

# **Singing at menopause: a systematic review with pedagogical implications**

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## **Abstract**

Menopause is a certainty in a female singer's life; depletion of oestrogens may lead to physical, mental, and vocal symptoms. To investigate the extent to which these symptoms affect singers, a systematic literature review was carried out using eight interdisciplinary bibliographic databases. Combinations of the following key words were used: *menopause*, *climacterium*, *singing*, *singers*, and *choir*.

From 18 studies, including three doctoral dissertations and a master's thesis, only 10 met the inclusion criteria. The heterogeneity of study designs and methods of data collection and analysis precluded the carrying out of a meta-analysis. Instead, descriptors of symptoms affecting the voice, and vocal characteristics associated with menopause (*menopause descriptors*) were categorised, and their frequency of occurrence determined, according to six types of primary dataset: i) self-reported symptoms, ii) acoustic characteristics, iii) observations of the larynx, iv) perceptual evaluations, v) analysis of electrolaryngographic waveform characteristics, and vi) analysis of hormone concentrations. The descriptors that occurred most frequently in the literature concerned aspects of voice production, whereas those concerning vocal health, and vocal practice and performance, were less common. Of the three subsystems that comprise the vocal instrument, the vibrating vocal folds seem to be more affected than breathing and resonance. Changes in vocal range, timbre, endurance, and vocal fold mobility occur during menopause, affecting singers' voice quality. Some singers reported that their ability to perform was compromised, mainly due to memory lapses and lack of confidence. Maintaining regular singing and practicing semi-occluded vocal tract exercises throughout the menopausal transition seem to help singers to overcome the negative impacts of menopause on vocal performance.

**Keywords:** singers, sex steroid hormones, voice quality, vocal health, vocal practice and performance

Singers are highly skilled athletes whose success depends to a great extent on the quality of their voices. A singer's musicality and emotional expressivity are compromised by abnormal voice function (Radionoff, 2008). The bio-acoustical nature of the human voice makes singers particularly sensitive to changes in their biological and external environments; these may interfere with the physiology of the vocal instrument and, consequently, with the singer's ability to perform under optimal conditions (Lã, 2014). Brodnitz, (1971) reports treating 202 women, both singers and non-singers, with organic voice disorders. In 28 cases (14.1%), these could be attributed to an endocrine cause. Receptors for sex steroid hormones, namely, oestrogens, progesterone, and testosterone, have been found in several sub-units of the vocal folds mucosa (Kirgezen et al., 2017). Due to the complexity of the endocrine female reproductive system, female singers are more likely to be affected by variations in the concentrations of sex steroid hormones than male singers (Lã & Davidson, 2005). Female singers may experience voice changes not only in puberty but also in certain phases of the menstrual cycle (Lã et al., 2007), during pregnancy (Lã & Sundberg, 2012), and around menopause (Bos et al., 2020). The latter seems particularly relevant, given increasing life expectancy in many populations and the lack of available literature addressing the extent to which menopause may affect singers.

A woman is said to have reached a natural menopause (i.e., if she has not had a hysterectomy) when she has missed 12 consecutive menstrual periods. Thus menopause can only be determined retrospectively (Hale et al., 2007). Menopause is difficult to predict because oocyte depletion in the ovaries does not occur at a constant rate. As a consequence, the age of reproductive senescence is quite varied among women (42 to 58 years), and thus age is a weak stand-alone predictor for menopause. To circumvent these difficulties in determining onset of reproductive aging, the Stages of Reproductive

Aging Workshop (STRAW) proposed a system that combines information on menstrual cycles, and endocrine and biochemical markers as indicators (Hale et al., 2007; Soules et al., 2001b; Harlow et al., 2012). As shown in Table 1, stages –5 to –3 comprise the reproductive phase, whereas stages –2 to –1 and +1 to +2 represent early and late perimenopause and post-menopause, respectively. Menopause is used as an anchor for setting all phases and is therefore considered stage 0 (Harlow et al., 2012).

**Table 1.** Adaptation of the STRAW staging criteria used to define reproductive aging (adapted from Harlow et al., 2012).

