The Outcomes of the Voice Use Reduction Program on Voice Quality and Vocal Fatigue in Occupational Voice Users

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Abstract

The study aimed to describe the outcomes of the Voice Use Reduction (VUR) program on voice quality and vocal fatigue in occupational voice users (OVUs). A within-subject, quasi-experimental, pre-test, post-test research design was performed on 30 OVUs. Perceptual and acoustic outcome measures were employed pre-and post-implementation of the VUR, including the GRBASI 4-point rating scale, jitter, shimmer, fundamental Frequency (F_0), harmonic-to-noise ratio (HNR), maximum phonation time (MPT), frequency min and max, intensity min and max, the Dysphonia Severity Index (DSI) and the Vocal Fatigue Index (VFI). The pre-and post-test outcomes revealed significant (p <0.001) decreases in perceptual G (Grade of hoarseness), R (Roughness), A (Asthenia), S (Strain), and I (Instability). Perceptual normality in these areas increased significantly (p <0.001). Acoustic measures revealed significant ($p < 0.05$) decreases in *Jitter%*, Intensity (dB) Min, and DSI scores as well as significant ($p < 0.05$) increases

in MPT /a/, /s/ and /z/, Frequency (Hz) Max, and F_0 (Hz) Max, indicating improved voice quality at post-test. The VUR program positively affected and improved OVUs' perception of vocal fatigue (VF) in the areas of tiredness of voice and physical discomfort. OVUs strongly perceive improvement of VF symptoms with rest regardless of the current level of VF they are experiencing. When approaching OVUs, clinicians are encouraged to use a combination of direct voice therapy and vocal hygiene accompanied by VUR to help develop healthier use of the voice, facilitate healing, and prevent further/future injury or disorder.
Keywords: Occupational Voice Users; Voice Use Reduction Program; Vocal Quality; Vocal Fatigue.

Occupational voice user's (OVUs) livelihoods depend partially or entirely on their voice; however, the prevalence of voice disorders in OVUs is rising due to increased daily vocal demands and cumulative vocal fatigue (VF) (Devadas et al., 2019; Liu et al., 2020; Nallamuthu et al., 2021; Nusseck et al., 2019; Pomaville et al., 2019; Porcaro et al., 2019; Sezin et al., 2020). VF can be defined as a range of symptoms related to the overtaxing of the larynx, leading to a chronic subjective sensation of muscular tiredness of the voice that increases with voicing activity and progresses over time (Côrtes Gama et al., 2015; Franca & Wagner, 2015; Gaskill & Hetzel, 2017; Pacheco & Behlau, 2019). Research reveals that VF symptoms have a detrimental impact on the economic and vocational goals of OVUs, consequently also affecting their psychological well-being and quality of life (Aiken & Rumbach, 2018; Porcaro et al., 2019; Rangarathnam et al., 2018).

Literature suggests that when voice problems arise, employees exhibit reduced productivity, reduced work quality, restricted occupational activities, and increased absenteeism (Faham et al., 2016). Due to the sequelae of negative

consequences VF can have within this population, it is imperative that OVUs acquire voice care knowledge and implement vocal hygiene practices in order to circumvent resulting voice disorders (Franca & Wagner, 2015).

To prevent voice disorders in OVUs, the implementation of vocal hygiene education (VHE) programs is endorsed (Pomaville et al., 2019). The main goals of VHE programs are to educate individuals regarding preventative practices to ensure vocal health (VH), balancing muscles for optimal vocal production, and keeping the vocal folds and surrounding structures free of lesions and pathology, particularly for OVUs (Behlau & Oliveira, 2009; Faham et al., 2016; Pomaville et al., 2019). Although some OVUs receive various degrees of training on VH, their needs for vocal protection through VH practices are lifelong (Sezin et al., 2020).

VUR, voice conservation, or modified voice rest are central to VHE programs and can adapt daily routines and enhance VH (Van Der Merwe, 2004). Despite the standard recommendation for voice rest, a consensus regarding the specifics of implementation, type and duration of voice rest varies among clinicians (Kaneko et al., 2017). The recommendation of absolute voice rest, or complete silence, has become controversial as more recent studies suggest that the benefit of this practice could lead to adverse psychological effects on the client and deconditioning of the vocal apparatus as a finely tuned occupational tool (Kaneko et al., 2017). In contrast, VUR practices remain popular (Kaneko et al., 2017; Van Der Merwe, 2004) and are commonly recommended for anywhere between a few days to months, depending on severity and expected outcomes. A previous study suggested short-term (7 days or less) relative voice rest, followed by 1-4 weeks of gradual reintroduction of voice for acute overuse (Haben, 2012). This is similar to the VUR program, as it gradually increases voice use in stages until the voice has recovered (Van Der Merwe, 2004).

A structured behavior modification approach to reducing daily voice use, the VUR program, has been suggested by Van Der Merwe (2004). Currently, it is the only program that utilizes a controlled period of reduced daily voice use to enhance VH and quality, reduce VF, and improve vocal-fold appearance (Van Der Merwe, 2004). The rationale for VUR is to promote recovery in clients who present with laryngeal injury, pathology and VF by reducing daily voice use (Van Der Merwe, 2004). This is based on the notion that reduced voice use will facilitate the process of tissue repair and precipitate tissue re-epithelialization, which can be a useful preventative tool when treating vocal pathology and voice disorders (Kaneko et al., 2017; Van Der Merwe, 2004). Current VUR methods described in the literature are vague and, therefore, ineffective (Van Der Merwe, 2004). Although some prescribed VUR methods may have great value, they lack descriptions of procedural detail and consistency (Van Der Merwe, 2004). Further challenges to VUR include emotional issues, personality traits, and occupational demands (Van Der Merwe, 2004). Therefore, the VUR program uses behavior modification theory as a guideline and focuses on the three aspects of positive reinforcement, careful description of the target behavior and goal, as well as self-control to modify a client's daily voice use behaviors (Van Der Merwe, 2004).

Although a formalized approach to VUR has been available since publication in 2004, the effect has yet to be determined. Thus, the VUR program must be tested for the potential to be a simple, accurate, and sustainable solution to individualized management of daily voice use in OVUs. Therefore, the following research question is posed: What is the effect of the VUR program on voice quality and vocal fatigue in OVUs?

