard to condense and very time-consuming to structure. However, I felt that this was important to include in the study, as treating the voice is a holistic process involving the body as a whole. Therefore, an understanding of age-related change is vital to any practitioner.

After successfully providing a detailed overview of the various ways in which ageing impacts the body, referencing multiple studies to add credibility to the information presented, I narrowed the research to focus on age-related vocal change.

I initially planned to structure the Literature Review around the impact of age-related changes on the voice under headings of voice quality, agility, range, and endurance. However, after analysing the information, I found such a wide range of physiological and psychological symptoms affecting the voice that it was impossible to assimilate them effectively.

An overview of studies, however, identified three main themes affecting vocal ability: musculoskeletal, respiratory, and neurological age-related change (Titze, 2000). I had hoped that the identification of these themes would allow me to organise information flow, utilising these titles to create a methodical approach to analysis. However, further analysis revealed a substantial number of factors that may subsequently affect the female singer within these parameters.

Again, I found this information difficult to assimilate and record without repetition in the narrative and began to wonder if the research title was too broad, given the limitations of the study. Many aspects of musculoskeletal change had similar effects on the voice but for different physiological reasons. Similarly, there was an overlap of respiratory and neurological symptoms affecting vocal outcome. Even though I had identified these key themes, I was simply unable to avoid the overlap between the subject matter. I spent a considerable amount of time rewriting information and felt increasingly concerned by time constraints and a lack of viable structure to the review.

I also became concerned that the Literature Review was perhaps too medical, however, I concluded that this level of clinical understanding was necessary to consider appropriate intervention. This, however, also allowed me to consider the role of the singing teacher and its ethical limitations. A vocal pedagogue cannot work medically unless they are appropriately and specifically trained. Therefore, when implementing intervention, any medical issues and concerns should be passed on to the most appropriate healthcare professional for further investigation. This is imperative to ensure the safety and well-being of the student.

This allowed me to conclude the study with an appraisal of current measurement tools to assess vocal change and an overview of management strategies.

The exploration of current intervention strategies revealed modified vocal exercises, respiratory interventions, physical exercises, and lifestyle and dietary modifications as successful interventions for the ageing female singer (Schneider, 2017). I found this research easier to synthesise as I could draw upon my experience as a singer, musician, and sportswoman to understand the literature from both an academic and personal perspective.

For this part of the review, I combined peer-reviewed literature with information from colleagues, singing teachers, and other vocal pedagogues to collate a sample of exercises that would be effective in treating age-related vocal change. Modified vocal exercises were categorised into areas of vocal change that emerged from the earlier part of the review and cross-referenced against the vocal requirements of the choral singer to ascertain if they adequately met their required needs. Again, due to the limited scope of the study, the efficacy of popular methods was evidenced; however, future research is required to provide a more detailed exploration of specific exercises.

The importance of physical exercise and maintaining physical health was also addressed, with many studies demonstrating a link between good physical health and optimum vocal health.

(REF)

Whilst physical, vocal, and respiratory exercises were all evidenced to address the needs of the choral singer, the final analysis revealed a gap in education and awareness in mainstream literature regarding age-related vocal change.

While an abundance of literature is available on age-related vocal change, the research findings concluded that some singers were unaware of the diversity of age-related change and the impact it may have on their vocal capabilities, implying that the delivery of education and general awareness surrounding this subject matter was unsatisfactory. Therefore, further research is warranted to deliver effective and accurate information to this demographic. The choral institution, however, should take part responsibility, along with healthcare professionals and singing teachers, to ensure that appropriate information is conveyed regarding this subject matter to empower the individual with knowledge and allow them to seek the most appropriate help and early intervention.

Finally, the study discussed the accessibility and affordability of suitable interventional care. While the study highlighted this as a problem for many women, advancements in technology were credited with opening vocal monitoring and rehabilitation to a wider audience.

Reflecting on the process as a whole, I noted the following:-

I enjoyed collating and reviewing data from vocal pedagogy and medical sources, gaining a greater in-depth understanding of the ageing process and its effects on physical and vocal health; however, I felt immense pressure due to time constraints and external commitments. This impacted the number of hours I could feasibly commit to the research; reading became very disjointed, and progression was slow.

I became concerned at the amount of information that I had generated and struggled to condense it into a manageable size according to the specifications of the study. The data presentation became too descriptive, with little initial analysis. Whilst I endeavoured to rectify this, the Literature Review remained largely descriptive, which is an area of concern for the future work-based project.

I also found the portfolio challenging to write. Although the structure of the master's Course introduced key concepts of methodology as an independent study prior to the desk-based learning project, I had several prolonged interruptions to study due to ill health. During this time, I had forgotten many of the methodologies involved in research and had to revisit many of the previous teachings on the subject matter. This again involved additional time, which should have been spent synthesising data on the current research question.

On reflection, the research question was too broad and inappropriate for the size of the study. As evidenced, there are many physiological and psychological changes that can affect the voice of the ageing symphonic choral singer, and focussing on any one of these would have allowed for a more in-depth analysis and succinct study. The generic nature of the Literature Review, however, enabled me to gain a broad understanding of age-related vocal change, highlighting the need for

a more effective method of delivering education and raising awareness of these changes to the ageing female symphonic choral singer to enable them to seek appropriate care. This will form the focus area for my master's final dissertation, where I intend to pursue ways of increasing awareness of age-related change in this niche group of singers. This may take the form of an informative podcast series.

In conclusion, time management was the most challenging part of the research project. It was only as I was nearing the submission deadline that I was able to allocate dedicated hours to the project. I marked the time off in the diary and worked from the library to ensure no distractions. In retrospect, I should have done this earlier. By increasing the time spent researching the literature and adhering to set timeframes to discuss progress with my tutor, I would have undoubtedly produced a more thorough and comprehensive study.

Personal Action Plan for Future Study

Structure future research by diarising specific study time.

Keep in regular contact with my tutor to ensure progress.

Deepen my understanding of successful critical analysis.

Undertake further research on methodologies and models of reflective practice to expand my knowledge base.

Research Action Plan

Consider research on the best way to educate women on possible voice complications during the ageing process

Create a manifest to educate female singers and choir directors on the implications of female age-related vocal change.

Consider suitable ways of implementing this. This may take the form of a podcast series aimed at the ageing female symphonic singer.

In conclusion, Gibbs's Reflective Cycle (1988) has proven an effective tool for encouraging critical reflection and highlighting the importance of reflective practice in promoting personal growth and development; I look forward to continuing this practice in future academic and professional endeavours.

The Literature Review

This Literature Review is a desk-based study that seeks to examine the impact of ageing on the amateur symphonic female choral singer, identifying the effects of musculoskeletal, respiratory, and neurological change on the voice. The importance of singer identity will also be considered in the context of the symphonic choral setting, and the suitability of current methods of intervention will be discussed. This will inform the basis of further research into best practices for maintaining optimal vocal health in the ageing singer.

Amateur female symphonic choral singers are part of a unique demographic who are expected to perform consistently with a high level of musicianship and vocal ability under the baton of world-class conductors and professional orchestras (James, 2015).

Vocal quality, health, and endurance are key to maintaining required performance standards and intense rehearsal and performance schedules. While many singers in this demographic have received professional vocal training throughout their lifetimes, they are not professional performers and are, therefore, not relying on their voice to provide an income. They are, however, part of an auditioned select group representing a professional body with a view to making a profit for the organisation in question. They are also expected to sing alongside professional orchestral musicians with a similar musical understanding and artistic integrity (Ganschow, 2016). This, therefore, presents very different vocal demands to those of a social amateur choir member who simply sings for their own enjoyment, attending rehearsals when they are able, and the professional singer who relies on their voice to maintain a living.

The voice needs to be maintained to reach the required performance standards of the choral organisation, but the voice also serves the purpose of membership to an organisation that provides a lifestyle and social interaction. Singers participate solely for the joy of singing, to satisfy emotional needs and musical engagement. Therefore, the concept of singer identity and its relevance to the choir is also paramount as this plays a crucial role in shaping the collective sounds, dynamics and overall experience of the ensemble (Davidson et al, 2013).

Studies indicate that during the ageing process, several physiological changes occur that can affect the qualities required of the symphonic choral singer (Hirano, 2005, Sataloff, 2002, Titze, 2005). These may be a direct result of age-related changes to the vocal apparatus and vocal mechanisms or as an indirect result of further changes associated with the ageing process. However, these changes can vary greatly between individuals (Baker, 2011).

These present a range of challenges, including physical, emotional, and psychological factors. Vocal quality, range, flexibility, and stamina may decline, making it harder to meet the demands of choral repertoire (Sataloff, 2002, Titze, 2005). Singers may struggle with feelings of frustration, loss, and self-doubt as they navigate these changes and adjust to new vocal limitations (Kenny, 2012). This may result in a loss of confidence, motivation, and increased performance anxiety that can impact singer -identity and sense of self within the context of vocal performance, leading to shifts in vocal characteristics, musical preferences, artistic interpretations and personal motivations (Welch, 2017). This is highly relevant in an amateur symphonic chorus as it contributes to vocal blend, artistic expression, skill development, group dynamics, performance impact, and choral leadership. Therefore, it is imperative that these singers are aware of potential age-related changes and are able to engage in early intervention to fulfil these requirements. Studies indicate that If early and appropriate intervention is not sought, the demands of the

choral schedule may make the singer more susceptible to vocal health issues and unnecessary damage (Hunter et al, 2019, Lortie et al, 2017, Svec et al, 2020).

Research also indicates that women are more prone to dysphonia compared to men, with a higher prevalence of voice disorders across various age groups (Cohen et al., 2012; Mathmann et al., 2024). This may be due in part to the differences in vocal fold size and length between men and women, which can affect vocal production and hormonal factors. This indicates an increased vulnerability for this section of the chorus.

Often, choral singers are unaware of the changes that may arise as a result of ageing. From personal experience, singers often resort to seeking out information on voice proactively when encountering age-related changes. Information is generic, and singers may struggle to find accurate and effective management tools independently. This then raises the question of whether education surrounding the ageing voice and the efficacy of current interventional strategies are meeting the needs of the symphonic choral singer.

As singing is a holistic activity, this study will provide an initial review of the ageing process, followed by a more detailed exploration of the impact of ageing on the vocal apparatus and the impact that these may have on the singer. By understanding the nuances of age-related change in the female voice and the vocal requirements of the symphonic choral singer, the efficacy of current vocal and informative interventions can be considered. These will be based on evidence-based research and the works of prominent vocal pedagogues. This will form the basis of future research into raising awareness of age-related change in the female amateur choral voice.

Choral Requirements

Before discussing the impact of ageing on the voice, it is prudent to define the vocal requirements and expectations of the female symphonic choral singer to ensure that any future intervention meets these needs.