*<Please insert Table 1 about here>*

These stages of the menopause have been associated with physical and psychological symptoms that include irregular periods, hot flashes, mood swings, sleep disturbances, vaginal dryness, anxiety, and depression (Santoro et al., 2015). In relation to the voice, menopause has been associated with changes in the mucous membranes that line the vocal tract and the muscles of the larynx (Abitbol et al., 1999; Kahane, 1987; Linville, 1987). These changes have been related to vocal fold oedema, loss of vocal tonus, mucosal dryness, reduction in the production of glandular secretions, and muscular atrophy, the latter causing impairment of glottal closure (Abitbol et al., 1999; Patel et al., 2021). Examples of commonly reported symptoms include vocal fatigue, lowering of the speaking voice, difficulties with vocal control, lack of intensity, lowering of speaking pitch, and hoarseness (Lindholm et al., 1997; Meurer et al., 2004; Plexico et al., 2020).

The results of a recent meta-analysis of the effects of menopause on acoustic-related metrics found a decrease of about 1 semitone (ST) in post- as compared to premenopausal women, for both speaking fundamental frequency ( $Sf_0$ ) and mean

fundamental frequency ( $f_0$ ) of sustained vowels (Lã & Ardura, 2020). The authors argue that such a small effect could reflect: i) the incomplete nature of acoustic-related metrics; ii) age – which was not controlled – as a confounding variable when considering symptoms related to menopause; and iii) the absence of singers in the groups that were studied (Lã & Ardura, 2020). The question therefore remains as to the extent to which menopause has an impact on singers.

We therefore carried out a systematic literature review to identify the characteristics related to menopause that are reported most often, and their implications for singers' voice quality, vocal practice and performance, and vocal health. This information is relevant for women whose professional lives depend on the quality of their voices, because vocal discomfort may not be trivial, even if it is mild (Alexander, 1983). Given the practice-focused and formative nature of voice teaching, informed guidance is required, especially when pedagogical strategies are to be developed for providing high quality continuing training for singers (Lã, 2017; Ragan, 2018).

## **Methods**

### *Data sources and searches*

A search of primary studies was carried out using eight interdisciplinary electronic bibliographic databases, namely Scopus, PubMed, Medline, Web of Science, Science Direct, Academic Search Complete, SciELO, and ProQuest. To find records of studies not identified using electronic databases, including master's thesis and doctoral dissertations, a complementary search was also carried out using the reference lists of studies identified by Google Scholar. This bibliographic search was carried out between September 14<sup>th</sup> and December 4<sup>th</sup>, 2020. It explored and included all available records of studies concerning singers, with no restrictions as to year of publication, type of

singer, or style of singing. Combinations of the following key words were used:  
*menopause, climacterium, singing, singers, and choir.*

#### *Criteria for inclusion and exclusion*

For a record to be eligible for inclusion in the review, it had to meet the following criteria: i) to be a full-text scientific publication such as a dissertation, thesis, or journal article, ii) to be published in any European language, and iii) to contain sufficient information for the main elements of the research to be extracted. Secondary studies (e.g., reports in book chapters) were excluded, as were studies in which the primary focus of research was not the singing voice or natural menopause. The results of studies testing the effects of hormone replacement therapy (HRT) were excluded if they derived from HRT users, although results deriving from non-HRT users were included.

#### *Data extraction and synthesis*

The authors screened the titles of each record and those of potential interest were saved. Their abstracts were scrutinised, identifying those only concerning singers and menopause. These were inspected for duplicates, which were then removed. The full text of the remaining studies was assessed by the three authors independently. The ultimate selection of references meeting the inclusive criteria and, therefore, eligible for inclusion in the review, was made by consensus.

## **Results**

#### *Identification of records*

A total of 15,960 records were identified in the initial search; the screening of their titles revealed that 15,905 were not relevant. The abstracts of the remaining 55

records were scrutinised. Thirty-seven were duplicates, and therefore excluded, yielding a total of 18 to be inspected further. As eight failed to meet one or more of the inclusion criteria, only ten full-text articles were included in the review (see Figure 1).

< Please insert Figure 1 about here >

**Figure 1.** Flowchart showing search strategy and results.

Relevant information was extracted from these studies and systematized in a table containing their main elements under the following headings: i) study identification (i.e., authors and date of publication), ii) aims, iii) sample characteristics, iv) data collection, v) data analysis, and vi) main outcomes (see Table 2).