Methods

Aim

The study aimed to determine the outcomes of the Voice Use Reduction (VUR) program (Van Der Merwe, 2004) on voice quality and vocal fatigue in occupational voice users.

Research Design

The research design employed in this study was a within-subject, quasi-experimental, pre-test post-test design (Leedy & Ormrod, 2023).

Participants

A total number of 30 male and female OVUs were invited via email to voluntarily participate in this study using a random sampling technique. Using a previous OVU participant pool, every second participant was selected to participate. This study investigated an adult population; a minimum age of 18 years was set. The average age of the 30 participants was 27,4 years (*Mdn*=24.0, *SD*=8.7, *IQR*=10.0). Almost all participants were female (93.3%; n=28), with only two (6.6%) being male. High vocal demand OVUs were targeted; thus, the professionals who participated were call centre agents (n=6), teachers (n=6), lecturers (n=4), singing students (n=10), and performing arts students (n=4).

Only OVUs who had not previously been diagnosed with a voice disorder by an otolaryngologist (ENT) or current infection or disease affecting vocal fold functioning were included, as these would have influenced perceptual and acoustic results. OVUs were excluded if they received prior voice therapy, as this may cause possible bias due to previous knowledge acquired on VUR. Factors that may have influenced voice quality, such as allergies,

gastroesophageal reflux disease (GERD), sinusitis, and smoking, were not regarded as exclusion criteria but were taken into consideration. Due to participants acting as their own control in this study, control was not implemented through exclusion but rather by describing the population in detail to understand possible influences.

Voice Assessment Protocol (Figure 1)

IRB approval was obtained for this study [HUM019/0321], and all participants signed informed consent forms before data collection procedures commenced. Prior to starting the VUR program and upon its completion (Pre- and Post-test), a case history, a self-reported questionnaire probing vocal fatigue, a perceptual assessment, and an acoustic analysis were conducted. The case history questionnaire was completed to gather the participants' voice histories and information, including age, level of voice training, general health (reflux and allergies), medical history, and vocal habits (smoking, alcohol consumption, and vocal abuse).

Participants were also asked to complete the vocal fatigue index (VFI) (Nanjundeswaran et al., 2015) pre- and post-test. The VFI is a standardized tool that can identify individuals with probable VF with good reliability, validity, sensitivity, and specificity (Nanjundeswaran et al., 2015). The VFI is a scale used to quantify the amount of vocal fatigue suffered by a given individual and discriminate between those with dysphonia and those without. Participants rated 19 voice statements (e.g. "My voice feels tired when I talk more"). Ratings were from 0-4, 0 being "never" and four being "always". Three factors relating to vocal fatigue were examined due to questions being separately aimed at: 1. Tiredness of voice, 2. Physical discomfort, and 3. Improvement of symptoms with rest. A higher score indicated increased vocal fatigue with factors 1 and 2.

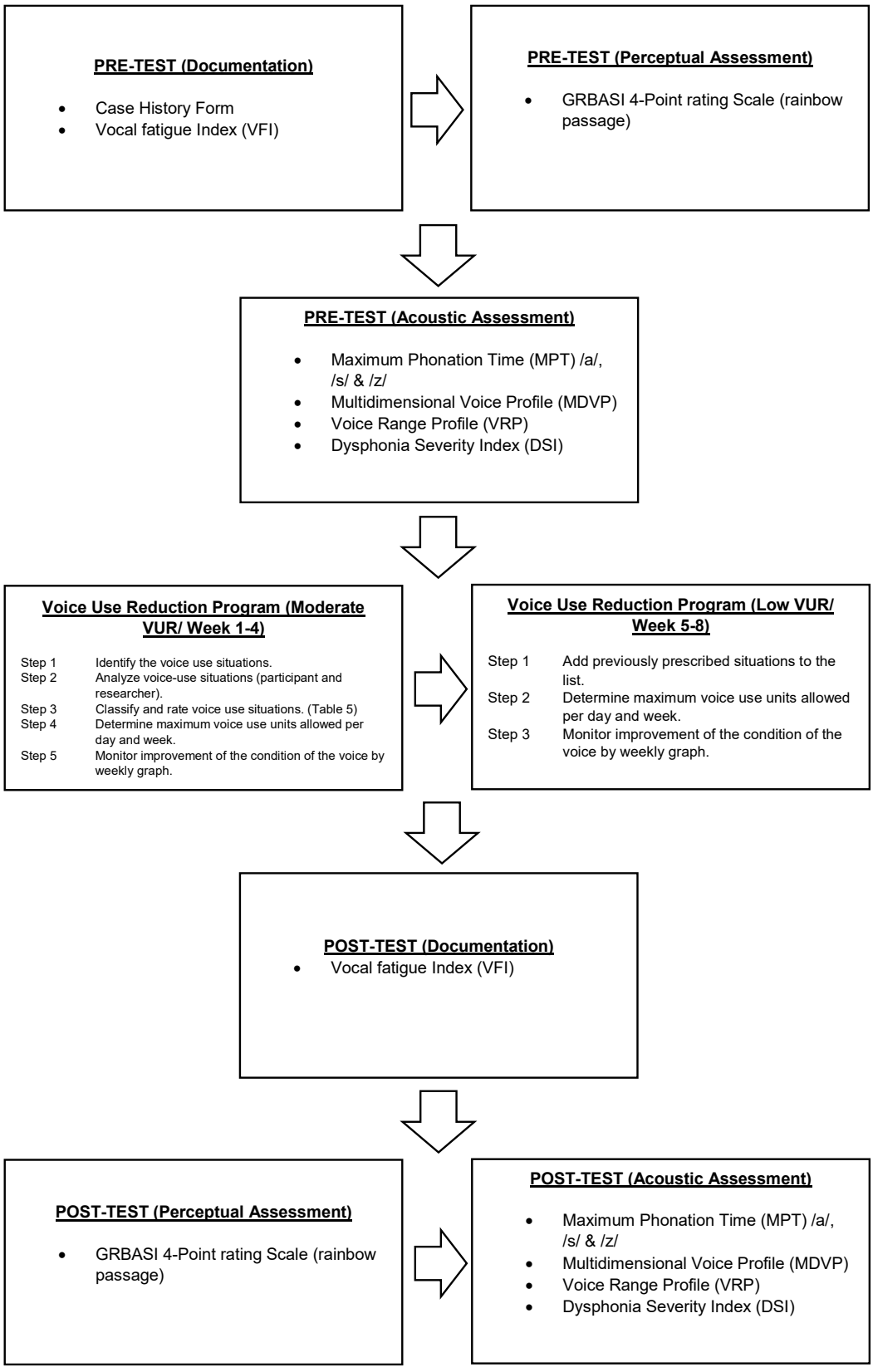


FIGURE 1. Process of Voice Assessment Protocol

Inversely, with factor 3, an increased score indicated decreased vocal fatigue (Nanjundeswaran et al., 2015).