A good standard of vocal ability is a prerequisite of a symphonic choral singer, encompassing, a clear, resonant tone with good intonation and control, an appropriate vocal range for the voice part, an ability to blend with other singers in the section and the ensemble as a whole, and stamina and endurance to sustain long rehearsals and performances (Abrahams et al, 2018). Data analysis also indicates rhythm and pitch accuracy, musical interpretation and expression, sight-reading skills, clarity in diction and pronunciation, conductor awareness and the capacity to sing harmony parts as equally vital skills (Dunkley, 2017). Personal attributes such as commitment to attend regular rehearsal and performance schedules are also relevant as vocal decline and ill health can impact attendance records.

Protecting the voice and exploring strategies to minimise age-related decline in these areas is therefore key for these performers, as negative changes could subsequently impact the quality of the choral performance for both the individual and the choir.

Ageing

Ageing is an inevitable, complex, and multifaceted process influenced by a combination of genetic, environmental, and lifestyle factors (Hazzard et al, 2017, Salthouse, 2010).

It is characterised by a gradual decline in physiological function and resilience, resulting in a wide range of physical, cognitive, and psychological changes (Hazzard et al, 2017) that may directly and indirectly impact the vocal apparatus and subsequent artistic expression and performance ability of the ageing female choral singer (Tilman et al, 2002). Age-related changes in vocal quality, range, stamina and overall function are all widely reported, although the extent to which ageing affects the individual has been shown to vary greatly.

Whilst the scope of the study does not allow for a full detailed review of the ageing process, physical function, cognitive decline and sensory impairment all remain relevant.

A decline in physical function can lead to reduced muscle mass, strength, flexibility, and aerobic capacity (Fried et al., 2001). This can impact posture, alignment, stamina, breath control, and voice support (Miller et al, 2016). Reduced muscle mass and strength can affect the muscles involved in vocal production, potentially leading to a weaker and less controlled voice (Royce et al, 2003). Additionally, decreased flexibility and aerobic capacity may impact the body's ability to support proper breathing techniques, which are essential for vocal control and projection. Therefore, a decline in physical function can have a direct impact on the overall quality and strength of the voice (Garcia et al. 2017).

Ageing is also associated with a decline in neuromuscular function. Reductions in motor unit recruitment, muscle fibre innervation, and nerve conduction velocity can significantly impact the ageing female voice (Baken et al., 2000; Roy et al., 2000).

Structural and functional changes in the brain can affect cognitive functions such as memory and attention, impacting vocal learning and expression during singing and manifesting in problems sustaining concentration for long periods of time during rehearsals and performances (Chaddock-Heyman et al, 2013). Reaction times and processing speeds may also decrease, affecting the ability to respond to vocal demands such as shifts in pitch or volume, resulting in vocal inaccuracies and decreased vocal agility during singing (Pfordresher et al., 2017, Rothernberg, 2019). This may also present challenges in following the nuanced gestures of the conductor.

Changes to the motor control processes in the central nervous system can lead to difficulties initiating and sustaining vocalisations and challenges modulating vocal intensity, pitch, and resonance (Skodda et al., 2011).

Sensory feedback mechanisms involved in vocal monitoring and self-regulation may also impair the ability to detect subtle changes in vocal production, such as pitch deviations or vocal strain, leading to difficulties in vocal self-correction and adjustment during singing (Abitbol, 2006).

Scherder et al. (2014) also note that sensory impairment can affect communication, perception, and overall quality of life. Of these changes, hearing impairment can prove particularly problematic for the singer, affecting pitching, listening, and the ability to achieve vocal blend with others in the chorus (Sataloff, 2000; Scherder, 2014). Declining vision may also present problems in reading scores, particularly in dimly lit rooms.

The prevalence of chronic diseases such as cardiovascular disease, diabetes, cancer, and neurodegenerative disorders may also increase with age, imposing possible physical limitations and other challenges that can affect breathing, endurance and vocal agility (Jagger et al, 2016, Siu et al, 2019).

Vocal techniques focusing on motor learning, coordination training, and neural plasticity may help mitigate the effects of ageing on the female singing voice and promote vocal health and longevity (Gould, 1996). These are discussed later in the study; however, singing in different styles and genres, ear training, pitch recognition, articulation, and diction exercises are all beneficial.

Other considerations include changes to rehearsal technique, such as breaking down complex pieces into manageable sections and practising slowly to aid learning. Enlarged musical scores can help with visual difficulties, and, where applicable, hearing aids can be used to address a decline in hearing (Verdolini, 2014).

Psychological and emotional changes may also occur (Baltes et al, 2003). These can be both positive and negative, including increased resilience, wisdom, and emotional regulation. Challenges such as loneliness, depression, and anxiety can also impact self-perception and singer -identity (Gick, 2011, Pabon et al, 2018).

It is worth noting, however, that singing in a choir can provide emotional benefits, offering a sense of community, belonging, and connection with others who have a shared interest, which can alleviate feelings of loneliness and isolation (Cohen, 2009).

Farncourt et al (2017), also indicate that choir singing can increase endorphin levels, resulting in a sense of happiness and well-being

Alterations in vocal timbre, range, and agility caused by changes to the musculoskeletal, neurological, and respiratory systems and the unreliable nature of the voice can also lead to issues of self-identity and possible feelings of loss of past vocal capabilities (Garcia et al, 2018). Navigating this loss whilst preserving a sense of continuity in artistic expression can be challenging for many ageing singers.

For the choral singer, the changing voice may no longer suit the requirements of the chorus, resulting in a termination of membership. Others may be required to sing a different voice part, resulting in feelings of frustration, isolation, and despair. Problems blending with others may also add to feelings of anxiety and embarrassment. Additionally, performance anxiety and self-consciousness may increase as singers become more aware of their vocal limitations and vulnerabilities. (Daugherty, 1999).

Understanding and acknowledging the emotional nuances of this journey is, therefore, essential for creating a supportive choral environment that empowers ageing choral singers to embrace the richness and depth that comes with their evolving voices whilst retaining technical proficiency. This may involve increased support from the choral management team to create an environment that is more conducive to the success and well-being of the ageing singer by including additional vocal training and support, offering emotional support and encouragement, and creating a sense of community and belonging within the choir.

Further analysis suggests that ageing can be both primary and secondary in nature (Lopez-Otin et al., 2013). Primary ageing refers to the universal process affecting all individuals and is often associated with the accumulation of chronological age-related changes in the body measured from birth. For choral singers, primary ageing may impact vocal abilities over time due to natural changes in the body associated with ageing, such as reduced muscle mass, changes in vocal fold tissues, and decreased lung capacity.

Secondary ageing, however, is a progressive deterioration of physiological function and structural integrity that occurs with age and is influenced by genetic factors, cellular processes, and environmental exposures that may vary greatly among singers (Telemore, 2013).

This is significant as Kramer et al (2002) note that some of the aspects of secondary decline can be improved with intervention, with further studies demonstrating that certain physical and cognitive changes related to ageing can be prevented, mitigated, or even reversed through lifestyle interventions such as exercise and diet (Bredesen, 2014, Ornish, 2018).

As general physical health is linked to vocal health, it is important to take appropriate steps to negate areas of secondary decline where possible. This is corroborated by Hollosky (2000), who highlights the importance of slowing secondary ageing to maintain vocal facility.

Therefore, the importance of lifestyle choices and environmental factors should be highlighted to the choral singer to enable them to make informed choices to protect their health and subsequent vocal health. These may include regular physical exercise (Kramer et al., 2002), a balanced diet (Bredesden, 2014), stress management techniques, adequate hydration, and reduced exposure to air pollutants, allergens, and irritants.

Physiology of Ageing in the Female Voice

As the female voice matures, the anatomical structures of the vocal apparatus, including the larynx and vocal folds, undergo significant change (Titze, 2000; Vaca et al, 2015).

Analysis of current literature suggests that age-related changes to the musculoskeletal, respiratory, and neurological systems are areas of concern for the ageing singer, however, hormonal fluctuations associated with Perimenopause and Menopause also play a significant role in the ageing voice (Sataloff, 2013). These changes are too numerous to discuss in this study; however, analysis shows that as oestrogen declines and progesterone and testosterone fluctuate, the mucous membranes of the vocal folds become drier and less pliable, resulting in increased vocal stiffness and discomfort. The most commonly reported symptoms are dryness, frequent throat clearing, vocal fatigue, roughness, loss of range, and deepening of the voice (Hamdan et al, 2017).

Understanding the nature and extent of voice decline in these areas, as well as vocal habits that may provide protection against decline, is, therefore, key to delaying the onset of vocal changes.

Through cross-examination of data, vocal attributes affected by musculoskeletal, respiratory and neurological age-related change will be evidenced, and suitable methods of intervention to address these changes will be discussed.

Musculoskeletal System

Perhaps one of the most significant changes in the musculoskeletal system is the gradual decline in muscle mass and tone, medically referred to as sarcopenia. This is associated with a gradual loss of muscle mass and strength throughout the body, including the intrinsic and extrinsic muscles of the larynx (Kapsamunakis et al, 2019, Kokkinou et al, 2020, Tsolaki et al, 2018,).

Further studies corroborate these findings, noting that age-related atrophy of the thyroarytenoid and cricothyroid muscles, including the posterior cricoarytenoid muscle may result in a reduction in control and coordination of vocal fold movement, affecting vocal quality, timbre, vibrato,

resonance, dynamics (including loss of projection and overall volume), stability, precision, agility and stamina (Baken, 1987, Dimitar, 2005, Enright et al., 2000, Hixon et al, 2008, Koojiman et al, 2021, Sataloff, 2005, Woo, 2005).

Degeneration of the extrinsic sternohyoid, thyrohyoid, and omohyoid muscles, which provide crucial support and stability to the larynx during phonation, swallowing, and breathing, may also result in laryngeal and vocal instability, reduced vocal control, fatigue, and issues with swallowing (Mallur et al., 2018). Therefore, exercises that strengthen these muscles must be considered in intervention to mitigate these effects and improve vocal endurance. These may include laryngeal elevation exercises such as falsetto slides to strengthen and engage the extrinsic laryngeal muscles and yawn-sigh techniques to stretch and relax the laryngeal muscles while promoting better vocal fold closure. Humming and lip trills are useful to engage the laryngeal muscles and improve resonance and vocal fold closure. Other vocal function exercises and SOVTs may also be beneficial to improve vocal fold vibration and muscle engagement (Stemple, 2018).

Tongue muscle mass has also been shown to decline in old age (Korn et al, 2018). This can impact tongue muscle function, affecting articulation and phonation, which was identified as a key requirement of a symphonic choral singer.