**Table 2.** Summary of the main elements of each study.

< Please insert Table 2 about here >

The heterogeneity of research designs is evident. Studies were carried out using quantitative and qualitative methodologies, describing datasets representing self-reported, acoustic, perceptual variables, observations of the larynx, and concentrations of sex hormones. The variety of study designs precluded the pooling of statistical results. To systematize and compare the outcomes of the studies that were reported, descriptors of clinically relevant symptoms affecting the voice and vocal characteristics associated with menopause (*menopause descriptors*) were extracted from the main outcomes shown in Table 2 and grouped into categories and subcategories (see Figure 2). Through this process of categorization it was possible to determine the frequency



with which each type of dataset and menopause descriptor was distributed. Quotations from the findings of primary studies are also presented to complement our results.

< *Please insert Figure 2 about here* >

**Figure 2.** Categorization of menopause descriptors.

### *Menopause descriptors*

Figure 3 displays the types of dataset included in primary studies, showing their distribution according to type of publication (i.e., doctoral dissertation, master's thesis, and peer-reviewed journal article). The majority of primary studies were published in the form of articles. These included all types of dataset found in this review, which were, in decreasing order of occurrence: i) self-reported symptoms, ii) acoustic characteristics, iii) observations of the larynx, iv) perceptual evaluations; v) analysis of electrolaryngographic (ELG) waveform characteristics, and vi) analysis of sex steroid hormone concentrations.

Self-reported symptoms were collected from interviews, diaries, and questionnaires both specifically designed and, to a lesser extent, validated patient-related outcome (PRO) measures, namely the Singing Voice Handicap Index (SVHI) (Cohen et al., 2007). Self-reported symptoms were found in four articles (Boulet & Oddens, 1996; Elliott, 2017; Ouyoung et al., 2018; Price, 2013), three doctoral dissertations (DeMaio, 2013; Price, 2010; Richie, 2013) and one master's thesis (Allen, 2006).

Acoustic characteristics were extracted from voice recordings of i) sustained vowels sung as isolated tones at different degrees of vocal loudness, ii) ascending and descending *glissandi*, iii) staccato exercises, and iv) phrases extracted from songs.

These types of dataset were collected and analysed in four articles (Abitbol et al., 1999; Clarós et al., 2017; Ouyoung et al., 2018; Price, 2013) and one unpublished doctoral dissertation (Price, 2010). In addition to acoustic-related voice metrics, qualitative interpretations of spectrographic displays were also reported (Abitbol et al., 1999; Price, 2013).

In the category of observations of the larynx, menopause descriptors included interpretations of laryngoscopic and stroboscopic images of the vocal folds and the vocal tract, which appeared in four articles (Abitbol et al., 1999; Clarós et al., 2017; Ouyoung et al., 2018; Price, 2013).

Perceptual evaluations of voice quality were also made, described in one article (Clarós et al., 2017) and one doctoral dissertation (Price, 2010).

Finally, datasets consisting of ELG waveform characteristics and concentrations of sex hormones were collected and analysed in a single study (Abitbol et al., 1999).

*<Please insert Figure 3 about here >*

**Figure 3.** Frequency of types of dataset, distributed by type of publication.

Table 3 lists the categories and subcategories in which menopause descriptors were organised. Self-reported symptoms included: i) voice function, ii) vocal practice and performance, iii) vocal health, iv) physical symptoms, and v) mental symptoms. As there were many different outcomes for voice function, we subcategorised them as follows: i) pitch range, ii) timbre characteristics, iii) vocal endurance, iv) voice flexibility, v) breath management, vi) hydration levels, vii) voice stability, viii) register transitions, ix) properties of vibrato, x) tension, xi) intonation, and xii) vocal loudness.

Acoustic characteristics were categorised as references to i) timbre, ii) pitch range, iii) loudness, iv) properties of vibrato, and v) characteristics of staccato.

Observations of the larynx included menopause descriptors categorised as references to i) vocal folds mobility, ii) mucosal characteristics, iii) muscular tension, iv) vascularity, and v) mucous viscosity.

Datasets of perceptual evaluations comprised i) phonation types and ii) overall voice quality.

ELG analyses concerned the characteristics of waveforms with respect to the regularity and strength of the signal. Analyses of hormone concentrations focused on sex steroid hormones, namely i) 17  $\beta$ -oestradiol, ii) progesterone, iii) androstenedione, iv) oestrone, and v) oestrone sulphate.

**Table 3.** Categories and subcategories of menopause descriptors.

*< Please insert Table 3 about here >*

### *1.1 Self-reported symptoms*

Figure 4 presents the frequency of menopause descriptors, distributed according to categories of self-reported symptoms. Descriptors of voice function were most frequent; those referring to physical and mental symptoms, vocal practice and performance, and vocal health issues, were less frequent.

