Impact of masks on voice in COVID-19 era: a vocal hygiene protocol to reduce voice fatigue in a population of speech therapists. (A proposal by G.I.Vo.C.)

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Abstract.
Background: To assess the effects of prolonged face mask usage on vocal emission in a sample of speech therapists and to identify potential intervention and prevention strategies. Methods: We recruited 250 speech therapists who used face masks daily for work at the time of the study (August-September 2021). Participants completed a self-assessment voice questionnaire, which included the Voice Fatigue Index (VFI), and provided information on demographic data, type of mask used, average time and method of use, symptoms, and any sensory deficits perceived as related to mask usage. Subsequently, participants received a handbook containing vocal hygiene guidelines to follow for one month. After this period, the self-assessment voice questionnaire was administered again.
Results: 111 speech therapists completed the study and responded to the second questionnaire. Results showed an improvement in phonasthenia and reported symptoms following the adherence to vocal hygiene standards. In particular, there was a statistically significant improvement in VFI scores in both the first and second parts. Concerning symptoms, a significant reduction was observed in both perceptual and sensory symptoms during the second questionnaire administration, particularly in phonasthenia, dryness of the mouth, air hunger, difficulty in communication, and oral breathing/sensation of a blocked nose.
Conclusion: The use of face masks has a substantial impact on vocal emission, and incorporating simple vocal hygiene practices into daily routines can be a valuable preventive measure for improving phonasthenia and reported symptoms. Further specific studies are needed for different job tasks and work environments to determine appropriate voice protection tools for diverse contexts.

Keywords*: Covid-19, Voice, Phonastenia, Dysphonia, Voice Disorders, DPI*

1. Introduction

The COVID-19 pandemic has brought significant changes to our daily life habits and clinical practice (Castillo-Allendes et al. 2021), particularly through the introduction of personal protective equipment (Doll et al. 2021).

The use of the masks, a fundamental precaution to safeguard our health and that of others, has inevitably led to changes in our vocal behavior and communication (Julka-Anderson 2020).

Numerous studies conducted during the pandemic in healthcare settings have illustrated the implications of mask use on communication.

In particular, a compromise of the vocal signal emerges, especially with regard to the

transmission of some frequencies (mostly mid-high), resulting in compromised speech intellegibility and the need to speak at high intensity (Magee et al. 2020; Porschmann et al. 2020; Hampton et al. 2019).

Further studies conducted on healthcare workers have correlated the number of working hours, daily mask use hours, simultaneous use of multiple facial filters and the belonging to medium or high risk units with the presence of vocal disorders (Muzzi et al. 2021). Heider et al., in a study conducted in 2020 to determine the prevalence and risk factors associated with vocal disorders in 221 healthcare workers, found that a high number of working hours, numerous daily mask use hours, simultaneous use of surgical and FFP2 masks and working in intensive care units are independently correlated variables statistically significantly associated with higher VHI-10 scores (Heider et al. 2021).

This study aims to investigate the effects of prolonged mask use on vocal emission, particularly with regard to vocal fatigue, in a sample of healthcare professionals (speech therapists), proposing possible intervention and prevention tools for voice preservation. Specifically, a handbook containing some vocal hygiene rules was prepared and distributed to the participants.

The study's objective was to determine whether observing these principles daily for a month resulted in an improvement in phonasthenia.

To our knowledge, this is the first study that, in addition to studying the effects of masks on the voice, focuses on vocal fatigue and proposes practical prevention tools.

2. Materials and Methods

This non-controlled trial before-after study was conducted by the Gruppo Italiano Vocologi Clinici (GIVoC).

Participants were recruited through convenience non-probabilistic sampling. A sample of 250 speech therapists aged between 18 and 65 years, from different Italian cities, was selected. All participants were daily mask users due to their work at the time of the study.

The choice to conduct the study on speech therapists was dictated by the easier accessibility, relatively homogeneous vocal effort and reliability of judgment on perceptual voice characteristics.

Due to the distancing rules imposed by the COVID-19 pandemic, participant recruitment was carried out through email.

The study was conducted in Italy in the period between April and September 2021. In August 2021, a voice self-assessment questionnaire was sent via e-mail divided into two parts to be answered through the Google Forms platform.