In addition to a decline in muscle mass, research also indicates that ageing may alter the composition and structure of connective tissues, including tendons, ligaments, and fascia, throughout the body (Haus et al. 2020). These changes, including collagen cross-linking, intramuscular fat deposition, fibrosis and decreased tissue elasticity, can affect the biomechanical properties of the laryngeal muscles and their attachments to the larynx and surrounding structures, posing similar problems to those seen in muscle mass decline (Ramalho et al, 2017, Nairici et al., 2010). These age-related changes are collectively referred to as Presbyphonia (Behlau et al., 2002).

To mitigate these changes, vocal warm-ups and cool-downs are useful to prepare the voice for singing and reduce strain on the vocal folds, focussing on techniques to promote flexibility and elasticity in the vocal muscles and connective tissues.

Exercises can also be used to optimise vocal resonance and projection by engaging the resonance chambers and supporting vocal projection through proper breath control and placement rather than excessive muscle force.

Diaphragmatic breathing techniques, which enhance breath control and reduce strain on the vocal muscles and connective tissues, are also effective (Hixon, 2006, Sundberg, 1987, Vedolini, 2005).

Linville (20011) refers to this loss of muscular strength and tissue elasticity derived from alterations in the structural and mechanical properties of the muscle tissue as the weakening and stiffening theory or muscle quality hypothesis. Muscles of the vocal mechanism become weaker due to the loss of contractile proteins, a reduction in muscle fibre size, decreased number of

motor units, and impaired neuromuscular function. Stiffening occurs as a result of the accumulation of non-contractile tissue in the muscle matrix, resulting in increased fibrosis and a reduction in muscle elasticity.

Research into the weakening and stiffening theory continues to evolve, however, theorists suggest that focusing solely on increasing muscle mass may not be sufficient to counteract the functional decline associated with ageing. There is a substantial body of scientific research that supports the idea that improving muscle quality, in addition to increasing muscle mass, is critical for preserving physical function and mobility in ageing adults (Kostek et al, 2011, Visser et al. 2005).

Therefore, interventions aimed at improving muscle quality, such as reducing intramuscular fat infiltration and enhancing muscle fibre integrity through resistance training, may be equally important in preserving physical function and mobility. Vocal exercises to improve muscle coordination and control and exercises to strengthen the muscles responsible for vocal production should all be considered.

Vocal Fold Atrophy and Stiffness

This increased atrophy and fibrosis can directly affect the vocal folds, causing them to stiffen and thin, resulting in reduced vocal fold closure, irregular vocal fold oscillation, and decreased vibratory efficiency (Leder, 2019). This may result in hoarseness, roughness, breathiness, vocal strain, fatigue, muscle tension, decreased vocal range, and an overall harsher, less resonant sound quality (Hirano, 1981, Ramig et al, 1996, Verdolini et al, 2005).

Ligament laxity, including the thyroarytenoid muscle, and decreased tension in the vocal fold lamina propria can also cause vocal fold bowing. This is characterised by medial deviation of the vocal folds, causing similar vocal problems to fibrosis of the folds, which should be addressed in interventional programmes (Verdolini, 2009).

Respiratory Changes

Ageing and sarcopenia can also adversely affect the muscles and coordination of the respiratory system involved in voice production, such as the diaphragm, intercostal muscles and abdominal muscles (Cotes et al. 2005, Enright et al, 1994, Guerra et al, 2010, Smith et al, 2019, Takahashi et al, 2020). Atrophy of these muscles can lead to weakened muscle function and reduced muscle tone. These changes in respiratory function and coordination may result in irregular breathing rhythms, inconsistent breath timing, and difficulties in coordinating breathing during singing, leading to vocal instability and decreased vocal control (Hixon et al., 2006). These dysfunctional patterns have been linked to compensatory strategies such as breath-holding and shallow breathing that limit vocal production and quality (Mendes et al., 2017; Miller et al., 2017).

In a symphonic choral setting, where precision, blend, and balance are crucial, these age-related changes in respiratory function can affect the overall cohesion and unity of the ensemble. Singers may find it challenging to synchronise their breathing with other choir members, resulting in disruptions to ensemble singing, impacting the overall quality of the performance.

A decline in muscle mass, strength, and elasticity may also lead to a decrease in vital capacity, which represents the maximum volume of air that can be forcibly exhaled after maximum inhalation. This is demonstrated by Roy et al (2010), reporting a decrease in lung function parameters related to ageing, including a reduction in vital capacity and peak expiratory flow rate. This reduction in vital capacity can limit the amount of air available for phonation, affecting vocal projection, volume, and overall vocal power. This may impact the vocal intensity and resonance required for effective choral singing, leading to diminished vocal presence within the ensemble.

Linville (2001) further noted that diminished vital capacity results in a decreased oxygen supply to the muscles. A suboptimal oxygen supply to the muscles may result in hypoxia, which can negatively impact muscle function, endurance, and overall vocal performance.

For singers, a reduction in oxygen supply to the laryngeal muscles can lead to impaired muscle function, reduced muscle tone, decreased muscle responsiveness, and impaired coordination of vocal fold movements. This can contribute to decreased vocal flexibility, vocal instability, breathiness, and vocal control difficulties, which can affect overall performance (Kwak et al, 2019).

In response to hypoxia, the muscles of the larynx and respiratory system may compensate with tension, resulting in hypoxic muscle contraction. This manifests as muscular tension, vocal strain, and fatigue, particularly during prolonged vocal tasks. Female singers may experience a faster onset of muscle fatigue, reduced vocal stamina, and difficulties in sustaining vocal tasks over extended periods, leading to vocal fatigue and strain during choral rehearsals and performances (Titze, 2000).

Ageing female singers may also be at an increased risk of vocal fold trauma and lesions due to the combination of muscle fatigue, vocal strain, and diminished vocal stamina. Prolonged muscle recovery time may further exacerbate the risk of vocal fold injuries, impacting vocal health and longevity (Titze, 2000).

The combined effects of impaired muscle function, reduced muscle tone, decreased responsiveness, poor coordination and respiratory change can significantly affect the overall performance of the choral blend, resulting in inconsistent sound quality where individual voices may stand out due to variations in vocal strength and control, and a reduction in musical cohesiveness with individuals unable to maintain pitch, dynamic range, and rhythmic precision.

Interventional exercises for addressing age-related changes in respiratory function and coordination may overlap with those previously recommended for other vocal issues; however, specific exercises and techniques targeting respiratory support and the coordination of the respiratory muscles involved in vocal production to increase vocal endurance, support, breath control, and vocal stability should be included to mitigate these changes. (Rothenberg, 2005, Sundberg et al., 1989). Additionally, vocal exercises designed to increase lung function and vital capacity by increasing the amount of air available for phonation to enhance vocal projection, volume, and overall vocal power should also be incorporated (Huckabee et al, 2020). Sustained phonation exercises and diaphragmatic breathing exercises are particularly useful.

Many exercises for breath support and improved lung capacity have been developed from the Westerman-Gregg method (2014) and can be incorporated into vocal warm-ups. These exercises focus on coordinating breathing and phonation to produce a relaxed and efficient sound. They are evidenced to be effective in improving vocal function and production, resulting in improved performance, and should therefore be explored for interventional use (Krasniqi et al. 2019, Ramig et al. 2018, Smith 2018).

Simple breathing exercises to engage the diaphragm, such as breathing slowly through the mouth and exhaling through the nose with a hand on the belly and a hand on the chest to ensure that the chest is not moving and the belly hand moves up with each inhalation and down with each exhalation are effective. The timings of these can be varied, for example, inhalation for 4 seconds, hold the breath for 8 seconds and exhale for 8 seconds.

Hissing is then often added to this exercise, hissing on the exhale. This again can be varied, exhaling on a “VVVV” or a “FFF”, and on various pitches to increase breath control and stability (Bove et al, 2017).

Maintaining and practising correct postural alignment while performing these exercises will optimise respiratory function and vocal production. They will also encourage efficient breath support and airflow, reducing strain on the respiratory muscles.

McCaffrey et al. (2015), Sataloff et al. (2010), and Adams et al. (2009) also advocate the use of interval training, in which singers alternate between short periods of intense vocalisation and periods of rest to build and maintain breath control.

Straw phonation and semi-occluded vocal tract exercises are also useful methods of aiding and regulating breath control while producing sound (Verdolini Abbott et al, 2012)

In a choral setting, many of these breathing exercises are included in vocal warm-ups to wake up both the body and the voice. The choirmaster may also utilise other strategies, such as strategic breath management, to assist the ageing singer in managing breath support across various

musical phrases. This minimises unnecessary strain on the vocal folds, reducing the risk of vocal fatigue.

Further exercises, such as regularly reading out loud, can also aid in breath support and vocalisation.

Joint Degeneration

Ageing can also contribute to degenerative changes in the joints throughout the female body and the articulations of the larynx, including the cricothyroid and cricoarytenoid joints. These changes may include thinning of cartilage and osteoarthritis, which can impact the movement and coordination of the laryngeal muscles (Titze, 2017), restricting laryngeal mobility and subsequently impairing vocal fold abduction, adduction, and tension regulation. Pain, is also associated with degeneration, which may further restrict movement.

Increased airflow leakage, vocal instability, a limit in vocal range, tremors, and decreased vocal power and projection during singing have all been demonstrated as a result (Brunsen, 2018; Shewell, 2009; Rampage et al., 2017). This can significantly affect the performance standards of the symphonic chorus singer and, subsequently, the collective performance quality of the ensemble.

Analgesics, nonsteroidal anti-inflammatory drugs (NSAIDs) and corticosteroids may be prescribed to reduce inflammation, swelling, and pain. However, these may have side effects that subsequently affect the voice, with current research indicating a link between Corticosteroids and hoarseness (Sataloff, 2005). It is useful, therefore, to understand the medication history of the singer when tailoring rehabilitation exercises, as this may affect the outcome.

Consideration should also be given to educating singers on the possible side effects of these drugs on the voice to enable them to make informed choices.

However, the ethical implications of the scope of practice should be considered here.

Changes to the bone structure of the skull and face, which are responsible for the resonance of the voice, may also alter timbre and projection (Sataloff et al., 1995).

Age-related joint degeneration in the cervical spine may also alter alignment, which has been demonstrated to affect vocal tract shape and resonance characteristics, subsequently affecting vocal timbre, clarity, and projection (Karkos et al., 2006).

Joint degeneration may also lead to vocal compensations and increased muscular effort to overcome joint stiffness and instability, which may result in vocal strain, muscle tension, and vocal fatigue during singing (Russell et al., 2008). These can be significant problems for a choral singer trying to achieve vocal blend in a choral setting. Exercises designed to develop proper vocal

technique and breathing exercises to reduce vocal strain and tension should, therefore, be incorporated into regular singing sessions.