*< Please insert Figure 4 about here >*

**Figure 4.** Frequency of menopause descriptors, distributed according to categories of self-reported symptoms.

### 1.1.1 Voice function

Menopause descriptors in the subcategories of pitch range and timbre characteristics were most frequent, and were equally distributed among primary studies (see Figure 5). Descriptors related to changes in pitch range were mostly negative, such as *decreased higher and lower vocal ranges, smaller and expanded vocal range, and loss of lower notes*. The few positive descriptors included *easier higher range*, but these were associated with increased singing and regular vocal practice. References to changes in the characteristics of vocal timbre, such as “richer” (Price, 2010, p. 60), and “fuller” (Price, 2010, p. 63), “more mature voice” (Price, 2010, p. 110), “sexy voice” (Price, 2010 p. 175), and “strengthening of low notes” (DeMaio, 2013, p. 98) were considered positive outcomes of menopause. However, most timbre changes were referred to as having a negative impact on singers’ voice quality, including “loss of voice colour” (Abitbol et al., 1999, p. 440), “brittleness in the sound” (Richie, 2013, p. 65), “more punchy voice” (Price, 2010, p. 177), “rougher voice” (Price, 2010, p.177), “deeper voice” (Price, 2010, p. 160), “not as clear voice” (Price, 2010, p. 183), and “husky voice” (Boulet & Oddens, 1996, p.17).

Descriptors subcategorised as vocal endurance occurred nine times in primary studies, and included references to negative changes, such as “decreasing stamina” (DeMaio, 2013, p. 50), “increased vocal fatigue” (Price, 2010, p. 50), “less strength” (Price, 2010, p. 115), and “need to work harder to do the same thing” (Price, 2010, p. 63).

In the subcategory of voice flexibility, descriptors labelled *loss of flexibility, less supple vocal folds, stiffness, less elasticity, and decreased vocal freedom* occurred seven times in five primary studies.

In the subcategories of breath management, hydration levels and voice stability, menopause descriptors were equally distributed among primary studies and once again indicated perceived negative outcomes. For breath management, descriptors included *loss of breath control, decrease in breath management, less breath support, and difficulty controlling breathing*. For hydration levels, common descriptors were *dryness* and *sensation of thickness*. For voice stability, descriptors included *voice cracking, difficulties controlling the voice, unpredictable voice, and difficulties sustaining the voice*. There was only one positive descriptor in this subcategory of voice stability: a *more controlled voice*; this was, however, associated with the effects of increased singing practice and regular singing lessons.

Descriptors subcategorised as register transitions and characteristics of vibrato occurred five times in primary studies; the former comprised *problems with lower and higher passaggio*, whereas the latter included *problems with vibrato, slower vibrato, and more vibrato*. In the subcategory of tension, descriptors occurred four times, including references to *tongue and jaw tension, and throat tightening in higher range*; only one singer reported feelings of being “more relaxed” (Price, 2010, p. 175) during menopause.

Descriptors subcategorised as intonation and vocal loudness both occurred three times. For intonation, they included *loss of perfect pitch, difficulties with intonation, and harder to sing in pitch*. For loudness, descriptors were both negative and positive including *loss of vocal power, and louder and more powerful voice*, respectively.

<Please insert Figure 5 about here >

**Figure 5.** Frequency of menopause descriptors, distributed according to subcategories of self-reported symptoms related to voice function.

#### *1.1.2 Physical symptoms*

Menopause descriptors relating to physical symptoms were also found in primary studies. *Hot flushes* and *mood swings* appeared most often, followed by *sweats*, *insomnia*, and *acid reflux*. Less frequently mentioned symptoms included *dry skin*, *vaginal atrophy*, *migraines*, *uterine fibroids*, *weight gain*, *vaginal dryness*, *decreased libido*, and *longer recovery time after sickness*. Symptoms related to asthma were also reported in one study.

#### *1.1.3 Mental symptoms*

While changes in levels of *confidence* were described in both positive and negative terms, menopause descriptors categorised as mental symptoms mostly referred to negative outcomes including *emotional block*, *difficulties in concentrating*, *depression*, *severe stress*, *sensation of loss*, *sadness*, *fear*, *frustration*, and *surprise*. Some singers reported substantial changes to their self-identity, making comments such as “I am not the same singer any more” (Elliot, 2017, p. 14).