Participants received a comprehensive voice assessment to establish a baseline for vocal quality. The GRBASI 4-point rating scale (Yamauchi et al., 2010) was used to rate the perceptual quality of the participant's voices as they read the phonetically balanced rainbow passage (Fairbanks, 1960). This scale has been tested to be reliable and indicated in analyzing voice quality (Yamauchi et al., 2010). The perceptual attributes measured by the GRBASI 4-point rating scale are described in Table 1. A listener's panel of five qualified speech-language therapists scored the perceptual data in a single sitting. The voice recordings were presented in random order to remove bias. Each member of the panel of listeners gave a rating for each component of the GRBASI scale, and individual scores were averaged. Being blind to which recordings were from the pre- or post-test groups increased the objectivity and reliability of the listener's panel rating of perceptual measures.

All participants' maximum phonation time (MPT) was taken using the steady state vowel /a/ after maximum inspiration. After that, an s/z ratio was calculated by producing the voiceless /s/ and voiced /z/ on maximal inspiratory effort for as long as possible. The best of three attempts was recorded for both MPT and s/z ratio. MPT was considered normal when greater than or equal to 15.1 seconds (Goy et al., 2013). All audio recordings of the voices of each participant were made using a cellular phone (iPhone 12 Pro Max) in an MPEG-4 codec format (Awan et al., 2023). Previous studies have revealed that iPhone or Android phones can produce gold-standard recordings suitable for acoustic analysis of the pathological voice (Awan et al., 2023). The phone was held at a fixed distance of 15 cm (Awan et al., 2023) from the mouth to obtain the most

consistent results across different participants and to obtain optimal quality recordings (Van Lierde et al., 2010; Timmermans et al., 2004).

Table 1. *Description of Acoustic Parameters.*

Acoustic Parameter	Description
Jitter%	The parameter of frequency variation from cycle to cycle, affected mainly by the lack of control of vibration of the cords (Teixeira et al., 2013).
Shimmer%	The amplitude variation of the sound wave correlated with the presence of noise emission and breathiness (Teixeira et al., 2013).
F0 (Hz)	The number of times a sound wave produced by the vocal cords repeats during a given time period. It is also the number of cycles of opening/closure of the glottis (Teixeira et al., 2013).
MPT /a/ (sec)	The maximum amount of time a person can sustain the phonation of "ah" is timed (Christmann et al., 2013).
MPT /s/ (sec)	The maximum amount of time a person can sustain the phonation of a voiceless phoneme "s" is timed (Christmann et al., 2013).
MPT /z/ (sec)	The maximum amount of time a person can sustain the phonation of a voiced phoneme "z" is timed (Christmann et al., 2013).
S/Z Ratio	The ratio calculated by dividing the MPT /s/ by the MPT /z/. A ratio of 1.4 or above may indicate a degree of vocal fold dysfunction (Teixeira et al., 2013).
Harmonics -to-noise Ratio (dB)	The ratio between periodic components and non-periodic components comprising a segment of voiced speech. The first component arises from the vibration of the vocal cords, and the second follows from the glottal noise expressed in dB. The evaluation between the two components reflects the efficiency of speech. If a voice is characterized by a high HNR, it will be perceived as sonorant and harmonic. A low HNR denotes an asthenic voice and dysphonia (Teixeira et al., 2013)..
Frequency (Hz) Max	The highest number of times an individual's vocal folds can vibrate per second when phonating, corresponding to perceptual pitch (highest pitch) (Teixeira et al., 2013)..
Frequency (Hz) Min	The lowest number of times an individual's vocal folds can vibrate per second when phonating, corresponding to perceptual pitch (lowest pitch) (Teixeira et al., 2013)..
Intensity (dB) Max	A function of fundamental Frequency and lung pressure creating maximal sound pressure, corresponding to perceptual loudness (loudest voice) (Teixeira et al., 2013).
Intensity (dB) Min	A function of fundamental Frequency and lung pressure creating minimal sound pressure, corresponding to perceptual loudness (softest voice) (Teixeira et al., 2013).
Dysphonia Severity Index (DSI)	An objective and quantitative correlate of the perceived vocal quality (Wuyts et al., 2000).

The multidimensional voice program analysis (MDVP) and the voice range profile (VRP) of the computerized speech lab (CSL) (MODEL 4105B; KayPENTAX) were conducted on all the participants in a sound-proof voice laboratory. The CSL software (MDVP & VRP) is considered the gold standard

for accurate capture and playback of acoustic signals of speech and voice production (KayPENTAX, 2006). A microphone was set 30cm away from the mouth for the acoustic analysis. The MDVP was used to evaluate the jitter (*jitt %)*, shimmer (*shim %)*, fundamental frequency variation (vF_0), and harmonic-to-noise ratio (*HNR*) of each participant. The VRP depicted the participant's minimum and maximum volume and pitch capacities across their vocal range. The acoustic parameters measured in this study are described in Table 2.

Table 2. *Description of perceptual attributes measured by the GRBASI 4-Point Rating Scale (Yamauchi et al., 2010).*

GRBASI		Description
G	Grade of Hoarseness	Degree of hoarseness of the voice.
R	Roughness	Impression of irregularity of vibration of the vocal folds.
B	Breathiness	Degree of air escaping between the vocal folds can be heard.
A	Asthenia	Degree of weakness that can be heard.
S	Strain	Degree strain or hyperfunctional voice use can be heard.
I	Instability	Changes in voice quality over time.