The first part contained descriptive information: age range, gender and symptoms associated with mask use (such as hypoarticulation, stiffness in the shoulders and neck, phonasthenia, aphonia, air hunger, dry mouth, hoarseness and sensory deficits such as hearing loss, visual deficits, inflammation of the throat, and olfactory deficits).

The second part consisted of the Voice Fatigue Index (VFI), a self-assessment questionnaire to quantify vocal fatigue, consisting of 19 items and divided into three parts: the first (VFI1) regarding phonasthenia and vocal avoidance, the second (VFI2) concerning physical symptoms related to voice use and the third (VFI3) on symptom improvement after a period of rest.

Scores for each question range from 0 to 4 and are related to the frequency of symptoms (0-never, 1-almost never, 2-sometimes, 3-almost always, 4-always). VFI scores ≥24 for the first part and ≥7 for the second part are indicative of vocal fatigue. A score ≤7 for the third part indicates that vocal fatigue does not improve with rest.

A vademecum, designed by voice experts belonging to the GIVoC, containing some vocal hygiene rules to be observed daily for a month, was sent to the 157 participants who responded to the questionnaire. Specifically, the vademecum contained exercises and indications regarding hydration, costal-diaphragmatic breathing, stretching and muscle relaxation, posture and articulation (see Appendix 1):

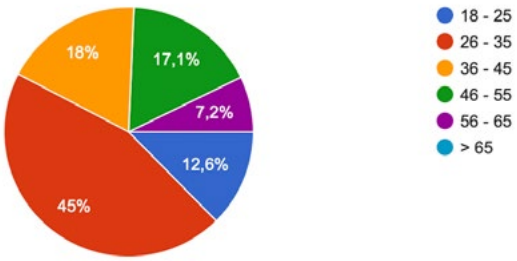
- perform stretching exercises with rotational, torsion and lateralization movements, to relieve neck and shoulders contraction;
- perform rotational and lateralization movements of the jaw, trying to main-

tain good postural alignment to improve articulation;
- maintain sufficient hydration of the upper respiratory tract, drinking at least 2 liters of water a day;
- favor the hydration of the nasal mucosa through nasal lavage with isotonic/hyaluronic acid solution;
- perform breathing exercises to restore good diaphragmatic coordination;
- de-fatigue the larynx with Roman chamomile fumigations.

After one month (September 2021) the questionnaire was sent again to the participants.

A total of 250 speech therapists were recruited, with no distinction of gender and professional experience. Among them, 157 responded to the first questionnaire but only 111 completed the process by answering both questionnaires, becoming part of the effective statistic sample (n=111), which consisted of 102 females (91,9%) and 9 males (8,1%). Age was distributed in bands as follows: 14 subjects (12,6%) aged between 18 and 25 years; 50 subjects (45%) aged between 26 and 35 years; 20 subects (18%) aged between 36 and 45 years; 19 subjects (17,1%) aged between 46 and 55 years; 8 subjects (7,2%) aged between 56 and 65 years. (fig. 1)

Figure 1. Statistic sample's age bands distribution



To investigate the specific variation in VFI values (particularly VFI_3, which is the component related to improvement in symptoms after rest) before and after the implementation of vocal hygiene principles, we isolated additional subgroups from the sample and conducted the same statistical analysis on them as we did on the entire sample:

- *Sub 1*: subjects with VFI1 and/or VFI2 pre-vademecum above the cut off (but not necessarily reporting the symptom of "phonasthenia") (n_{sub1} = 51);
- *Sub 2*: subjects with VFI1 and/or VFI2 pre-vademecum above the cut off who also reported phonasthenia (n_{sub2} = 23);
- *Sub 3*: subjects with VFI1 and/or VFI2 pre-vademecum within the cut off (n_{sub3} = 13).

Data were collected using Microsoft Excel (Version 16.65 for Mac, Microsoft, Redmond, WA, USA), by comparing questionnaire data before and after the adoption of vocal hygiene standards.

Statistical Analysis

Both for the whole sample and for all subgroups, mean and standard deviation (SD) for each of the three parts of the VFI were calculated for pre- and post- vademecum administration values, in order to make a comparison between before and after vocal hygiene principles implementation.

Kolmogorov-Smirnov test was used to study the normality of the distributions. A Wilcoxon signed rank test for means or a paired t test for means was used to detect statistical differences between measurements before and after exercise both in the experimental and in the control group.