#### *1.1.4 Vocal practice and performance*

Menopause descriptors categorised as vocal practice and performance included *increased need for warming up the voice*, *need for longer warming up*, *less steady voice*, *repertoire changes*, *decrease of musical memory*, and *changing voice classification*. These largely negative descriptors were found in nine studies; *singing*

*better* was found in just one study (Price, 2010), in the context of singing lessons during menopause or as a consequence of increased vocal exercise.

#### *1.1.5 Vocal health*

Menopause descriptors referring to vocal health were all negative, including reports of “sensation of nodes” (Price, 2010, p. 188), “frogs in the throat” (Price, 2010, p. 62), “pain in the throat while singing” (Price, 2010, p. 114), and perceived presence of “swelling of the vocal folds” (Richie, 2013, p. 16).

#### *1.1.6 Acoustic characteristics*

Acoustic characteristics were derived from the results of both qualitative and quantitative studies. The frequency of qualitative menopause descriptors is shown in Figure 6, distributed by category. The majority of descriptors referred to alterations in timbre, and included reports of “loss of harmonics” (Abitbol et al., 1999, p. 441), “lack of overtones” and “presence of noise elements” (Price 2013, p. 124), “loss of formants in the higher range” (Price, 2013, p. 119). Reports of changes in pitch range included loss of notes “at the extremes of the vocal range” (Abitbol et al., 1999, p. 440) and “decreased range” (Price, 2013, p. 119), while those referring to loudness included “loss of intensity” (Abitbol et al., 1999, p. 440) and “reduction in the calling and projected singing voice” (Abitbol et al., 1999, p. 441). References to staccato were rarest but included “loss of speed in staccato at extremes of vocal range” (Abitbol et al., 1999, p. 440).

*<Please insert Figure 6 about here >*

**Figure 6.** Frequency of menopause descriptors derived from qualitative studies, distributed by category.

Acoustic characteristics reported in quantitative studies included  $f_0$  in sustained vowels and the number of tones included in *glissandi*, revealing a general decrease in vocal range (Clarós et al., 2017). Rate and extent of vibrato were also analysed; the latter seemed to increase with menopause (Price, 2010). Relative average perturbation (RAP), maximum phonation time (MPT) and pitch range were compared in pre- and post-menopausal women who were randomly allocated to one of two types of voice therapy, one a session of Resonant Voice Therapy (RVT) and the other a session in which participants carried out Cervical-Thoracic Focussed Exercises (CTFE) (Ouyoung et al., 2018). Significant decreases in RAP were reported for both pre- and post-menopausal groups, especially after RVT (by 60% for pre-menopausal and 54.35% for post-menopausal groups). After RVT, MPT increased by 61.8% and 67.7% for pre- and post-menopausal groups, as did pitch range, by 9.36% and 27% respectively. Fewer improvements were observed following CTFE although pitch range decreased by 12% in the pre-menopausal group (Ouyoung et al., 2018). Comparisons between the percentages of jitter produced by pre and post-menopausal women were made (Clarós et al., 2017; Price, 2010), and also shimmer (Clarós et al., 2017), but no statistically significant differences were found between the two groups for either of the parameters that were evaluated (Price, 2010; Clarós et al., 2017).

### *1.2 Observations of the larynx*

As shown in Figure 7, observations of the larynx included menopause descriptors categorised in five ways. The category referring to vocal folds mobility revealed the



descriptors that occurred most often. These included *vibratory asymmetry*, *less supple vocal folds*, *less supple ligaments*, *reduced vibratory amplitude*, *unilateral and bilateral muscular atrophy*, and *bowing of the vocal folds*. Next, the category referring to mucosal characteristics included descriptors of *oedema*, and *thinner mucosa*. Only one reference was made in the category of muscular tension, namely “inappropriate tension to close the glottis and phonate” (Price, 2013, p. 124). The category of vascularity included references to “increased vascularization” (Clarós et al., 2017, p. 190) with the presence of “microvarices” (Abitbol et al., 1999, p. 141) associated with menopause. Finally, in the category of mucous viscosity, there were references to “dryness” and “elevated viscosity” (Clarós et al., 2017, p. 190) associated with menopause.