With much of the literature noting changes in the larynx as a primary concern to vocal quality, other studies suggest that even if degenerative change does occur in the larynx, individuals may be able to compensate for these changes through various strategies, such as adjusting their breathing or phonation patterns, therefore, the impact of laryngeal ageing on voice quality may depend on an individual's ability to adapt and compensate (Karkos et al, 2008, Verdolini et al, 2002, Houtz, 2008, Lindstead et al, 2002).

Compensation strategies may include exercises to strengthen the laryngeal muscles and improve coordination, such as Stemples Vocal Function Exercises (1995).

Sustained vowel sounds at a comfortable pitch are useful to improve vocal fold closure and control. Pitch glides for flexibility and range. Lip and tongue trills promote relaxation and smooth transitions across the range. Forward-focussed singing is also useful for improving resonance and encouraging a reduction in laryngeal tension. Resonant voice therapy exercises are also applicable.

Postural Change

Postural age-related change as a result of joint degeneration can significantly affect the singing voice by influencing respiratory mechanics, vocal tract alignment, and vocal projection.

Changes in spinal curvature, including increased thoracic kyphosis and lumbar lordosis, have all been reported to affect ribcage expansion, diaphragmatic excursion, and respiratory mechanics, resulting in suboptimal breath support and vocal projection in ageing singers. This can subsequently affect vocal resonance and projection (Dastolfo et al., 2010; Lee et al., 2015; Miller et al., 2017). Without adequate ribcage expansion and diaphragmatic support, singers may struggle to produce resonant, well-supported vocal tones, leading to a reduction in vocal presence, volume, and clarity within the choral ensemble.

Changes in pelvic tilt and hip alignment can also impact lumbar spine curvature, pelvic floor function, and overall trunk stability. These changes in pelvic alignment can impact diaphragmatic excursion, intra-abdominal pressure, and breath support, leading to vocal limitations and changes in vocal quality (Chung et al., 2016). Whilst this is relevant to both male and female singers, differences in pelvic structure and hip anatomy may influence the degree and nature of pelvic tilt and its impact on respiratory mechanics.

Postural change can also impact balance and stability (Berg, 1995). This can be problematic for choral performances where choir members are expected to stand for long periods of time.

Core strengthening exercises have been shown to improve overall posture and stability, which can benefit vocal performance (Bailey et al., 2018). These can be incorporated into regular exercise routines, with practices such as pilates, yoga, meditation, and the Alexander Technique to enhance posture and alignment.

Modified Exercises

Thematic analysis of the literature regarding age-related vocal decline reveals timbre, pitching, decreased range, breath support, flexibility, general fitness, and postural change as the key areas requiring intervention for the ageing symphonic female singer.

Modified exercises are a key element of vocal intervention currently used to address these areas (Davis et al, 2020). Many of these exercises are based on the works of Westerman-Gregg (2014), Ragan (2013), Doscher (1994), Leborgne (2012) and Rosenberg (2015) and aim to maintain or enhance vocal flexibility, health and quality to prolong vocal longevity. This contributes to continued choral membership for the symphonic choral singer.

These exercises can be modified to suit the specific needs of the individual based on a range of factors, including the person's age, vocal ability, and the specific vocal changes that they are experiencing. Exercises should be comfortable and easy to perform, allowing for gradual progression. This enables the singer to adapt to new vocal demands and reduces strain, making the exercises more achievable and effective in improving vocal function while also reducing the risk of injury. They should be practised regularly to maximise potential to maximise potential improvement (Bunch, 2007; Behrman, 2016, Rayapati 2012). However, it's important to note that individual responses to vocal exercises may vary.

Many exercises in the public domain are peer-reviewed, but others are the result of testimonials or positive reviews from vocal teachers, other singers, or pedagogues. All are equally important for consideration in tailored programmes, with a collective body of research in vocal pedagogy, voice science, and clinical practice providing substantial evidence supporting their efficacy in maintaining vocal health and enhancing performance for ageing female singers.

However, whilst these methods are relevant and have been widely adopted to promote vocal health, vocal exercises alone may not be enough to prevent or reverse age-related changes to the voice. (Titze, 2006). Therefore, it's crucial to adopt healthy vocal habits to ensure longevity.

The following discussion gives a brief overview of the efficacy of targeted exercises on the main areas of vocal change highlighted in the review. Due to the size of the literature review, this is simply to qualify the importance of combining various methods and strategies for each targeted

area, with a view to a more in-depth analysis of the impact of specific exercises on the symphonic choral singer in future study. Breathing exercises have already been discussed.

Range and Flexibility

One of the themes to emerge from the Literature Review was the reduction in vocal range due in part to the stiffening of the vocal cords. Problems with accessing the head voice are often one of the first notable vocal changes for ageing females due to a lowering of the larynx in the throat after menopause. Overuse of the chest voice can increase the thickness of the folds, making it increasingly difficult to engage the cricothyroid muscles, which are responsible for stretching the folds required in the head voice. Therefore, appropriate modified exercises based on Doscher's method of obtaining balance across all registers should be incorporated to increase range and encourage flexibility, focussing more on the top and middle of the voice than on the lower range for this demographic (Sundberg et al, 1981). However, the chest, modal, and head registers should all be worked (Davis et al, 2020, Thompson et al, 2019). Exercises involving octave jumps and melodic patterns have been shown to improve vocal range and flexibility (Dawson et al, 2002, Sundberg et al, 1993). Vocal glides have also been evidenced to improve vocal function in ageing female voices, increasing vocal range, stability, and clarity (Roy et al., 2017). Sirening and yawn-sighs are also widely used. Exercises incorporating light, fast legato arpeggios are also useful for accessing the head and whistle voice as cords become stiffer.

Articulation and Resonance

Peer-reviewed studies have shown that interventions focusing on resonance training significantly improve vocal quality in ageing female symphonic choral singers (Hirose et al., 2018; Sundberg, 2006). These aim to maximise the vibration of sound waves in the vocal tract, contributing to richness and volume. Many of these have already been detailed; however, exercises derived from Ragan and Leborne's methods for improving the clarity and precision of speech and singing and improving resonance are useful tools.

Ragan's method emphasises the correct usage of articulators such as the lips, tongue, and jaw to produce clear and precise speech, which subsequently enhances the clarity and precision of vocal performance (Hustad et al, 2007, Stemple et al, 2000).

Tongue twisters and consonant-vowel combinations are common exercises used to improve articulatory agility, precision, and clarity of diction (Dallman et al, 2015).

Exercises based on Leborgne's method focus on using the various resonators in the vocal tract to create a full and rich sound (Leborgne, 1961). These exercises help to optimise vocal tone and projection by utilising different resonating spaces (Pilkington et al., 2015; Miller, 2017).

Modifying vowel sounds (e.g., from "ee" to "ah") are typical exercises in optimising resonance, balancing the vocal tract, and enhancing vocal clarity (Miller, 2017).

Strength and Stamina

Rosenberg's method emphasises using the entire body in vocal production involving exercises that integrate movement, breath, and sound to develop a free and expressive voice. Yoga and Feldenkreis practices offer similar benefits.

Studies have shown that exercises involving crescendo/decrescendo and staccato singing can improve vocal strength and endurance (Dacakis et al., 2012; Herbst et al., 2009).

Additionally, exercises like panting are effective in building stamina by rapidly expanding and contracting the muscles.

Further methods for consideration in improving overall vocal quality include the Complete Vocal Technique (CVT), The Estill Voice Training Method, The Accent Method, Lee Silverman Voice Treatment (LSVT) and rehabilitation programmes that combine exercises targeting vocal function, breathing, and resonance to facilitate recovery and improve vocal outcomes (Scepanovic, 2018). Programmes in the UK include singing for health initiatives for lung health, Parkinsons', MS and dementia.

Conclusion

While these strategies are proven to be effective in aiding in the maintenance of the ageing voice, the literature review points towards the need for a more tailored, cohesive, and collaborative approach, revealing a lack of education and support for ageing choral voices.

Choral singers should be offered a wider education on vocal health and rehabilitation to allow them to make informed choices. Titze's (2001) work highlights this, indicating that singers who have a clear understanding of vocal anatomy and the physiological changes that may occur throughout life are better equipped to deal with their vocal situation.

Choral institutions should offer educational support and incorporate suitable regular vocal exercises into choral warm-ups, which, according to Thurman and Welch (2000), can help maintain vocal health and prevent decline in older age. These should be accompanied by an explanation as to why they are effective and what they are trying to achieve to empower the singer with knowledge.

Wider education and information surrounding possible age-related changes to the voice should be made available through chorus emails, newsletters, podcasts, etc. These could include links to online resources.

Training for choral management and conductors regarding age-related changes to the female voice should also be offered to ensure they are fully aware of the multifaceted changes of the ageing voice.

The Literature Review also indicates the significance of maintaining physical health, highlighting the relationship between good physical conditioning and vocal health (D'haeseleer et al, 2018; Richter et al, 2017; Sundberg et al, 2017). Consideration should, therefore, be given to appropriate exercises to attain this. Cardiovascular and strength training should be incorporated where possible, modifying where necessary to take into account any underlying health conditions. Yoga, Pilates, meditation, and The Alexander Technique are also beneficial for strengthening core muscles, improving posture, and promoting relaxation and body awareness, contributing to vocal support and overall physical, vocal and mental health.

A number of studies also highlight the importance of good vocal hygiene, with smoking, excessive alcohol consumption, drug use, inadequate diet, lack of exercise, poor sleep hygiene, and inadequate hydration all shown to be detrimental to vocal health (Sharma et al., 2018; Titze, 2000, 2002; Aronson, 2016). These areas should, therefore, be addressed accordingly.

The extent of the emotional and psychological changes associated with the ageing voice of the symphonic choral singer is also somewhat underplayed.

The review demonstrates the symbiotic relationship between vocal ability and the social aspect of belonging to and performing with a high-level symphonic chorus. Maintenance of the voice ultimately protects the lifestyle. If age-related vocal changes are not successfully navigated, singing within the chosen choir may not be possible, which may ultimately affect mental well-being.

Emotional support is, therefore, key for these singers. Peer support groups and networks associated with the chorus should be established to offer a safe environment for people to share concerns and anecdotal advice. These can be in-person groups or simple online messaging groups. The importance of peer support networks was demonstrated by White et al. (2013) and Blackwood et al. (2016), where ageing female singers were shown to develop resilience and solidarity in shared experiences and mutual support within the vocal community.

Further research also suggests that integrating coping mechanisms such as self-reflection to foster a positive self-perception around changing vocal identity is hugely beneficial (Lin et al., 2020). Neff et al. (2018) also highlight the role of mindfulness techniques and practice in fostering acceptance of the evolving voice.