The dysphonia severity index (DSI), a reliable, multi-parametric tool, generated an objective vocal quality score based on acoustic results (Wuyts et al., 2000). The following measurements were taken into consideration when calculating the DSI: maximum phonation time (MPT in seconds), highest Frequency (F_0 (F_0 high in Hz), lowest Intensity (I—low in dB), and jitter (%) (Yu et al., 2001). The DSI is interpreted as follows: scores may range from –5 to +5. A score of +5 indicates a perceptually normal voice, whereas a score of –5 indicates a severely dysphonic voice (Sobol et al., 2020; Wuyts et al., 2000).

Participants were asked to use the VUR program (Van Der Merwe, 2004), a structured behavior modification approach to reduce daily voice use for eight weeks. The stages and steps of the VUR program are outlined in Table 3.

Firstly, all participants' problematic vocal behaviors were identified and specified in quantitative terms, quantifiable goals were set, and the participant was guided on how to apply the program. Voice use in all communication situations was quantified and rated by allocating several voice-use units to each situation. The number of units assigned to each situation depends on the effect the situation will have on the participant's voice. The more detrimental the effect, the more voice-use units are assigned (Table 4). The client is then allowed to use a specified maximum number of voice-use units daily and weekly (Table 5). The participant decides how allocated voice-use units will be spent. The VUR program is usually started at stage one (severe VUR) and gradually, dependent on the improvement of the condition of the vocal folds, vocal quality, vocal fatigue, vocal effort, and laryngeal pain levels, progresses to stage two (moderate VUR) and finally, ends in stage three (low VUR). In this study, no participants presented with a current diagnosis of organic vocal-fold pathology. Therefore, the VUR was started for all participants (n=30) at moderate VUR (stage two) as severe VUR (stage one) is intended for patients presenting with vocal-fold pathology (Van Der Merwe, 2004). Progress was tracked weekly through the use of the VUR program graphs (Figure 2), indicating the number of voice use units (y-axis), the days of the week and the number of weeks on the (x-axis). Almost all of the participants (96.7%; n=29) spent four weeks in stage two (moderate VUR) and then progressed to stage three (low VUR) for four weeks. Only one participant (3.3%) remained in stage two (moderate VUR) for five weeks before progressing to stage three (low VUR) as they had not experienced sufficient improvement in vocal quality or reduction of vocal fatigue by the end of week four.

Table 3. *Stages of The Voice Use Reduction Program.*

Stage	Step	
Severe Voice Reduction	Step 1	Identify the voice use situations.
	Step 2	Analyze voice-use situations (participant and researcher).
	Step 3	Classify and rate voice use situations.
	Step 4	Determine maximum voice use units allowed per day and week.
	Step 5	Monitor improvement of the condition of the voice.
Moderate Voice Use Reduction	Step 1	Add previously prescribed situations to the list.
	Step 2	Determine maximum voice use units allowed per day and week.
	Step 3	Monitor improvement of the condition of the voice.
Low Voice Use Reduction	Step 1	Add previously prescribed situations to the list.
	Step 2	Determine maximum voice use units allowed per day and week.
	Step 3	Monitor improvement of the condition of the voice.

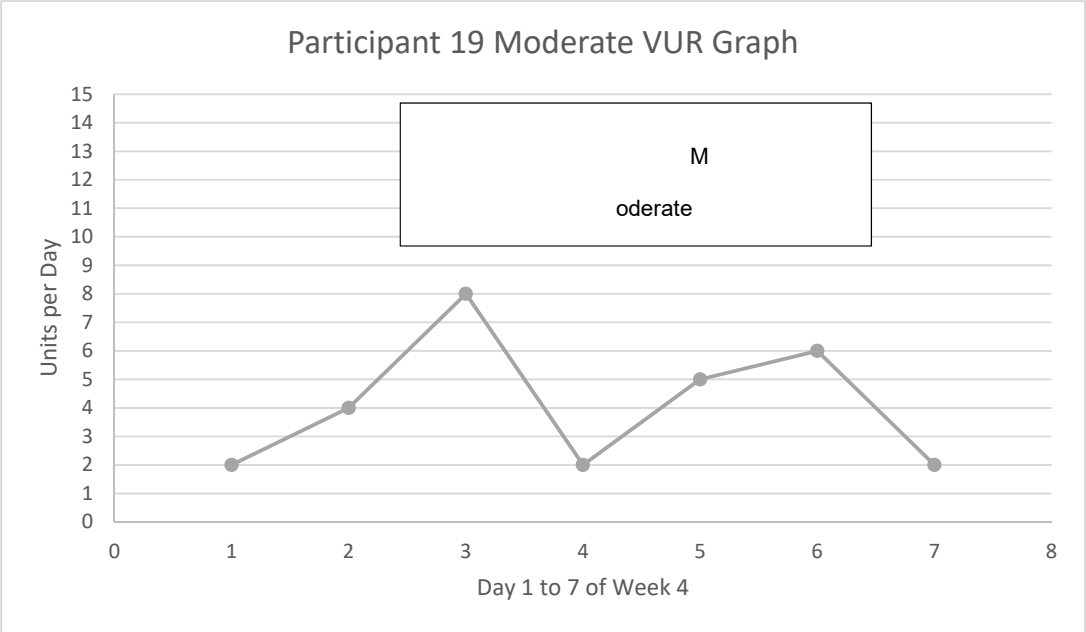
Table 4. *Examples of How to Rate Voice-Use Situations.*