<Please insert Figure 7 about here >

**Figure 7.** Frequency of menopause descriptors derived from observations of the larynx, distributed by category.

### *1.3 Perceptual evaluations*

Clarós and associates (2017) assessed vocal quality perceptually using a standardised scale evaluating grade (overall severity), roughness, breathiness, asthenia (weakness), and strain (GRBAS) (Hirano, 1981). They assessed the effects of menopause by comparing the GRBAS scores of pre- and post-menopausal women. The latter scored higher on all items except roughness (Clarós et al., 2017). One other study using perceptual evaluations compared pre-, peri-, and post-menopausal women’s phonation when singing (Price, 2010). Five expert listeners were asked to evaluate excerpts from performances of *Over the Rainbow* (Harburg & Allen, 1939), using a

Likert-type scale with breathy and pressed phonation at the extremes. No significant differences between the three groups of women were found (Price, 2010).

#### *1.4 ELG waveform characteristics*

ELG waveform characteristics were analysed in only one study (Abitbol et al, 1999). Post-menopausal women produced a “weaker” and a more “irregular” signal (p. 441) than that of pre-menopausal women.

#### *1.5 Sex hormone concentrations*

Concentrations of oestrogens, progesterone and androgens were also measured in only one study (Abitbol et al., 1999). “Reduced” concentrations of oestrogens, androgens and progesterone were reported in 100 women (p. 439) although the authors do not mention the size of the reduction or the number of singers in the sample.

#### *Pedagogical implications*

Recommendations for vocal practice and performance to help singers cope with menopause-related changes were made in one master’s thesis (Allen, 2006), three doctoral dissertations (DeMaio, 2013; Price, 2010; Richie 2013) and two articles (Price, 2013; Ouyong, 2018). The singers, teachers of singing, and voice health specialists who were interviewed were unanimous in their view that a singing routine is important for maintaining a functional voice before, throughout, and after the menopause. Three of Price’s (2010) participants said, for example, “because I’m doing more singing, now that I’m retired, [my] voice is much stronger with a broader range” (p. 180); “because of my voice lessons, my voice is much freer, louder, with a much higher range” (p. 183); “[my] voice is better, perhaps because I never had training before” (p. 189-190).

Some of the voice health specialists recommended not only vocal training through menopause but also the adoption of healthy vocal practice and performance when singers are at a younger age. If they take good care of their voice before menopause, singers may more easily overcome changes with regular vocal exercise (Allen, 2006).

Of the three subsystems comprising the vocal instrument – the respiratory system, the larynx with its vibrating vocal folds and the vocal tract (Herbst, 2017) – the vibrating vocal folds seem to be most affected by menopause (DeMaio, 2013). According to the results of Price’s dissertation research (2010), 56.47% of the post-menopausal singers she studied, described in Table 2, referred in their reports to “vocal source” (p. 61), i.e., the sound produced by the airflow passing through the vibrating vocal folds, and 67.94% of these reports mentioned “problems” (p. 65). Only 36.84% of reports referred to “vocal tract alterations” (p. 61). Also, the 52.84% of singers in her sample with more than 10 years of singing experience were more likely to mention alterations in vocal source than the 48.39% of singers in her sample with between 1 and 10 years of singing experience (p. 83). Price (2010) therefore sets out guidelines for a “healthier more stable voice” (2010, p. 118). These include practicing exercises with the vocal tract closed (semi-occluded vocal tract exercises or SOVTE), as described by Titze (2006), scales and staccato exercises, among others, together with physical and respiratory exercises.

SOVTEs are also used by teachers and voice specialists for (re)habilitating the voices of menopausal singers. For example DeMaio (2013) recommends the use of straws, humming and closed vowels (/i/ and /u/) to improve the vibration of the vocal folds with respect to stabilization and blending of registers. Based on the results of interviews with elite singers, teachers of singing and other voice specialists, she also suggests stretching the voice and using a lighter mechanism, in other words, producing

the voice with minimum contact between the vocal folds, especially from the middle to the top of the vocal range. Other recommendations include hydration, to counter the effects of dryness, the strengthening of the three vocal subsystems, and regular physical exercise. Otolaryngologists interviewed by Allen (2006) highlighted the importance of practicing voice function exercises (Stemple et al., 1994) to maintain overall vocal health and voice function.