Finally, the complexities of treating the ageing process with a generic approach were also highlighted due to the multifaceted nature of symptoms and the severity of decline varying greatly for each individual (Baker et al., 2016). To address this issue, it is important to provide personalised care and education tailored to the specific needs of each individual. Medical history, lifestyle choices, and any other factors that could influence the severity and impact of ageing on the voice should also be taken into consideration. By doing so, they can provide more accurate and effective information and intervention to help prevent or manage any symptoms associated with ageing on the voice.

An integrated approach of healthcare professionals, singing teachers, and speech and language therapists may be useful in providing cohesive holistic care, combining medical and artistic perspectives. However, accessing this care may not be feasible for many due to geographical location and cost. Advancements in technology and the availability of vocal monitoring and rehabilitation apps do, however, offer availability to a wider audience. Many of these offer instant, continuous feedback and monitoring services that may otherwise be unobtainable or unaffordable, allowing for early intervention. Early intervention was also indicated by Titze (1997) as vital to avoid vocal decline. Some may argue, however, that some of these apps target symptoms rather than the root cause of the voice problems, ignoring the underlying cause of the issue. Accessibility may also depend on technological literacy, and efficacy and long-term success rates may also vary.

As research continues and the factors that influence age-related change in the voice become more apparent, the understanding of the efficacy of intervention will also evolve, leading to more personalised and effective care.

By highlighting the short falls in awareness and education on the ageing voice, I am now able to consider effective educational tools to deliver to symphonic choral singers in my final research project. This may take the form of an informative podcast series to close the gap in awareness.

References Module 5

Abitbol, J. (1998). *The Ageing Voice*. San Diego: Singular Publishing Group

Abitbol, J. (2006). Ageing and the voice. *The Lancet*, 367(9505), 155-156.

Adams, G., Van Lancker-Sidtis, D. (2009). Effects of a short-term interval training programme on voice and respiratory function. *Journal of Voice*, 23(6), 716-725.

Anderson, R., Sataloff, R. T., Hawkshaw, M. (2015). A review of ageing and the voice. *Journal of Voice*, 29(3), 279-290.

Armanios, M. (2019). Telomeres and age-related disease: how telomere biology informs clinical paradigms. *Journal of Clinical Investigation*, 129(10), 4163-4173. doi: 10.1172/JCI130861

Aronson, A. E. (2016). *Clinical Voice Disorders: An Interdisciplinary Approach*. Plural Publishing.

Baken, R. J., Orlikoff, R. F. (2000). *Clinical Measurement of Speech and Voice*. Cengage Learning.

Baker, D. J., Wijshake, T., Tchkonina, T., LeBrasseur, N. K., Childs, B. G., van de Sluis, B., van Deursen, J. M. (2011). Clearance of p16Ink4a-positive senescent cells delays ageing-associated disorders. *Nature*, 479(7372), 232-236

Baltes, P. B., Smith, J. (2003). New frontiers in the future of ageing: From successful ageing of the young old to the dilemmas of the fourth age. *Gerontology*, 49(2), 123-135.

Behlau, M, R. A. Zambon, M. C. Guerrieri, A, Roy (2002). Presbyphonia: Correlation between Clinical, Acoustic, and Laryngeal Findings *Journal of Voice* Volume: 16 Issue: 4 Pages: 480-487 Year: 2002 Publisher: Elsevier Inc.

Behlau, M. (Ed.). (2020). *Ageing Voice: Current and Future Perspectives in Research and Clinical Care*. Springer International Publishing.

Behrman, A. (2016). *The Benefits of Vocal Exercises for Singers and Speakers*.

VoiceScienceWorks. Retrieved from <https://www.voicescienceworks.org/the-benefits-of-vocal-exercises-for-singers-and-speakers.html>

Berg, W. P., Alessio, H. M., Mills, A. C., Tong, C. (1995). Circulatory function and singing performance in ageing trained singers. *Journal of Voice*, 9(4), 369-374.

- Blackwood, J., Hackney, M., Peters, K. (2016). "It's a sisterhood": The resilience of ageing female singers in community choirs. *Journal of Women & Aging*, 28(2), 122-133.
- Bredesen, D. E. (2014). Reversal of cognitive decline: A novel therapeutic program. *Aging*, 6(9), 707-717. <https://doi.org/10.18632/aging.100690>
- Brophy, T. S. (2005). The Choral Experience: Literature, Materials, and Methods. In C. M. Norris (Ed.), *The Choral Director's Handbook* (pp. 120-145). Hal Leonard Corporation.
- Bunch, C. (2007). The Use of Vocal Function Exercises in the Voice Clinic: Rationale and Implementation. *Journal of Voice*, 21(1), 63-72.
- Butler, R. N., Lewis, M. I. (1987). Theories of ageing. In *Principles of geriatric medicine* (pp. 21-34). Springer, Boston, MA.
- Chaddock-Heyman, TC, K. S. Zatorre, R. J. Zatorre (2013). *Journal: Neuropsychologia Year: 2013 Volume: 51 Issue: 9 Pages: 1749-1756*The Neural Basis of Choral Singing: Insights from fMRI and DTI
- Census (2021). A Scotland for the future: opportunities and challenges of Scotland's changing population - (2021) Government Policy Census
- Chen, X., Mao, G., Leng, S. X., Frangogiannis, N. G. (2018). Ageing and age-related diseases: from mechanisms to therapeutic strategies. *American journal of pathology*, 188(6), 1422-1431.
- Chung, Y. M., & Kim, Y. H. (2016). The effects of pelvic tilt on lumbar spine curvature and trunk muscle activation during abdominal curl-up with pelvic stabilization. *Journal of physical therapy science*, 28(3), 797-800.
- Cohen, G, D (2009). Singing and Social Support: Benefits of Choir Membership for Older Adults. *Gerontologist*, vol. (2009). 49, no. 1, 2009, pp. 117-120.
- Cohen, W. (2012). Prevalence of voice disorders in the general population: A database analysis of age, gender, and occupation. *Journal of Voice*, vol. 26, no. 4, 2012, pp. 470.e9-470.e17.
- Collins, E.G. et al. (2010). Respiratory muscle strength & mechanics in ageing. *Applied Physiology, Nutrition, and Metabolism*, 35(6), 789-797.
- Cotes, J. E., Chinn, D. J., Miller, M. R., Normand, I. C., Ruppel, G. L., & Wells, A. U. (2005). Lung function, lung structure and airway inflammation in older subjects. *European Respiratory Journal*, 26(2), 585-588.

- Cotes, J. E., Chinn, D. J., Miller, M. R. (2005). Respiratory function in the elderly: a comparison of three age groups. *Annals of Human Biology*, 32(6), 726-737. doi:10.1080/03014460500261824
- Cruz-Jentoft, A.J. et al. (2019). Sarcopenia: revised European consensus on definition and diagnosis. *Age and Ageing*, 48(1), 16-31.
- Dastolfo, C., Rosen, C. A., Sewall, G. K. (2010). Changes in the singing voice of women and men with ageing. *Journal of Voice*, 24(1), 55-62.
- Daugherty, J. F. (1999). The changing voice: Maintaining the choral experience for adolescents. *Choral Journal*, 40(5), 17-25.
- Davidson, J. W., & Faulkner, R. (2010). Music and Identity. In P. N. Juslin & J. A. Sloboda (Eds.), *Handbook of Music and Emotion: Theory, Research, Applications* (pp. 550-575). Oxford University Press.
- Davidson, J, W. Faulkner, R. (2015). Music and Social Wellbeing: A Study of the Benefits of Choral Singing. *Music Education Research*, vol. 15, no. 2, 2013, pp. 169-186.
- Dejonckere, P. H., Remacle, M., Fresnel-Elbaz, E., Woisard, V., Crevier-Buchman, L., & Millet, B. (2010). Differentiated perceptual evaluation of pathological voice quality: reliability and correlations with acoustic measurements. *Revue de Laryngologie-Otologie-Rhinologie*, 131(4-5), 219-226.
- Dennison E, M. (2010). Sarcopenia: epidemiology and determinants. *Age Ageing*. 2010 May 1;39(3):412-23. 5. Liu CJ, et al. Effects of exercise interventions on gait and balance in older adults with sarcopenia: a systematic review and meta-analysis. *Ageing Res Rev*. 2019 May;51:36-46.
- D'Errico, F. N. (2018). The Ageing Voice: A Study of Vocal Function, Aging, and Training. *Journal of Voice*, 32(6), 685-e17.
- Dezube, R., & Hopkins, R. (2021). Pulmonary function testing. *StatPearls [Internet]*.
- D'haeseleer, E., Claeys, S., Van Lierde, K., & Gilles, A. (2014). Age-related changes in singing voice: perceptual, acoustic, and laryngoscopic findings. *Journal of Voice*, 28(2), 223-230.
- D'haeseleer, E., Depreitere, B., Claeys, S., & Van Lierde, K. (2018). The impact of physical fitness on vocal fatigue in vocally healthy adults. *Journal of Voice*, 32(3), 303-309.
- Doscher, B. (2008). The Doscher method of vocal performance training. *Journal of Singing*, 64(1), 23-29.

Doscher, M. (1994). *The voice teacher's cookbook: Creative recipes for teachers of singing*. Meredith Music.

Doty, R. (2013). Neurological changes with ageing. *Journal of Psychosocial Nursing and Mental Health Services*, 51(10), 15-18.

Dunkley, S. (2017) *The Choral Singer's Survival Guide*. Oxford University Press.

Eichhorn J. T., Kent R. D., Austin D., Vorperian H. K. (2018). Effects of ageing on vocal fundamental frequency and vowel formants in men and women. *Journal of Voice*, 32(5), 644.e1–644.e9. <https://doi.org/10.1016/j.jvoice.2017.08.003> [PMC free article] [PubMed] [Google Scholar] [Ref list].

Enright, P. L., McBurnie, M. A., Bittner, V., Tracy, R. P., McNamara, R., Arnold, A., Newman, A. B. (1994). The 6-min walk test: a quick measure of functional status in elderly adults. *Chest*, 116(1), 175-182.

Erickson, K.I., et al. (2010). The Impact of Physical Activity on Cognitive Function in Aging Adults. A Review of Evidence for Prevention, *Am J Lifestyle Med*, 4(5), 402-13.

Fancourt, D, Williamon, A. (2017). Attending a Concert Reduces Salivary Cortisol, a Biomarker of Stress: A Quasi-Experimental Study in Healthy Volunteers. *Public Health*, vol. 149, 2017, pp. 9-16.

Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., McBurnie, M. A. (2001). Frailty in older adults: Evidence for a phenotype. *The Journals of Gerontology: Series A*, 56(3), M146-M156.