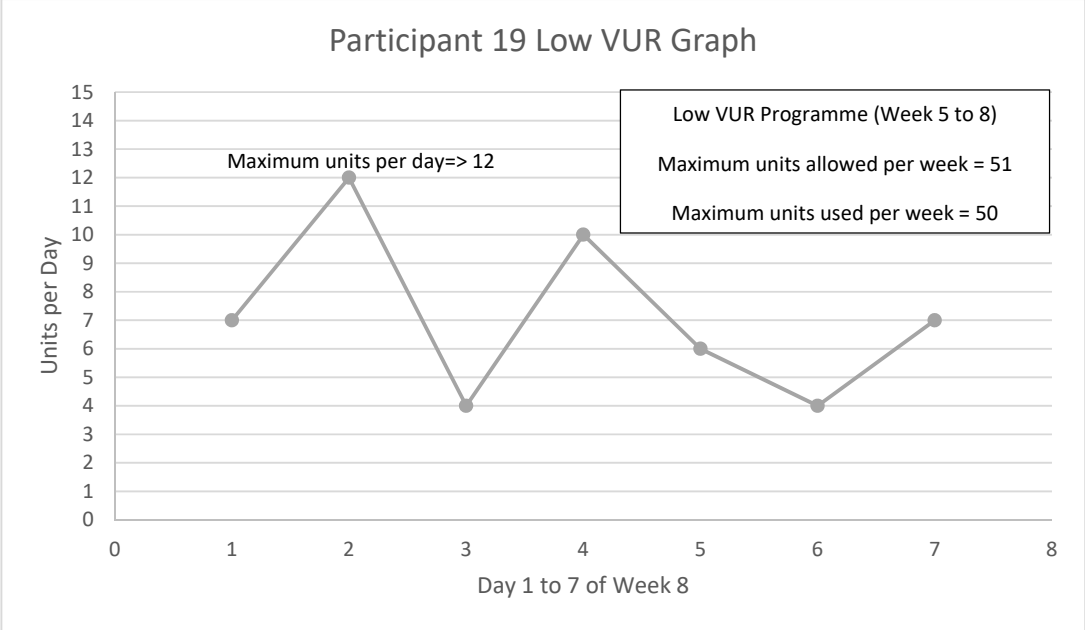
Units	Voice Use Situations
1	Intermittent use of voice at home or work in optimum communication conditions (no background noise or communication competition) for basic communication or to convey only the most important information during 1 day.
2	Intermittent conversation in optimum communication conditions for 30 minutes or telephonic conversation for 10 minutes in a soft voice.
3	Intermittent conversation in optimum communication conditions for 1 hour in a soft voice.
4	Intermittent conversation in unfavorable communication conditions (background noise or communication competition) for 30-min or uninterrupted voice use for 5-10 min in unfavorable communication conditions.
5	Uninterrupted voice use in optimum conditions for 30 minutes (lecture or presentation) or intermittent professional voice use for 1 hour.
6	Uninterrupted voice use in optimum conditions for 1 hour or intermittent professional voice use for 2 hours.

Table 5. *Examples of How to Assign Voice-Use Units Per Day in the VUR Stages.*

Stage	Maximum number of voice-use units per day
Severe VUR	1 unit is allowed for basic communication, plus the units for the highest rated situation (e.g. 6) = 1+6=7 voice use units per day.
Moderate VUR	1 unit is allowed for basic communication, plus the units for the highest rated situation (e.g. 6), plus 3 units for social or professional voice use = 1+6+3 =10 voice use units per day.
Low VUR	1 unit is allowed for basic communication, plus the units for the highest rated situation (e.g. 6), plus 5 units for social or professional voice use = 1+6+5 =12 voice use units per day.

Figure 2. *Participant 19 Moderate and Low VUR Graphs*





All participants were reassessed using the protocol mentioned above after completing the eight-week VUR program. All assessments were conducted by the researcher, a qualified speech-language pathologist, at the Voice Laboratory at the University of Pretoria and scheduled at the same time of day for initial assessment (pre-test) and reassessment (post-test).

Data Analysis

The Statistical Package for Social Sciences (SPSS) software program version 28, with a significance level of 5%, was used in all data analyses. Since the sample size was less than 50, Shapiro-Wilk's statistic was used instead of the Kolmogorov-Smirnov statistic to test for normality with a p-value greater than 0.05 indicating normality. These two tests are the same in that they both test for normality; however, the Shapiro-Wilk test is known to have more power in detecting differences from normality (Field, 2018). Since many of the p-values were less than 0.05 for many of the continuous variables considered in this study, normality could not be assumed for all variables, and, accordingly, nonparametric methods were used. Researchers have shown that nonparametric tests using ranking procedures outperform their parametric counterparts when the distribution is skewed or peaked (De Winter & Dodou, 2010). In addition, since not all variables are normally distributed, the median (*Mdn*) and interquartile range (*IQR)* are reported along with the mean (*M*) and standard deviation (*SD)*.

For continuous variables, the Wilcoxon signed-rank test (Z_{WSR}) was used to determine statistically significant differences for related/dependent samples (Field, 2018), for example, for detecting significant differences between pre-test and post-test values. For categorical variables, McNemar's test (Z_{McN}) was used to determine whether the frequencies/percentages differed statistically significantly between the pre-and post-test data, as this test is designed to test for the proportion of change in the same group of people (Field, 2018).

Table 6. *Participant Medical, Voice-Use, Emotional, and Intake Characteristics (n=30)*

Medical Characteristics	Pre-test	Post-test
GERD	73.3% (n=22)	43.3% (n=13)
Allergy (food, animals, environmental, or medication)	73.3% (n=22)	30.0% (n=9)
Hormonal treatment (contraceptives, testosterone)	43.3% (n=13)	33.3% (n=10)
Prescribed chronic medication	43.3% (n=13)	20.0% (n=6)
Post-nasal drip	43.3% (n=13)	20.0% (n=6)
Ear problems	43.3% (n=13)	16.7% (n=5)
Sinusitis	43.3% (n=13)	20.0% (n=6)
Chronic colds	3.3% (n=1)	3.3% (n=1)
Previous intubation	3.3% (n=1)	3.3% (n=1)
Previous laryngeal injuries	3.3% (n=1)	3.3% (n=1)
Previous laryngeal procedure (tonsillectomy)	3.3% (n=1)	3.3% (n=1)
Family history of voice problems	3.3% (n=1)	3.3% (n=1)
Asthma	0.0% (n=0)	0.0% (n=0)
Chronic cough	0.0% (n=0)	0.0% (n=0)
Chronic laryngitis	0.0% (n=0)	0.0% (n=0)
Voice Use Characteristics		
Voice use in noisy or dusty environments	100.0% (n=30)	100.0% (n=30)
Sings often	100.0% (n=30)	100.0% (n=30)
Symptom/complaint improves with rest	100.0% (n=30)	100.0% (n=30)
Throat clearing	96.7% (n=29)	96.7% (n=29)
Experiences sensory symptoms (dryness, lump in throat, pain)	93.3% (n=28)	93.3% (n=28)
Experiences vocal fatigue or laryngeal discomfort	90.0% (n=27)	90.0% (n=27)
High voice use (8 hours a day)	90.0% (n=27)	90.0% (n=27)
Symptom/complaint worsens with continued voice use	90.0% (n=27)	90.0% (n=27)
Perceived worst voice production - Evening	76.7% (n=23)	76.7% (n=23)
Compensates with use of "another voice/pitch"	76.7% (n=23)	76.7% (n=23)
Perceived best voice production - Morning	70.0% (n=21)	70.0% (n=21)
Mouth breathing	66.7% (n=20)	66.7% (n=20)
Emotional Characteristics		
Bodily signs of tension (neck, throat, back)	100.0% (n=30)	100.0% (n=30)
Stressful work or home environment	96.7% (n=29)	96.7% (n=29)
Connection noted between voice and psychological state	96.7% (n=29)	96.7% (n=29)
Stressed emotional state	90.0% (n=27)	76.7% (n=23)
Intake Characteristics		
Water	100.0% (n=30)	100.0% (n=30)
Caffeine	46.7% (n=14)	30.0% (n=9)
Carbonated drinks	26.7% (n=8)	20.0% (n=6)
Smoking	3.3% (n=1)	3.3% (n=1)