An alpha of 0.05 was considered for the statistical procedures. Statistical analysis was carried out with GraphPad InStat software (Version 3.06 for Windows, San Diego, CA, USA).

3. Result

Comparison between pre- and post-vademecum VFI for the full sample showed significant statistical differences for VFI_1 ($p < 0,0001$) and VFI_2 ($p = 0,002$) mean values; VFI_3 showed no significant differences between pre- and post-vademecum ($p = 0,57$) (table 1).

Concerning *Sub1*, comparison between pre- and post-vademecum VFI showed significant statistical differences for VFI_1 ($p = 0,0001$) and VFI_2 ($p = 0,0001$) mean values; VFI_3 showed

no significant differences between pre- and post-vademecum mean values (p = 0,14) (table 1).

Concerning *Sub2*, comparison between pre- and post-vademecum VFI showed significant statistical differences for VFI_1 (p = 0,02) and VFI_2 (p = 0,03) mean values; VFI_3 showed no significant differences between pre- and post-vademecum mean values (p = 0,54) (table 1).

Concerning *Sub3*, comparison between pre- and post-vademecum VFI showed significant statistical differences for VFI_1 (p = 0,03); VFI_2 (p = 0,40) and VFI_3 (p = 0,23) showed no significant differences between pre- and post-vademecum mean values (table 1).

For what concerns self-assessment, comparison between symptoms perceived following the use of mask before and after vademecum observation are reported in fig 2-5.

Table 1. Means and SD of VFI parts before and after the introduction of vocal hygiene principles in whole group and subgroups.

	Voice Fatigue Index part	Pre-Vademecum Mean and SD	Post-Vademecum Mean and SD	P value*
Whole group (n = 111)	VFI_1	17,49 ± 8,92	14,63 ± 9,10	<0,0001†
	VFI_2	6,07 ± 4,80	4,97 ± 4,05	0,002†
	VFI_3	7,60 ± 3,30	7,33 ± 3,28	0,57
Subgroup 1 - *Sub 1* (n_{sub1} = 51)	VFI_1	23,35 ± 7,37	19,37 ± 8,80	0,0001†
	VFI_2	9,96 ± 3,62	7,10 ± 3,88	<0,0001†
	VFI_3	9,00 ± 2,40	8,08 ± 2,89	0,1443
Subgroup 2 - *Sub 2* (n_{sub2} = 23)	VFI_1	24,78 ± 6,49	20,87 ± 9,51	0,0170†
	VFI_2	9,09 ± 3,33	7,35 ± 4,22	0,0348†
	VFI_3	8,65 ± 1,85	8,35 ± 2,72	0,5399
Subgroup 3 - *Sub 3* (n_{sub3} = 13)	VFI_1	18,85 ± 7,29	14,77 ± 4,85	0,0330†
	VFI_2	4,38 ± 4,17	3,38 ± 2,36	0,4100
	VFI_3	9,77 ± 1,36	8,77 ± 3,14	0,2355

** Wilcoxon Signed Rank Test / paired t test †Significance*

Figure 2. Symptoms reported following the use of masks before the implementation of vocal hygiene principles (survey 1)