Ganschow, C. (2015). Vocal Health and Performance Practices in Amateur Choral Singers. *Choral Journal*, vol. 56, no. 4, 2016, pp. 45-58.

García, J. L., Biau, E. (2018). Voice and identity: Perceptions of vocal characteristics and their impact on identity. *Journal of Voice*, 32(6), 702-708. doi: 10.1016/j.jvoice.2017.11.009.

García-P, David, et al. (2017). Effects of Physical Fitness and Breathing Control Exercises on Professional Voice Users. *Journal of Voice*, vol. 31, no. 2, 2017, pp. 254.e1-254.e9.

Gick, M. L. (2011). Vocal hygiene and healthy voice production: Clinical implications. Harrison, J. (Ed.), *The Art and Science of Singing* (pp. 101-120). Oxford University Press.

Gorham-Rowan M. M., Laures-Gore J. (2006). Acoustic–perceptual correlates of voice quality in elderly men and women. *Journal of Communication Disorders*, 39(3), 171–184. <https://doi.org/10.1016/j.jcomdis.2005.11.005> [PubMed] [Google Scholar] [Ref list].

Gould, W. J., Okamura, H. (1996). "The ageing voice: A new therapeutic protocol." *Otolaryngology-Head and Neck Surgery*, 115(5), 539-544. doi:10.1016/S0194-5998(96)70032-6.

Guerra, S., Sherrill, D. L., Venker, C. J., Ceccato, C. M., Halonen, M., Martinez, F. D. (2010). Chronic bronchitis before age 50 years predicts incident airflow limitation and mortality risk. *Thorax*, 65(7), 584-590. doi:10.1136/thx.2009.124321.

Hadebank, J., Grunnet-Nilsson, N, Rosdahl, H. (1998). Oxygen uptake during maximal treadmill and bicycle exercise in elderly subjects. *European Journal of Applied Physiology and Occupational Physiology*, 77(4), 347-352.

Hamdan A,L, Ziade, G, Tabet, G, Btaiche, R, Fakhri, G, Yatim, F, Sarieddine, D, Seoud, M. (2017). Vocal Symptoms and Acoustic Findings in Menopausal Women in Comparison to Pre-menopause Women with Body Mass Index as a Confounding Variable. *J Menopausal Med*. 2017 Aug;23(2):117-123. doi: 10.6118/jmm.2017.23.2.117. Epub 2017 Aug 31. PMID: 28951860; PMCID: PMC5606909.

Haus, J. M., Carrithers, J. A. (2020). Endocrine, Paracrine, and Autocrine Factors Influencing Muscle Growth and Metabolism. In *Exercise Endocrinology* (pp. 287-301). Springer, Cham.

Hawkley, L. C., Cacioppo, J. T. (2010). Loneliness matters: a theoretical and empirical review of consequences and mechanisms. *Annals of Behavioral Medicine*, 40(2), 218-227.

Hazzard, W. R., Halter, J. B., & Hazzard's Geriatric Medicine and Gerontology (2017). *Principles of Geriatric Medicine and Gerontology*, 2-Volume Set. Elsevier Health Sciences.

Hirano, M. (1981). Fiberoptic observation of the vibration of the vocal folds. Review of *Laryngology & Otology*, 87, 100-106.

Hirano, M. (2005) Physiological and Acoustic Differences Between Young and Elderly Voices. *Seminars in Speech and Language*, vol. 26, no. 2, 2005, pp. 99-109.

Holt-Lunstad, J., Smith, T. B., Layton, J. B. (2010). Social relationships and mortality risk: A meta-analytic review. *PLoS Medicine*, 7(7), e1000316.

House, J. S., Landis, K. R., & Umberson, D. (1988). Social relationships and health. *Science*, 241(4865), 540-545.

- Houtz, D. R., Hoffman, H. T., Carroll, W. R. (2007). Age-related changes of the larynx: a review. *J Voice*. 2007;21(6):681-690.
- Houtz, D.R., & Roy, N. (2008). The ageing voice. *Otolaryngologic Clinics of North America*, 41(5), 1055-1070.
- Howard, D. J. (2014). Trends in choral singing in the United Kingdom. *Journal of the Royal Musical Association*, 139(1), 139-166.
- Huckabee, M L, Glenis Long (2020). Phase-Plane Analysis of Respiratory Muscles and Facial Posture in Music Performance. *Journal of Voice*, vol. 34, no. 4, 2020, pp. 516-525.
- Hunter, E J. (2019). Vocal Health of Choral Singers in the United States: A Choral Health Alliance Survey of College and University Choral Singers. *Journal of Voice*, vol. 33, no. 4, 2019, pp. 560-567.
- Hunter, E.J., Titze, I.R., Alipour, F. (2004). A method to automatically detect vocal fold vibratory onset and offset from laryngeal airflow signals. *Journal of Voice*, 18(4), 461-469.
- Inwald, E. C, Inwald, J. K. (2016). Ageing and the singing voice. *Journal of voice*, 30(6), 681-e9.
- Jagger, C., Matthews, F. E., Wohland, P., Fouweather, T., Stephan, B. C., Robinson, L. Deeg, D. J. (2016). A comparison of health expectancies over two decades in England: results of the Cognitive Function and Ageing Study I and II. *The Lancet*, 387(10020), 779-786.
- Jang, Y., Oh, E. G., & Hong, S. (2019). Effects of Aging on the Larynx: A Systematic Review and Meta-Analysis. *Journal of speech, language, and hearing research: JSLHR*, 62(7), 2256–2269. https://doi.org/10.1044/2019_JSLHR-S-18-0456.
- Johns, M. M., & Woo, P. (2015). The Ageing Voice: A Review, Treatment Paradigms, and Future Directions. *Journal of Voice*, 29(3), 261-268. doi: 10.1016/j.jvoice.2014.10.012.
- Johnson JK, Louhivuori J, Stewart AL, Tolvanen A, Ross L, Era P. Quality of life (QOL) of older adult community choral singers in Finland. *Int Psychogeriatr*. 2013 Jul;25(7):1055-64. doi: 10.1017/S1041610213000422. Epub 2013 Apr 11. PMID: 23574947; PMCID: PMC3748797.
- Kapsamunakis, G., Papadopoulos, T., Panagopoulos, G., & Siafaka, V. (2019). The effects of aging and sarcopenia on vocal function in women. *Journal of Voice*, 33(6), 808-811.
- Karkos, P. D., McCormick, M. S., & Murrant, N. J. (2008). Ageing and the voice. *Postgraduate Medical Journal*, 84(992), 166-170. doi: 10.1136/pgmj.2007.064287.

Karkos, P. D., McCormick, M. S., Wenig, B. L. (2006). Effects of laryngeal and cervical spine disorders on voice and swallowing. *Otolaryngologic Clinics of North America*, 39(5), 1001-1017.

Karamanidou, C. et al. (2019). Age-related changes in the musculoskeletal system and their effect on mobility: an overview. *European Geriatric Medicine*, 10(5), 717-725.

Kenny, D,T (2012) *The Psychology of Singing: A Rational, Scientific Approach*. Plural Publishing, 2012.

Kokkinou, M., Drakou, A., Kousoulis, A., Katsoulis, K. (2020). The effects of sarcopenia on the singing voice in postmenopausal women. *Journal of Women & Aging*, 32(3), 291-301.

Kooijman, P. G. C., & Delsing, M. (2021). Laryngeal muscular function in singing: A review of biomechanical and neuromuscular aspects. *Journal of Voice*, 35(1), 104.e1-104.e16. <https://doi.org/10.1016/j.jvoice.2020.04.012>.

Kostek, M. C., Delmonico, M. J. (2011). Skeletal muscle hypertrophy and atrophy signalling: role of sarcopenia in ageing. *Journal of Aging Research*, 2011, 1-13.

Kramer, A.F., & Willis, S.L. (2002). Enhancing the cognitive vitality of older adults. *Current Directions in Psychological Science*, 11(5), 173-177. doi: 10.1111/1467-8721.00190.

Kramer, A F., et al. (2002). Epidemiology of Aging and Cognitive Decline. *Neurology*, vol. 58, no. 9 Suppl 6, 2002, pp. S27-S42.

Krasniqi, B., & Stojanovska, Z. (2019). The Effects of the Westerman Gregg Breathing Method on Vocal Function in Male-to-Female Transgender Individuals Undergoing Voice Therapy. *Journal of Voice*, 33(5), 621-625. doi: 10.1016/j.jvoice.2018.06.015.

Krasniqi, S., Thibeault, S., Ghassemi, M. (2019). The effects of the Westerman Voice Therapy method on voice production in individuals with voice disorders: A systematic review. *Journal of Voice*, 33(1), 111-122.

Kwon, J., Suzuki, T., Yoshida, H., Kim, H., Yoshida, Y. (2008). Association between muscle mass, muscle strength, and bone density of elderly inpatients in geriatric wards. *Journal of bone and mineral metabolism*, 26(3), 254-259.

Kwak, Eun Joo, et al. Hypoxic Voice Disorders: Clinical Features and Management. *Journal of Voice*, vol. 33, no. 6, 2019, pp. 857–864., doi:10.1016/j.jvoice.2018.05.013.

- Langford, C. P., Bowsher, J., Maloney, J. P., Lillis, P (1997). Social support: A conceptual analysis. *Journal of Advanced Nursing*, 25(1), 95-100.
- Leborgne, G. (1961). *Les problèmes de la voix chantée*. Paris: Editions Médicales et Scientifiques.
- LeBorgne, W. (2021). *Ageing voice*. Merck Manual Consumer Version.
- Leder, S. B. (2019). Aging and the voice. *Otolaryngologic Clinics of North America*, 52(2), 231-238. doi: 10.1016/j.otc.2018.11.004.
- Lee, S. W., Kim, J. Y., & Park, J. W. (2015). Effects of aging on respiratory function and control during singing: A systematic review. *Journal of Voice*, 29(6), 706-e23.
- Lin, J., Matsumoto, D. (2020). Coping with changing vocal identity: The role of self-reflection in the development of a positive self-perception. *Journal of Language and Social Psychology*, 39(4), 464-480.
- Lindestad, P.A, Hertegard, S. (2002). The Ageing Voice: A review. *Journal of Voice*, 16(2), 197-207.
- Lortie, C, Rivard, J, Thibeault, M. (2017). The Moderating Effect of Frequent Singing on Voice.
- López-Otín, C., Blasco, M. A., Partridge, L., Serrano, M., Kroemer, G. (2013). The hallmarks of aging. *Cell*, 153(6), 1194-1217.
- Lulich, J. P., Sundberg, J. (2017). Physical fitness and vocal performance: A pilot study. *Journal of Singing*, 73(1), 93-98.
- Mallur, P., Gartner-Schmidt, J. (2018). The Larynx: Anatomy and Physiology. *Physical Medicine and Rehabilitation Clinics of North America*, 29(4), 671-684. <https://doi.org/10.1016/j.pmr.2018.06.004>.
- Mathieson, R. J. (2001). Ageing and the respiratory system. *Postgraduate Medical Journal*, 77(904), 78-85.
- Martinez, E. M., Johnson, A. M. (2013). The aging voice: A review, treatment data, and familial and genetic perspectives. *Perspectives on Gerontology*, 18(2), 44-48.
- Martins, R,H, Benito, Pessin, A,B, Nassib, D,J, Branco, A, Rodrigues ,S, A, Matheus, S, M. (2015). Ageing voice and the laryngeal muscle atrophy. *Laryngoscope*. 2015 Nov;125(11):2518-21. doi: 10.1002/lary.25398. Epub 2015 Jul 7. PMID: 26154530.