Table 7. *Frequency Distribution of GRBASI scores (n=30)*

GRBASI		*Comparison*	*Normal (Score=1)*	*Slight (Score=2)*	*Moderate (Score=3)*
G	*Grade of Hoarseness*	Pre-test	10.0% (n=3)	90.0% (n=27)	0% (n=0)
		Post-test	86.7% (n=26)	13.3% (n=4)	0% (n=0)
		Z_{McN}	-4.796	4.796	-
		p-value	<0.001*	<0.001*	-
R	*Roughness*	Pre-test	16.7% (n=5)	33.3% (n=10)	50.0% (n=15)
		Post-test	90.0% (n=27)	10.0% (n=3)	0% (n=0)
		Z_{McN}	-4.690	2.333	3.783
		p-value	<0.001*	0.020*	<0.001*
B	*Breathiness*	Pre-test	60.0% (n=18)	40.0% (n=12)	0% (n=0)
		Post-test	63.3% (n=19)	36.7% (n=11)	0% (n=0)
		Z_{McN}	-0.302	0.302	-
		p-value	0.763	0.763	-
A	*Asthenia*	Pre-test	23.3% (n=7)	76.7% (n=23)	0% (n=0)
		Post-test	96.7% (n=29)	3.3% (n=1)	0% (n=0)
		Z_{McN}	-4.690	4.690	-
		p-value	<0.001*	<0.001*	-
S	*Strain*	Pre-test	10.0% (n=3)	90.0% (n=27)	0% (n=0)
		Post-test	80.0% (n=24)	20.0% (n=6)	0% (n=0)
		Z_{McN}	-4.583	4.583	-
		p-value	<0.001*	<0.001*	-
I	*Instability*	Pre-test	46.7% (n=14)	53.3% (n=16)	0% (n=0)
		Post-test	96.7% (n=29)	3.3% (n=1)	0% (n=0)
		Z_{McN}	-3.873	3.873	-
		p-value	<0.001*	<0.001*	-

**Significant difference: $p < 0.05$*

Results

Just below three-quarters of the participants reported suffering from GERD (73.3%; n=22) [Table 6]. Almost half of the participants (43.3%; n=13) reported having an allergy related to either food, animal, environment, or medication, with 43.3% (n=13) reporting being on hormonal treatment and 43.3% (n=13) reported being on chronic medication. Only one participant (3.3%) reported a family history of voice problems (Table 7).

All of the participants (100.0%; n=30) reported using their voice in noisy and dusty environments, singing often, and that their voice symptoms improved with rest. Almost all of the participants (96.7%; n=29) reported throat clearing frequently, with 93.3% (n=28) experiencing sensory symptoms and 90.0% (n=27) using their voice 8 hours a day for occupational reasons, vocal fatigue, or laryngeal discomfort, and that their symptoms worsen with continued voice use. Two-thirds of the participants (66.7%; n=20) reported mouth breathing.

All participants reported drinking water daily, with two-thirds (66.7%; n=20) reporting drinking 2 liters per day, just below one-third (30.0%; n=9) reporting drinking only 1 liter per day, and one participant (3.3%) reporting drinking between 1 and 2 liters per day. Almost half of the participants (46.7%; n=14) reported ingesting caffeine, ranging from as low as one serving three times a week to three servings per day. Only one participant (3.3%) reported smoking.

In Table 7, all differences between pre-and post-test were significant, except for B (Breathiness), which only decreased marginally (3%, n=1) in the "Slight" category and increased equally (3%, n=1) in the "Normal" category. For the "Moderate" category, R (Roughness) differed significantly between pre-and post-test. The most significant differences seen were a decrease of slight G (Grade of Hoarseness) (76,7%, n=23) and an increase of normality of G (76,7%, n=23 and R (73,7%, n=22) at post-test.

Table 8 summarizes whether there were significant differences ($p < 0.05$) between pre- and post-test acoustic outcomes. Amongst the significant decreases seen in Jitter % and Intensity (dB) Min and the significant increases seen in MPT /a/, MPT /s/, MPT /z/, Frequency (Hz) Max, F_0 (Hz) Max, the most significant *M* differences seen were the decrease of Intensity (dB) Min (11.33) and the increase of Frequency (Hz) Max (205.90) and F_0 (Hz) Max (149.42).