Finally, the effects of exercise protocols on menopause-related voice characteristics were investigated in two further studies. Price (2013) reports a case study of a post-menopausal singer, evaluating the effects of a regular 12-week singing exercise protocol. The results showed i) a reduction in laryngeal tension, ii) improved acoustic outcomes, such as the presence of higher number of overtones in spectrographic displays of the voice, and iii) a better self-perception of vocal range and breath control, overall. Ouyoung et al., (2018) compared two therapies for pre and post-menopausal singers and found that both resulted in significant decreases in voice instability and handicap (according to the SVHI; Cohen et al., 2007). Pitch range and MPT, representing greater vocal efficiency, increased more after RVT than CTFE.

## **Discussion**

In the current investigation we systematized the results of previous studies of the effects of menopause on singers' i) voice quality, ii) physical, mental, and vocal health, and iii) vocal practice and performance. Ten studies were scrutinized, of which three were doctoral dissertations and one a master's thesis. The pooling of statistical results was precluded by the heterogeneity of study designs and methods of data collection and analysis. Instead, descriptors of clinically-relevant symptoms affecting the voice and vocal characteristics associated with menopause (menopause descriptors) were

extracted, categorised and subcategorised to determine their frequency of distribution in primary studies. We aimed to identify the descriptors investigated most frequently and those that are still understood poorly. Our goals were to provide singers going through the menopausal transition, and those who work with them, with relevant information, and to provide guidance to those undertaking future investigations.

The majority of studies refer to menopause descriptors in the form of self-reported symptoms. Those reported most often concern aspects of voice function, namely complaints of decreased pitch range and alterations to timbre; reports of singers' endurance, flexibility, breath management, levels of hydration, register transitions, and intonation were all negative. The few positive reports that were identified (fuller timbre, wider lower range, stable voice produced in a more relaxed way, and louder voice) were associated with increase in voice use and singing lessons during the menopausal transition. These findings seem to contradict Price's (2010) conclusions of a stronger effect of menopause on more advanced singers. There was a higher percentage of singers reporting voice source and vocal health problems during menopause in singers with more than 10 years of experience as compared to those with 1 to 10 years of experience. One might speculate that this could be related to the fact that more experienced singers are generally more aware of the voice than less experienced ones. Vocal training improves kinaesthetic feedback for controlling voice production (Sundberg, 1987).

The prevalence of voice problems associated with menopause varied from 17% (Abitbol et al., 1999) to 76% (Elliott, 2017) and 77% (Boulet & Oddens, 1996). This variation is attributable to different definitions of voice problem, and different methodological approaches to data collection, although prevalence may also vary because validated PRO measures are used so rarely. Although these are increasingly

recognised by national health institutes as crucial to the identification of clinically relevant patient-centred information (Francis et al., 2017), only two primary studies in our sample used a PRO measure, the SVHI (Cohen et al., 2007), to assess the effects of menopause on singers (Price, 2010; Ouyong et al., 2018). These should be used in future studies. On the basis of the results of this systematic review, we would also recommend the use of the Vocal Fatigue Index (Nanjundeswaran et al., 2015), and Ability to Sing Easy (Phyland et al., 2013).

Studies of the acoustic characteristics of the voice and observations of the larynx corroborated the findings of studies on self-reported symptoms. Menopause seems to have a particular effect on normal phonatory physiology. There are changes in the way sound is produced by the vocal folds, such that spectrographic interpretations of menopausal voices are described as “loss of harmonics” (Abitbol et al., 1999, p. 441), “lack of overtones”, and “excess of noise components” (Price, 2013, p. 124). These observations substantiate the findings of altered patterns in vibration of the vocal folds during observations of the larynx reported in the cross-sectional studies included in this review (Abitbol et al., 1999; Clarós et al., 2017). In some singers, impairment of vocal folds mobility was visualized and attributed to oedema (Abitbol et al., 1999; Clarós et al., 2017). The airflow induces the vocal folds to vibrate and this produces a complex tone with harmonic partials covering a wide range of frequencies (Fant et al., 1985). If the pattern of vibration of the vocal folds is irregular, as in the case of vocal fold asymmetry caused by oedema, fewer partials are produced, compromising the perceived quality of the tone (Patel et al., 2020).

Decreases in singers’ confidence, memory, and ability to concentrate were also reported. These clearly affect singers’ ability to be musical and emotionally expressive, abilities that can determine the quality of their performance (Radionoff, 2008). In one

primary study, Allen (2006) reports that a singer was forced to retire due to a loss of confidence, energy, and concentration associated with a severe depression experienced over the menopausal transition.