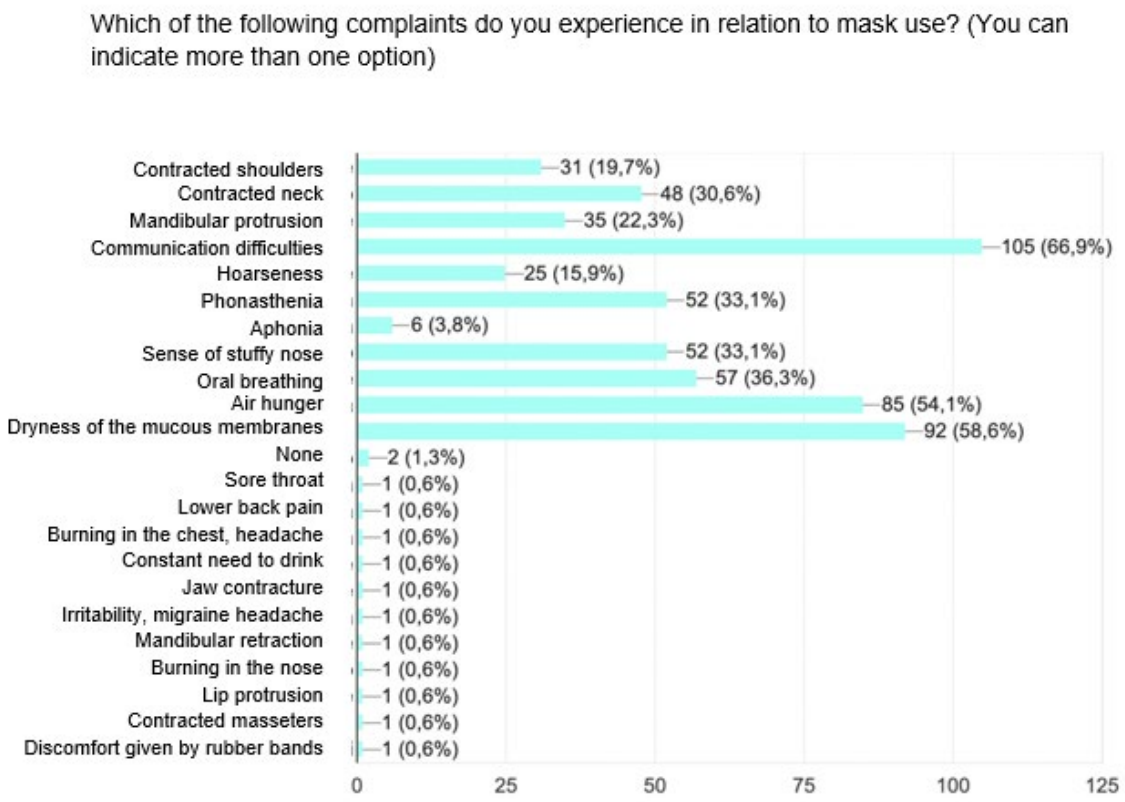


Figure 3. Symptoms reported following the use of masks after the introduction of vocal hygiene principles (survey 2)

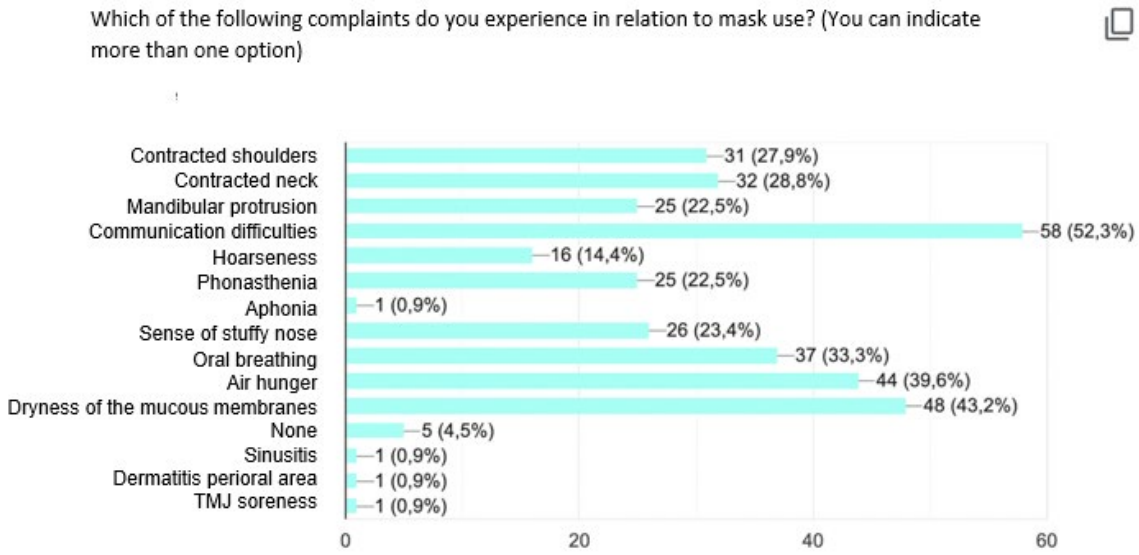


Figure 4. Sensory deficits reported following the use of masks before the introduction of vocal hygiene principles (survey 1)