Table 8. *Acoustic Parameter Outcomes and Pre-test -Post-test Comparisons (n=30)*

Acoustic Parameters	*Pre-test*		*Post-test*		*Significance*
	M (SD)	*Mdn (IQR)*	*M (SD)*	*Mdn (IQR)*	Z_{WSR} (*p*-value)
Jitter%	1.16 (0.56)	1.15 (0.68)	0.83 (0.38)	0.67 (0.64)	-2.653 (0.008*)
Shimmer%	3.67 (1.77)	3.21 (3.51)	4.30 (1.88)	3.40 (3.33)	-1.615 (0.106)
F0 *(Hz)*	318.18 (200.78)	290.79 (112.03)	468.59 (274.32)	387.68 (230.63)	-1.715 (0.106)
MPT /a/ (sec)	13.63 (4.03)	12.00 (4.00)	18.03 (4.24)	16.00 (7.25)	-3.991 (0.000*)
MPT /s/ (sec)	20.23 (6.17)	19.50 (4.50)	23.53 (7.19)	27.00 (15.00)	-1.957 (0.050*)
MPT /z/ (sec)	17.46 (5.19)	16.50 (6.25)	21.66 (6.11)	20.00 (10.75)	-3.151 (0.002*)
Harmonics-to-noise Ratio (dB)	0.13 (0.05)	0.13 (0.06)	0.15 (0.07)	0.15 (0.06)	-1.44 (0.150)
S/Z Ratio	1.21 (1.33)	1.13 (0.42)	1.12 (1.36)	1.10 (1.42)	-0.919 (0.358)
Frequency (Hz) Max	633.63 (172.46)	587.33 (257.11)	839.53 (220.72)	848.93 (268.41)	-3.579 (0.000*)
Frequency (Hz) Min	148.62 (29.76)	160.18 (37.95)	146.24 (30.77)	139.99 (24.94)	-0.342 (0.733)
Intensity (dB) Max	108.80 (24.56)	105.00 (11.00)	114.46 (29.27)	106.50 (19.25)	-0.769 (0.442)
Intensity (dB) Min	76.13 (8.13)	75.00 (16.00)	64.80 (5.49)	64.50 (5.50)	-4.055 (0.000*)
F0 *(Hz) Max*	516.15 (241.08)	493.88 (436.83)	665.57 (274.32)	678.86 (460.63)	-2.368 (0.018*)
F0 *(Hz) Min*	237.94 (112.01)	196.00 (106.69)	229.61 (200.71)	196.00 (138.59)	-1.594 (0.111)
DSI	-3.43 (2.91)	-3.70 (5.25)	1.57 (2.19)	1.90 (2.67)	-4.433 (0.000*)

**Significant difference: $p < 0.05$*

Table 9. *Outcomes and Comparisons for Individual Factors on the VFI (n=30)*

VFI Factors	Pre-test		Post-test		Significance
	M (SD)	*MDN (IQR)*	*M (SD)*	*MDN (IQR)*	Z_{WSR} (*p*-value)
Factor 1. Tiredness of voice	34.10 (7.42)	35.50 (7.75)	15.43 (5.41)	14.50 (9.00)	-4.788 (0.000*)
Factor 2. Physical discomfort	14.30 (3.78)	15.00 (6.50)	3.233 (2.38)	3.00 (4.00)	-4.791 (0.000*)
Factor 3. Improvement of symptoms with rest	11.30 (1.48)	12.00 (1.00)	11.30 (1.14)	12.00 (2.00)	-0.079 (0.937)

**Significant difference: $p < 0.05$*

When comparing the change between pre-and post-test VFI outcomes (Table 9), a significant difference ($p < 0.05$) was seen with an average decrease to 15.43 (*Mdn*=14.50, *SD*=5.41, *IQR*=9.00) for VFI Factor 1 (Tiredness of voice), 3.23 (*Mdn*=3.00, *SD*=2.38, *IQR*=4.00) for VFI Factor 2 (Physical discomfort) at post-test.

Discussion

OVUs are faced with multiple risk factors for vocal pathology and subsequent voice disorders due to prevalent medical, voice-use, and emotional characteristics within this population. Furthermore, most of the participants (73.3%) reported suffering from GERD. It is essential to consider the diagnosis of GERD when treating OVUs, as 50% of patients with voice disorders also present with a form of reflux, and their understanding of the disorder will significantly improve subsequent voice treatment (Franco & Andrus, 2007; Koufman et al., 2000).

Most participants (90.0%, n = 27) reported using their voices eight hours a day for occupational reasons. This is similar to many previous studies where various OVUs reported high daily vocal demands (Bottalico & Astolfi, 2012; Cantarella et al., 2014; Gaskill & Hetzel, 2017; Gunasekaran et al., 2016; Hapner & Gilman, 2012; Lehto et al., 2008; Morrow & Connor, 2011; Munier & Farrell, 2016; Schloneger, 2011). Literature has shown that OVUs are likely to engage in prolonged and continuous voice use with only occasional periods of voice rest and loud and effortful talking (Devadas et al., 2019; Van Lierde et al., 2010; Van Overmeiren et al., 2018).

All participants (100.0%; n=30) reported using their voices in less than optimal (noisy and dusty) environments and singing often. Literature has shown that environmental factors such as poor acoustic environments, high levels of background noise, poor atmospheric humidity, exposure to environmental irritants, raising your voice due to not having access to amplification systems, and inadequate VHE can also increase the risk of vocal trauma seen in OVUs (Devadas et al., 2019; Franca & Wagner, 2015; Garzón García et al., 2017; Porcaro et al., 2019; Reed & Sims, 2017). Participants reported engaging in vocally harmful or strenuous activities such as singing for extended periods

(100%) and often clearing their throat (96.7%, n=29). Vocal abuse and misuse patterns are commonly noticed in OVUs (Devadas et al., 2019; Franco & Andrus, 2007; Munier & Farrell, 2016). Thus, improper vocal behaviors and compounding risk factors may cause variations in vocal quality, reduced vocal range, limited flexibility in voice, and, occasionally, inflammation of the vocal folds that subsequently result in vocal fold pathology (Devadas et al., 2019; Franco & Andrus, 2007; Rangarathnam et al., 2018).

It is central to the findings that all (100%; n = 30.0) of the participants reported that their voice symptoms improved with rest. Voice rest is often a first-line empiric treatment for phonotrauma (Haben, 2012). However, literature reviews show the absence of a standard protocol for modified voice rest that can be applied in voice therapy (Behrman & Sulica, 2003; Kaneko et al., 2017). In the findings presented it can be seen that the implementation of eight weeks of moderate to low VUR not only significantly improved perceptual voice quality and therefore reduced the degree of voice disorder present (hoarseness, roughness, asthenia, strain, and instability of the voice), but also the enhanced acoustic characteristics of voice by significant ($p < 0.05$) decrease in *Jitter %*, Intensity (dB) Min and DSI scores and significant ($p < 0.05$) increases MPT /a/,/s/ and /z/, Frequency (Hz) Max, and F_0 (Hz) Max as well as overall reduction of VF in OVUs.