Singers often decide whether advice has been beneficial to them based on the way they sound to themselves and on the way others perceive their voices (Kreiman et al., 1993). Perceptual evaluations are therefore crucial when investigating the effects of menopause on singers but the results of this systematic review reveal that few studies of this nature have been reported. The exceptions were those in which the GRBAS (Hirano, 1981), a scale designed to assess the quality of the speaking voice, was adapted by Clarós et al. (2017) to the evaluation of the singing voice using a sustained vowel, and Price's (2010) use of a Likert-type scale to evaluate types of phonation when singing. Teachers often guide students to use different types of phonation when building their vocal instruments as these produce different timbres (Borch & Sundberg, 2011; Herbst & Švec, 2014; Sundberg et al., 2004). Accordingly, the effects of menopause on phonation on types of phonation, and their correlates with perceptual evaluations of voice quality, should be explored in future research.

Another limitation of the studies identified in our review is that participants were largely defined as pre-, peri-, or post-menopausal on the basis of their age and self-reported stage of menopause. Reported measures of hormonal concentrations were provided in only one study (Abitbol et al., 1999). Given substantial variations in the symptoms of menopause and the age at which it may occur, STRAW recommends age as the criterion for determining menopausal stages (Soules et al., 2001a). In addition, WHO (1996) recommends including only middle-aged women within a restricted age range and using age as a covariant when studying symptoms associated solely with

menopause. For example, it would be worth undertaking longitudinal studies assessing the same singers at each of the stages -1, +1a and +1b.

## **Conclusions**

Several dimensions of a singer's vocal performance can be jeopardized by menopause. According to the findings of the current systematic review, phonatory physiology has received the most attention in the literature to date. The severity of the effects of menopause on phonatory physiology has still to be explored, as does the number of menopausal singers affected, the stage of menopause at which they are most affected and in what ways, and why some singers are more affected than others.

Despite the incomplete nature of current knowledge, there seems to be an agreement that the negative effects of menopause might be circumvented if regular singing and voice lessons are maintained throughout the menopausal transition (Allen, 2006, DeMaio, 2013; Price, 2010). This assumption is supported by the other researchers which found that regular voice practice and performance can minimize the effects of aging on the voice, such as tremolo, lack of endurance, and reduced agility (Sataloff & Linville, 2005). Examples of potentially beneficial pedagogical approaches include RVT (Verdolini-Marston et al., 1995), voice function exercise protocols (Stemple et al., 1994), and SOVTE (Titze, 2006). However, given the multidimensional nature of voice production and the interactions between the three subsystems comprising the vocal instrument (Herbst, 2017), it is difficult to establish a causal relationship between specific exercises and aspects of voice production (Sabol et al., 1995). The voice reflects the physical, emotional and psychological characteristics of a singer. Therefore, the study of this unique instrument requires methods of assessment that address such individuality, particularly when investigating the effects of sex



hormones during the menopausal transition. A suggestion of a comprehensive sample assessment could include: i) **general health evaluation**, concerning endocrinological status (following the recommendations made by STRAW described in Table 1), measurements of Body Mass Index (BMI), and history of physical, psychological and vocal health, use of medication and lifestyle habits; ii) **educational assessment**, including questions on form and regularity of vocal practice and performance; iii) **measurements of perceived singing self-efficacy**; iv) **objective evaluation of the voice** using comprehensive protocols of mapping acoustical, physiological and aerodynamical changes of the voice over a wide range of  $f_0$  and sound pressure levels; v) **perceptual evaluations of phonation types in performances of singing repertoire**, using analogue visual scales; vi) and **risk assessment**, focussing on questions concerning working conditions, self-perceived work ability and general self-perceived vocal health, though the use of standard PRO measures, such as *Vocal Fatigue Index* (Nanjundeswaran et al., 2015), and *Ability to Sing Easy* (Phyland et al., 2013). The findings of such a sample assessment could be used to address questions that remain to be explored. Controlled experimental studies assessing the effects of exercises on menopausal voices should also be carried out, as we identified only one quasi-experimental study comparing the effects of two exercise programs on pre- and post-menopausal singers. The possibility of evidence-based exercise programmes designed to overcome menopause-related voice changes seems remote. These should be developed, as we know that informed practice can contribute to a substantial improvement in the quality of singers' training (Lã, 2017). To quote Miller (1996), "To contend seriously for the respect of informed minds, they must be based on factual, although perhaps as yet incomplete, information" (p. 225).

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