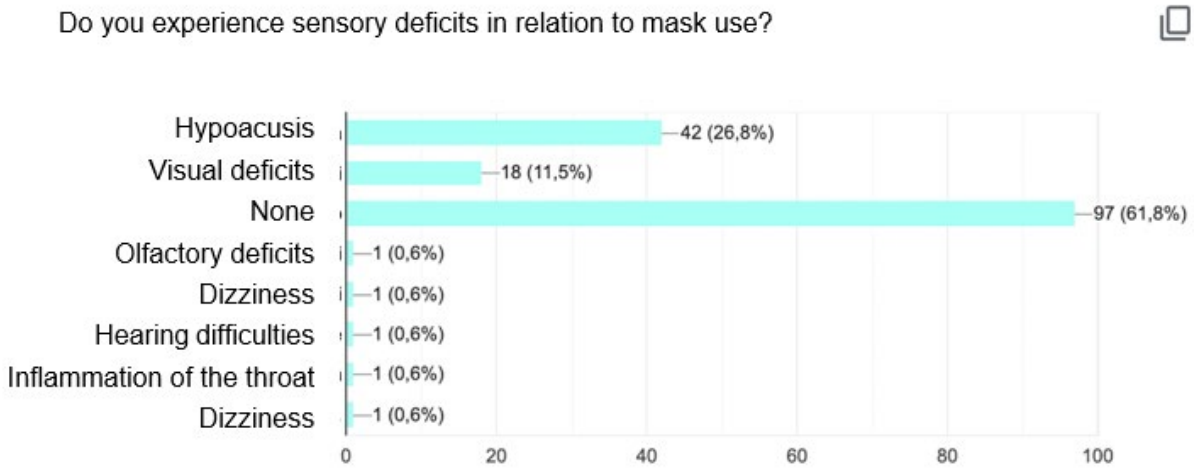
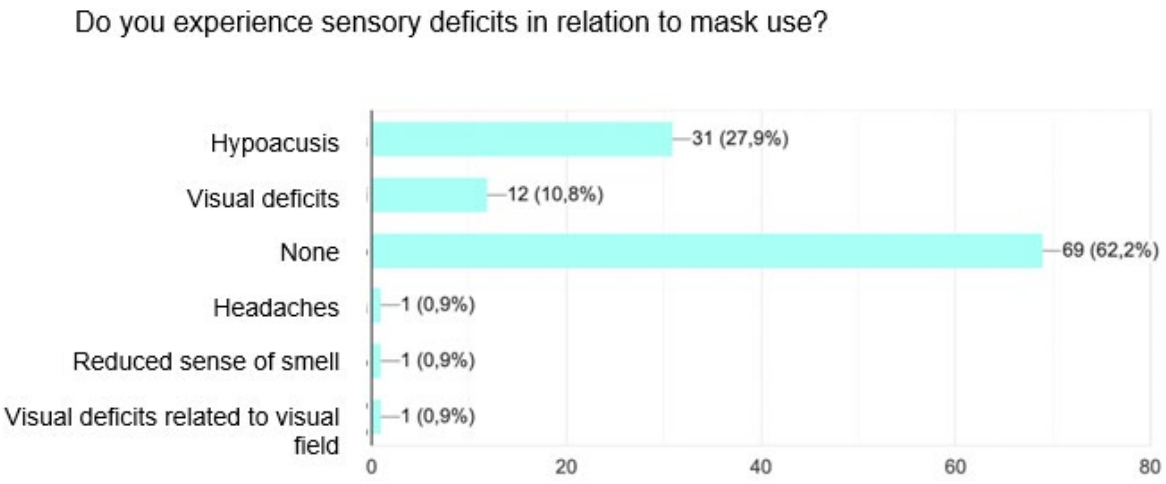


Figure 5. Sensory deficits reported following the use of masks after the introduction of vocal hygiene principles (survey 2)



4. Discussion

Our vocal habits have suddenly changed due to the COVID-19 emergency.

Previous studies have shown that the use of mask has resulted in significant changes in vocal behavior and communication due to the different transmission of some frequencies and different directionality of the acoustic signal.

Muzzi et al. in 2020 highlighted that the use of facial personal protective equipment (PPE) causes significant difficulties in verbal communication: the use of PPE compromises the transmission of medium-high voice frequencies, affecting speech intelligibility. Specifically, there is a loss of speech intelligibility in noisy environments ranging from 23.3% to 69% depending on the type of PPE used (Muzzi et al, 2021).

The study by Porschmann et al. in 2020, which investigated the impact of masks on voice radiation, showed a frequency-dependent loss of transmission above 2kHz with

a consequent impairment of speech intelligibility. Moreover, the use of the masks affects the directionality of the acoustic signal (Porschmann et al. 2020).