When perceived in a voice, the GRBASI perceptual characteristics all indicate dysphonia and, more specifically, the degree of voice disorder present(Sobol et al., 2020; Wuyts et al., 2000). The perceptual differences observed between the pre-and post-test (GRBASI 4-point rating scale) revealed a significant (p <0.001) decrease in slight G, R, A, S, and I as well as moderate and slight R. Perceptual normality in all of these areas also increased significantly (p <0.001) at post-test indicating significant improvement of

perceptual voice quality overall. B was the only area that did not present with a significant difference; however, a decrease in slight B and increased normality of B perceived indicated a positive yet insignificant effect after VUR.

When comparing acoustic outcome differences, post-test results indicated a significant improvement in voice quality parameters. A reduction in *Jitter %* results in a voice with decreased roughness associated with pathological voice (inflammation, nodules, polyps, and weakness of the laryngeal musculature) and dysphonia (Vasilakis & Stylianou, 2009). The decrease in roughness due to Jitter% reduction correlates to the reduction in roughness of voice perceived in the perceptual outcomes. Thus, the decrease in *Jitter %* may be due to the improved condition of the vocal folds following VUR. Enhanced vocal health is also indicated in a reduction of the Intensity Min (dB) as dysphonic patients were previously found to have increased minimum vocal Intensity when compared to healthy voice controls (Barrett et al., 2020). After implementing the VUR program, participants could produce voice at significantly lower Intensity Min (dB) and presented with a more extensive range of Intensity (dB). Overall, dysphonia levels amongst participants decreased significantly, as seen in the reduction in DSI scores. The VUR program thus resulted in a decrease in voice disorders present in participants. Increased MPT indicates that participants presented with better glottal control, efficiency, and levels of coordination of breathing and phonation (Christmann et al., 2013). Thus, improved vocal endurance was seen after VUR. Higher Frequency (Hz) Max and F_0 (Hz) Max indicate that participants could reach significantly higher frequencies than before and, therefore, presented with a more extensive vocal range of Frequency after VUR. Although some differences revealed were not significant ($p < 0.05$), an increase in *Shimmer %,* F_0, and Intensity (dB) Max and a decrease in S/Z Ratio, Frequency (Hz) Min, and F_0 (Hz) Min was observed at

post-test, again collating the positive effect of the VUR program on voice quality alongside the perceptual results.

VFI outcomes after VUR revealed a significant decrease in the areas of tiredness of voice and physical discomfort at post-test. This indicates that the VUR program positively altered OVUs' perception of the level of VF they experienced in the areas of tiredness of voice and physical discomfort. It can, therefore, be deduced that VF symptoms will improve through the use of VUR and its ameliorating effect on perceived VF (seen in Factors 1 and 2). Improvement of symptoms with rest (Factor 3) remained unchanged before and after VUR merely due to participants consecutively scoring this section high at pre-test as well as at post-test. This reinforces the notion that OVUs strongly perceive improvement of VF symptoms with rest regardless of the current level of VF they are experiencing. Thus, the hypothesis was accepted that OVUs significantly improve vocal quality and vocal fatigue outcomes through the use of the VUR program.

Limitations and Recommendations

The sample included in this study was mostly young (average age 27.4 (*SD*=8.7)), vocally healthy female OVUs. It may be that age and vocal health influence the knowledge and perceptions reported, and it is therefore recommended that future research be conducted on a sample with more significant age variation and gender balance in order to represent the broader population of OVUs. It may also be advantageous that the cohort was younger as the findings emphasize the importance and need for early intervention in this population. Future research studies should consider a wider variety of occupational groups that may benefit from the results and focus on profession-specific outcomes or only specific categories/levels of OVUs (Koufman & Isaacson, 1991), as this study used a diverse group of OVUs. When reproducing

the protocol, future researchers should consider controlling for conditions like allergies, GERD, and sinusitis that could affect vocal quality. When reporting on F_0 (Hz), measurements should be given separately for males and females in the future.

Including Cepstral Peak Prominence (CPP) and Acoustic Voice Quality Index (AVQI) assessments in future assessment protocols would be noteworthy. Due to this study being the first to explore the effects of the VUR program on voice quality and vocal fatigue, it is recommended that future studies are controlled, larger scaled, experimental in design, and continue to investigate how the VUR program may affect vocal pathology, vocal quality, and vocal fatigue in order to collect more evidence on which practice and treatment methods can be based. Due to the study's novelty, no previous literature currently exists on VUR or voice rest protocols that do not describe complete voice rest in relation to phonosurgery. Thus, future researchers should continue to investigate the area of VUR.

Conclusion

The numerous risk factors OVUs face make them vulnerable to altered voice quality and vocal fatigue. When OVUs are left unable to perform their daily occupational tasks due to voice changes and VF, this detrimentally affects their psychological well-being, professional lives, and, ultimately, quality of life (Pomaville et al., 2019). The insights gathered in this study have found that the use of a structured behavior modification approach to VUR, such as the VUR program (Van Der Merwe, 2004), significantly reduced the degree of voice disorder and dysphonia seen in OVUs as seen in perceptual and acoustic outcomes. The noteworthy enhancement of voice quality, possibly due to the improved condition and health of the vocal folds, is evident in acoustic and perceptual results. Overall, VF was also significantly improved. The prevailing

sentiment appears to be that OVUs strongly perceive improvement of VF symptoms with rest regardless of the current level of VF they are experiencing. The VUR program also decreased levels of stressed emotional state OVUs experience. When approaching OVUs, clinicians are encouraged to make use of a combination of direct voice therapy and vocal hygiene accompanied by the use of a sustainable program, such as the VUR, to help develop healthier use of the voice, foster patient autonomy, facilitate healing, and prevent further/future injury. Voice rest has been proposed to 'decondition the voice' whereas voice therapy is thought to 're-condition the voice' (Haben, 2012) and, therefore, should be used congruently. These findings promote vocal health consciousness and awareness of preventive voice care initiatives in this unique population through the use of the VUR program.

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