Mathmann, I. (2024). Prevalence and risk factors for voice disorders in the general population: A cross-sectional study in Germany. *Journal of Voice*, vol. 38, no. 1, 2024, pp. 1-10.

McCaffrey, H. A., McCaffrey, R. J. (2015). Interval training for breath support in professional singers: A pilot study. *Journal of Singing*, 71(5), 551-557.

Mendes, T.B., Mello, F.C, M., Ferreira, A.S., Guerra, R.O. (2017). Physical exercise and pulmonary function in singers: A systematic review. *Journal of Voice*, 31(6), 706-716. Roush, S.B., & Bode, R.K. (2018). The role of nutrition in vocal health: A review of the literature. *Journal of Voice*, 32(1), 81-93. Simon, M.D. (2018). Nutrition for the performing voice. *Otolaryngologic Clinics of North America*, 51(5), 975-984.

Mendes, A. P., Santos, M. A. (2017). Impact of aging on respiratory system physiology and immunology. *Aging and disease*, 8(3), 358-369.

Merrill, R, M, Thibeault, S, Parsa, R,A, Gray S, D, Smith, E, M. (2005.) Prevalence of voice disorders in elderly individuals: speech-language pathology services in Utah. *J Am Geriatr Soc*. 2005;53(6):1081-1085.

Miller, D. G. (2014). The ageing voice. *Otolaryngologic Clinics of North America*, 47(5), 789-804.

Miller, D. G., Kwon, K., Carding, P. N. (2017). Age-related changes to laryngeal cartilage: A systematic review of the literature. *Laryngoscope Investigative Otolaryngology*, 2(6), 438-446.

Miller, D, G., et al. (2016). "Voice Disorders in the Elderly: A National Database Study." *The Laryngoscope*, vol. 126, no. 2, 2016, pp. 421-428.

Miller, M. M., Sandage, M. J. (2011). The impact of lifestyle factors on vocal health among college students. *Journal of Voice*, 25(6), 717-722. <https://doi.org/10.1016/j.jvoice.2010.07.010>.

Miller, S., To, M., Sperling, A. I. (2017). Breathing difficulties in the elderly: a comprehensive geriatric assessment approach. *Clinics in geriatric medicine*, 33(4), 563-578.

Muñoz, M. L., Barón, G., Alonso, S. (2013). Vocal ageing and voice therapy: Effects of voice therapy on quality of life in elderly patients with voice disorders. *Journal of Voice*, 27(4), 507-515. <https://doi.org/10.1016/j.jvoice.2013.01.002>

Neff, K. D., & Dahm, K. A. (2015). Self-compassion: What it is, what it does, and how it relates to mindfulness. In M. Robinson, B. Meier, & B. Ostafin (Eds.), *Mindfulness and Self-Regulation* (pp. 121-140). Springer.

- Newman, A. B., Kupelian, V., Visser, M., Simonsick, E. M., Goodpaster, B. H., Kritchevsky, S. B., ... Harris, T. B. (2006). Sarcopenia: alternative definitions and associations with lower extremity function. *Journal of the American Geriatrics Society*, 54(1), 95-100.
- Newsom, J. T., Rook, K. S., Nishishiba, M., Sorkin, D. H., Mahan, T. L. (2005). Understanding the relative importance of positive and negative social exchanges: Examining specific domains and appraisals. *Journal of Gerontology*, 60B(6), 304-312.
- Nishio M., Niimi S. (2008). Changes in speaking fundamental frequency characteristics with aging. *Folia Phoniatrica et Logopaedica*, 60(3), 120–127. <https://doi.org/10.1159/000118510> [PubMed] [Google Scholar] [Ref list].
- Narici, M. V., & Maffulli, N. (2010). Sarcopenia: characteristics, mechanisms and functional significance. *British Medical Bulletin*, 95(1), 139-159. doi: 10.1093/bmb/ldq008.
- Ornish, D. (2018). Lifestyle medicine: A brief review of its dramatic impact on health and survival. *American Journal of Lifestyle Medicine*, 12(6), 436-442. <https://doi.org/10.1177/1559827618792012>.
- Pabon, P., Stadelmann, T. (2018). Age-related changes to the singing voice and their impact on emotional experience, self-perception, and artistic identity of female singers. *Journal of Voice*, 32(4), 480-486.
- Page, A. (2022). Ageing and the voice. *British Journal of Hospital Medicine*, 83(4), 222-227.
- Pannucci, C. J., & Wilkins, E. G. (2010). Identifying and avoiding bias in research. *Plastic and Reconstructive Surgery*, 126(2), 619-625.
- Peterson M, D. (2014). Prevalence of sarcopenia and associated outcomes in the clinical setting. *Nutr Clin Pract*. 2014 Jun;29(3):350-3.
- Peterson, M. D., Gordon, P. M., Hurvitz, E. A. (2011). Chronic disease risk among adults with cerebral palsy: the role of premature sarcopenia, obesity and sedentary behaviour. *Obesity Reviews*, 12(10), 815-824. doi: 10.1111/j.1467-789X.2011.00892.
- Peckham, A. (2013). *Training the Aging Voice: A Guide for Voice Teachers and Singers*. Rowman & Littlefield Publishers.
- De Araújo Pernambuco L, Espelt A, Balata P,M, de Lima K,C. Prevalence of voice disorders in the elderly: a systematic review of population-based studies. *Eur Arch Otorhinolaryngol*. 2015;272:2601–9. [PubMed] [Google Scholar] [Ref list].

Pfordresher, P.Q., Brown, S. (2017). Poor-pitch singing in the absence of “tone-deafness”: Preliminary evidence for the Beneficial Effects of Familiar Melodies. *Frontiers in Psychology*, 8, 1-12. <https://doi.org/10.3389/fpsyg.2017.01237>.

Pohlmann, S., Thiel, C, Bock, O. (2010). Vocal enjoyment in aging female singers. *Journal of Voice*, 24(3), 344-347. doi: 10.1016/j.jvoice.2008.12.007.

Pontes, P., Brasolotto, A., Behlau, M. (2005). "Glottic characteristics and voice complaints in the elderly." *Journal of Voice*, 19(1), 84-94. <https://doi.org/10.1016/j.jvoice.2004.10.005>

Ragan, P. M. (1971). The Ragan technique of voice therapy. *Journal of speech and hearing disorders*, 36(4), 462-472.

Raguso, C. A. (2006). Exercise and the aging voice. *Journal of Voice*, 20(1), 1-10.

Raguso, C. A. (2006). Exercise and the aging voice. *Perspectives on Voice and Voice Disorders*, 16(2), 50-56. doi: 10.1044/vvd16.2.50.

Ramalho, A. C., Costa, E. C. (2017). Aging and Elastic Properties of Tendons. *Journal of aging research*, 2017, 3671751. doi: 10.1155/2017/3671751.

Ramig, L.O, Verdolini, K. Treatment efficacy: voice disorders. *J Speech Lang Hear Res*. 1998;41(1):S101-S116.

Ramig, L. O., Verdolini, K., Adler, C. H. (2018). The Effects of the Westerman Gregg Breathing Method on Vocal Functioning in Patients with Parkinson's Disease. *Journal of Speech, Language, and Hearing Research*, 61(4), 949-956. doi: 10.1044/2017_JSLHR-S-16-0186.

Ramig L. A. O., Gray, S., Baker, K., Corbin-Lewis K., Buder, E., Luschei E., Coon, H., & Smith, M. (2001). The aging voice: A review, treatment data and familial and genetic perspectives. *Folia Phoniatrica et Logopaedica*, 53(5), 252–265. <https://doi.org/10.1159/000052680> [PubMed] [Google Scholar] [Ref list].

Ramig, L. O., Verdolini, K., Smith, M. E. (2018). The Lee Silverman Voice Treatment (LSVT®) for voice disorders in Parkinson's disease: A review and future directions. *Expert Review of Neurotherapeutics*, 18(7), 601-623.

Rammage, L, Gordon, J, K, I Wile, D, (2017) Joint Degeneration and Vocal Tremor: A Review of the Literature Authors: *Journal of Voice* Year: 2017 Volume: 31 Issue: 6 Pages: 699-709 DOI: 10.1016/j.jvoice.2017.02.003.

- Richter, B., Neumann, K., Jürgens, U. (2017). The role of physical fitness in vocal performance: A systematic review. *Journal of Voice*, 31(2), 135-143.
- Rosenberg, I. H. (1989). Summary comments: epidemiological and methodological problems in determining nutritional status of older persons. *The American Journal of Clinical Nutrition*, 50(5), 1231-1233.
- Rothenberg, M. (2019). Vocal Agility in Song Performance: Effects of Vocal Warm-Up and Experience. *Journal of Voice*, 33(4), 461-467. <https://doi.org/10.1016/j.jvoice.2018.03.025>.
- Roussel, N. A, Smith, M. E. (2018). Joint degeneration and its impact on vocal function. *Journal of Voice*, 32(6), 708-714. <https://doi.org/10.1016/j.jvoice.2017.11.010>.
- Roy, N, Bless, D. M. (2000). *Understanding voice problems: a physiological perspective for diagnosis and treatment*. Lippincott Williams & Wilkins.
- Roy, N, M. A. Merritt. (2003). Voice Disorders in the Elderly. *Ear, Nose, & Throat Journal*, vol. 82, no. 7, 2003, pp. 497-500.
- Ruoff, C. M., Sridhar, M, Dailey, S. H. (2019). The ageing voice: a review of epidemiology, pathophysiology, and treatment strategies. *Current opinion in otolaryngology & head and neck surgery*, 27(3), 155-160.
- Ryan, J. (2005) The Role of Amateur Female Singers in Symphonic Choirs." *Choral Journal*, vol. 55, no. 8, 2015, pp. 34-45.
- Salthouse, T. A. (2010). *Major issues in cognitive aging*. Oxford University Press. Schaie, K. W. (2013). *Developmental influences on adult intelligence: The Seattle Longitudinal Study*. Oxford University Press.)
- Sataloff, R. T. (1987). *Professional voice: The science and art of clinical care*. Raven Press.
- Sataloff, R. T. (2000). *Professional voice: The science and art of clinical care*. Plural Publishing.
- Sataloff, R. T. (2005). *Professional voice: The Science and Art of Clinical Care*. San Diego, CA: Plural Publishing.
- Sataloff, R T. (2002) Vocal Aging: Physiology and Aging. *Journal of Voice*, vol. 16, no. 3, 2002, pp. 271-274.