Another study (Magee et al. 2020) investigated the effects of wearing masks on acoustic analysis and perceived intelligibility, observing significant differences in the distribution of acoustic power at frequencies above 3kHz and a reduction in intelligibility with all types of masks analysed.

Along these lines, in a prospective study using questionnaires (the Vocal Tract Discomfort Scale and the Mini-SCL scale) and the collection of vocal symptoms, Schuster et al. found that psychological problems, somatization, and vocal tract discomfort were more frequently reported by caregivers of the elderly than in the normal population (Schuster et al. 2022). Training on vocal hygiene should be included in workplace health promotion during the pandemic.

Furthermore, an association has been found between mask use and an increase in vocal disorders. Hampton et al., in 2020 highlighted how wearing PPE can impact communication in healthcare settings, emphasizing that an increase in voice intensity for prolonged periods can lead to vocal strain and abuse (Hampton et al. 2020).

Heider et al., in a study conducted in 2020 on 221 healthcare workers, found that approximately 33% of the sample reported voice problems during the month in which the study was conducted, as measured by the Voice Handicap Index-10 (VHI-10). Additionally, the study found a prevalence of 26.24% of vocal disorders in the population of healthcare workers examined.

In 2022 Hamdan et al. evaluated the impact of face masks on voice in a sub-population of healthcare workers using a web-based questionnaire including VHI-10 and the visual analogue scale for vocal effort and vocal fatigue. In line with what was reported by Heider et al., they found that out of 178 participants, one third had an abnormal score on the VHI-10 questionnaire, one third reported moderate to severe vocal fatigue, and 45% of the participants had moderate to severe vocal effort based on a visual analogue scale score. Also, there was a significant association between the type of mask used and vocal fatigue, while no significant association was seen between the duration of mask used and the different voice outcome measures (Hamdan et al. 2022).

On the other hand, a recent longitudinal study assessed the effects of longterm-use of surgical face masks on acoustic and auditory-perceptual voice parameters in normophonic subjects. 25 people who were previously included in a couple of studies before the COVID-19 outbreak were re-evaluated to assess the long-term effect of surgical face mask on voice. The data in this study, revealed that long-term use of surgical face masks (SFM) would not appear to be negatively affecting the acoustic parameters of the voice in normophonic subjects (particularly females) without any related risk factors such as tobacco use, reflux, etc. (Tunç-Songur et al. 2023).

This study aimed to investigate whether adhering to vocal hygiene norms for one month could promote an improvement in vocal disorders associated with the use of masks. To the best of our knowledge, at the time it was carried out, this was the first study aimed at proposing practical prevention strategies for voice disorders due to long-term mask use in healthcare professionals.

The results showed a general improvement in phonasthenia and reported symptoms, with a percentage reduction in almost all the symptoms considered in the questionnaire (Figures 2-3) following the adoption of vocal hygiene principles, especially regarding phonasthenia, dry throat, air hunger, communication difficult and mouth breathing/nasal congestion. The perceived sensory deficits remained almost unchanged in percentage terms (Figures 4-5).

In particular, a statistically significant improvement was observed in the scores of both the first and second parts of the VFI (VFI1 and VFI2) after adhering to vocal hygiene norms, both for the overall group and all subgroups, except for Sub3. Sub3, which consisted of subjects complaining of phonasthenia despite having normal VFI1 and VFI2 values, exhibited a reduction in VFI2 scores that did not reach statistical significance.

It is possible that this statistical discrepancy is precisely due to the method of sample selection (which initially showed reduced VFI2

values within the cut-off) or to the small sample size (n_{sub3} = 13).

The third part of the VFI (VFI3) did not show statistically significant differences in the comparison between pre- and post-handbook, although an improvement in values was recorded in all groups and subgroups. However, it is interesting to note that in the Sub1 and Sub3 (respectively consisting of subjects with pre-vademecum altered VFI1 and/or VFI2 and subjects who reported phonasthenia with normal VFI1 and/or VFI2), the p value for the comparison between pre- and post-handbook VFI3 was lower than in the whole group, although not reaching statistical significance in any case.

This could hypothetically indicate, with reference to Sub3, that a more accurate selection of subjects to whom the VFI is administered (e.g., limiting it to subjects who complain of phonasthenia) could improve its sensitivity; likewise, with reference to Sub1, it is conceivable that making the completion of VFI3 (related to the improvement of phonasthenia after rest) exclusive to those who reach the cut-off in one of the first two parts could improve its sensitivity. These preliminary hypotheses about possible improvements to be applied to the VFI are, in our opinion, an interesting topic for future investigations.

Conclusions

The use of face masks has a significant impact on vocal emission: the mask reduces the auditory feedback of the voice and the intelligibility of speech and consequently modifies the vocal and communicative behavior, leading to the onset of vocal disorders.

This study highlights a significant improvement in phonasthenia after adherence to the vocal hygiene protocol we proposed for one month. Adequate daily vocal hygiene can therefore be a valid tool for preventing and treating vocal disorders caused by prolonged use of face masks in healthcare professionals. However, the generalization of this finding is limited by the inclusion of only speech therapists in our sample. Additionally, the responsiveness of the sample to the second questionnaire was limited and we are unaware of the actual compliance of the subjects to the given norms.

Future studies on vocal variations in different environments appear necessary in order to provide appropriate vocal safeguard tools in various contexts.

Conflict of Interest

No potential conflict of interest was reported by the authors.

References

Castillo-Allendes A, Contreras-Rouston F, Cantor-Cutiva LC, Codino J, Guzman M, Malebran C, Manzano C, Pavez A, Vaiano T, Wilder F, Behlau M. (2021) "Voice Therapy in the context of the COVID-19 pandemic: guidelines for clinical practice." J Voice; 35(5):717-727.

Doll EJ, Braden M, Thibeault S. (2021) "COVID-19 and speech language pathology clinical practice of voice and upper airway disorders." Am J Speech-Lang Pat.; 30(1):63-74.

Hamdan AL, Jabbour C, Ghanem A, Ghanem P. (2022) "The Impact of Masking Habits on Voice in a Sub-population of Healthcare Workers." J Voice. Jan 2:S0892-1997(21)00380-5.

Hampton T, Crunkhorn R, Lowe N, Bhat J, Hogg E, Afifi W, De S, Street I, Sharma R, Krishnan M, Clarke R, Dasgupta S, Ratnayake S, Sharma S. (2019) "The negative impact of wearing personal protective equipment on communication during coronavirus disease." J Laryngl Otol. 2020; 134:577-581.

Heider CA, Alvarez ML, Fuentes-Lopez E, Gonzalez CA, Leon NI, Verastegui DC, Badia PI, Napolitano CA. (2021) "Prevalence of voice disorders in healthcare workers in the universal masking COVID-19 era." Laryngoscope; 131(4):E1227-E1233.

Julka-Anderson N. “How COVID-19 is testing and evolving our communication skills.” (2020) J Med Imaging Radiat Sci.; 51(4S):S11-S13.

Magee M, Lewis C, Noffs G, Reece H, Chan J, Zaga C, Paynter C, Birchall O, Rojas Azocar S, Ediriweera A, Kenyon K, Caverlè MW, Schultz BG, Vogel AP. “Effects of face masks on acoustic analysis and speech perception: implications for peri-pandemic protocols.” (2020) J Acoust Soc Am.; 148 (6): 3562-3568.

Muzzi E, Chermaz C, Castro V, Zaninoni M, Saksida A, Orzan E. “Short report on the effects of SARS-CoV-2 face protective equipment on verbal communication.” (2021) Eur Arch Otorhinolaryngol.; 278(9):3565-3570.

Porschmann C, Lubeck T, Arend JM. “Impact of face masks on voice radiation.” (2020) J Acoust Soc Am.; 148 (6): 3663-3670.

Schuster M, Deitmerg U, Gantner S. “Vokaltraktbeschwerden und Gesundheitserleben von Pflegenden in Senioreneinrichtungen in der Pandemie [Vocal tract discomfort and wellbeing of caregivers for the elderly during the pandemic].” (2022) Laryngorhinootologie. Oct;101(10):797-804.

Tunç-Songur E, Gölaç H, Önen Ç, Duyar TR, Yılmaz M, Kemaloğlu YK. “How Does Long Term Use of Surgical Face Mask Affect the Voice in Normophonic Subjects?” (2023) J Voice. Mar 11:S0892-1997(23)00037-1.