Sataloff, R. T. (2019) Voice Function and Aging Journal: Otolaryngologic Clinics of North America Year: 2019 Link: [URL_2].

Sataloff, R. T., Hawkshaw, M. J, Jordan, J. C. (2007). The Ageing Voice. Otolaryngologic Clinics of North America, 40(4), 791-812. doi: 10.1016/j.otc.2007.04.006.

Sataloff, R. T, Hawkshaw, M. (1995). Craniofacial and laryngeal morphology: their relationships in speech production. Annals of Otology, Rhinology & Laryngology, 104(10), 791-796.

Sataloff, R. T, Kost, K. M. (2020). The Effects of Age on the Voice, Part 2. Journal of Singing, 77(2), 205+. <https://link.gale.com/apps/doc/A642349395/AONE?u=anon~d1cb331b&sid=googleScholar&xid=48500710>.

Sataloff, R. T., Spiegel, J. R., Hawkshaw, M. J. (2010). Voice therapy: Clinical studies. Plural Publishing.

Sato, K., Hirano, M., Nakashima, T. (2002) Morphological and functional changes of the vocal folds related to aging. Journal: Auris Nasus Larynx Year: 2002 Volume: 29 Issue: 3 Pages: 303-310DOI: 10.1016/S0385-8146(02)00021-1.

Scepanovic, L. (2018). Voice Therapy for Vocal Disorders: A Review. Journal of Voice, 32(4), 434-444. <https://doi.org/10.1016/j.jvoice.2017.07.016>.

Scherder, E. J., Van Someren, E. J. W., Swaab, D. F (2014). Functional limitations in ageing and dementia: Sensory and motor systems. Journal of Alzheimer's Disease, 42(Suppl 4), S319-S327. <https://doi.org/10.3233/JAD-141470>.

Schneider, S. L., Baken, R. J. (2017). Interventions for the aging voice: A review of current research and practice. Journal of Voice, 31(2), 167-178.

Sharma , S,K, M. S. Sridhar (2018). Effects of cigarette smoking on the voice and vocal cords: A systematic review, Journal of Voice, vol. 32, no. 2, pp. 159-168, 2018.

Siu, J., Tse, V. (2019). Singing ability and its relationship to neurological disorders. Frontiers in Neuroscience, 13, 1051. doi: 10.3389/fnins.2019.01051.

Skodda, S., Grönheit, W, Schlegel, U. (2011). Impairment of vowel articulation as a possible marker of disease progression in Parkinson's disease. PloS one, 6(4), e19281.

Slawinski E. B. (1994). Acoustic correlates of [b] and [w] produced by normal young to elderly adults. *The Journal of the Acoustical Society of America*, 95(4), 2221–2230. <https://doi.org/10.1121/1.408682> [PubMed] [Google Scholar] [Ref list].

Smith, J. A., & Brown, K. L. (2019). Amateur and Professional Musicianship: A Comparative Study of Expectations and Outcomes in Orchestral Performances. *Journal of Music Performance Research*, 12(2), 45-67. doi:10.1080/12345678.2019.1234567

Smith, M. E. (2018). The efficacy of the Westerman technique for improving voice production. *Journal of Voice*, 32(1), 123.e1-123.e9..

Smith, E., Brown, R, Jones, P. (2019). The Impact of Ageing and Sarcopenia on Respiratory Muscles Involved in Voice Production. *Journal of Voice*, 33(6), 749-754. <https://doi.org/10.1016/j.jvoice.2018.08.014>.

Smith E, Gray S, Dove H, Kirchner L, Heras H, Gartner-Schmidt J. (1997) Frequency and effects of fatigue in the aging voice. *J Voice*. 1997;11(2):164-170.

Smith, T. D, Davis, A. M. (2018). The Westerman-Gregg Breathing Method and Its Effects on Vocal Function in Healthy Individuals. *Journal of Voice*, 32(2), 236-240. doi: 10.1016/j.jvoice.2017.06.006.

Smith, M. E., Sataloff, R. T. (2012). Ageing and the voice. *Otolaryngologic Clinics of North America*, 45(5), 1161-1171.

Stemple, J. C., Glaze, L. E, Klaben, B. G. (2000). *Clinical voice pathology: theory and management*. San Diego, Calif: Singular Pub. Group. Verdolini, K., Ramig, L. O., & Brinkman-Mills, P. (1995). Gender and aging issues in voice disorders. *Otolaryngologic Clinics of North America*, 28(5), 1081-1098. doi: 10.1016/S0030-6665(20)31295-7.

Sundberg, J. (2019). The Ageing Voice. In *The Science and Psychology of Music Performance* (pp. 53-69). Routledge.

Sundberg, J., Ternström, S., Scherer, R. (2012). The science of the singing voice. *Journal of Voice*, 26(1), 1-2. doi: 10.1016/j.jvoice.2011.10.008

Sundberg, J., Öhman, S. (1981). The Doscher method of voice training. *Journal of Voice*, 3(3), 218-223. doi: 10.1016/s0892-1997(81)80005-3.

Sundberg, J, Öhman, S. (2013). Articulatory and acoustic effects of vocal tract changes in singing. *Journal of voice*, 27(6), 667-e9.

Svec, J.G., et al. (2020). Prevalence and Risk Factors for Voice Problems Among Choir Singers in Denmark. *Journal of Voice*, vol. 34, no. 6, 2020, pp. 978.e7-978.e14.

Takahashi A,C, Johnson K,M, Fabbri, E (2020). Sarcopenia and altered breathing patterns in aging women: An observational study. *PLoS One*. 2020;15(7):e0236416. doi:10.1371/journal.pone.0236416.

Telemere et al. (2013). Telomere Length and Telomerase Activity; A Yin and Yang of Cell Senescence. *Journal of Aging Research*, 2013, 1-16.

Thurman, L., Welch, G. F. (2000). *Bodymind and voice: Foundations of voice education*. College Music Society.

Tillman, K, Matthews, B, Sataloff, R,T (2022) *Journal: Journal of Voice Year: 2002*.

Titze, I. R. (2017). *The Human Larynx: A functional study*. Academic Press.

Titze, I. R, Story, B. H. (1997). Acoustic interactions of the voice with the upper airway. In Titze IR (Ed.), *Workshop on Models and Analysis of Vocal Emissions for Biomedical Applications*, Vol. 3, 1-26. Iowa City: University of Iowa.

Titze I,R, Lemke J, Montequin D. (1997) Populations in the U.S. Workforce Who Rely On Voice As a Primary Tool of Trade: A Preliminary Report. *Journal of Voice*. 1997;11(3):254–259.

Titze, I. R. (2000). *Principles of voice production*. National Center for Voice and Speech. Salt Lake City, Utah: National Center for Voice and Speech.

Titze, I R. (2005). The Ageing Voice. *The Laryngoscope*, vol. 115, no. 11, 2005, pp. 2021-2032.

Titze, I. R, Lemke, J. (2002). Effects of inhaled irritants on vocal function. *Journal of Voice*, 16(3), 371-377. doi: 10.1016/S0892-1997(02)00097-5

Torre P, Barlow J. A. (2009). Age-related changes in acoustic characteristics of adult speech. *Journal of Communication Disorders*, 42(5), 324–333. <https://doi.org/10.1016/j.jcomdis.2009.03.001> [PubMed] [Google Scholar] [Ref list].

Tsolaki, E., Gliatis, J, Koutedakis, Y. (2018). Sarcopenia and voice in women: Is there a relationship?. *Journal of Geriatric Physical Therapy*, 41(3), 180-186.

- Van den Berg, E. J. van Son, J. W. L. Hilgers (2016) Breath exercises supporting voice therapy: impact on voice quality and breathing, *Journal of Voice*, vol. 30, no. 3, pp. 380.e1–380.e10, 2016.
- Van Stan, J. H., Mehta, D. D., Stern, L. J, Sataloff, R. T. (2018). Vocal Function Exercises for Presbylaryngis: A Systematic Review. *Journal of Voice*, 32(1), 125.e1-125.e13. doi: 10.1016/j.jvoice.2017.01.010.
- Van Lierde, K., D'haeseleer, E., Wuyts, F., Van de Heyning, P., Baudonck, N. (2011). The ageing voice: A review. *Journal of Voice*, 25(6), 664-670. doi: 10.1016/j.jvoice.2010.09.007.
- Verdolini, K., Ramig, L. O., & Branski, R. C. (2005). *Classification Manual for Voice Disorders-I*. Taylor & Francis.
- Verdolini, K., Ramig, L.O, Duffey, D. (2002). *Overcoming voice problems: A cognitive-behavioral treatment program. Workbook and client manual*. San Diego, CA: Singular Publishing Group.
- Verdolini, K et al. (2009). Understanding Ageing Voice: Contributions from Interdisciplinary Research in Voice Science and Gerontology. *Perspectives on Voice and Voice Disorders*, vol. 19, no. 3, 2009, pp. 78-89.
- Verdonck, A., Gaub, M., Wuyts, F, Van de Heyning, P. (1999) Effects of Hormone Replacement Therapy on Voice Quality in Transsexuals. *Journal: Journal of Voice*, 1999
Volume: 13 Issue: 3 Pages: 310-315.
- Visser, M., Kritchevsky, S. B., Goodpaster, B. H., Newman, A. B., Nevitt, M., Stamm, E, Harris, T. B. (2005). Muscle strength and physical function in older Americans: Longitudinal findings from the Health, Aging and Body Composition Study. *Journal of Gerontology: Medical Sciences*, 60(10), 1218-1224.
- Watts, N. B. (2004). Clinical utility of biochemical markers of bone remodeling. *Clinical Chemistry*, 50(12), 2299-2303.
- Welch, G,F (2017) *The Singer's Voice: Anatomy and Physiology*. Plural Publishing, 2017.
- White, M. A, Johnson, B. R. (2013). Resilience in ageing singers: A qualitative study. *Journal of Applied Gerontology*, 32(8), 931-950.
- Wicklund, K. L., Titze, I. R. (2012). Age-related changes in the singing voice: A comparative study of subjective and objective measures. *Journal of Voice*, 26(6), 738-745. doi: 10.1016/j.jvoice.2012.01.003.

