Dysphonia Severity Index and Consensus Auditory-Perceptual Evaluation of Voice Outcomes, and Their Relation in Hospitalized Patients with COVID-19

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Abstract:

Objectives: This study aimed to compare the results of the Dysphonia Severity Index (DSI) and Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) between patients hospitalized with COVID-19 and healthy subjects, as well as to investigate the correlation between DSI and CAPE-V.

Study design: Cross-sectional survey.

Material and methods: Eighty subjects, 40 COVID-19 patients (with a mean age of 41.2± 5.41) and 40 healthy subjects (with a mean age of 44.50± 3.50) participated in this study. Assessments included the DSI for aerodynamic-acoustic measurement and the Persian version of CAPE-V for evaluating auditory-perceptual voice quality. Data were analyzed by means of the independent t-test and Pearson correlation at the 5% significance level.

Results: The results showed COVID-19 patients got significantly lower score in DSI compared to healthy subjects (P < 0.05). Moreover, the patients with COVID-19 had higher scores in all categories of voice production (severity, roughness, loudness, pitch, strain and breathiness) than the healthy group (P < 0.05). Comparing the result of the two voice assessments in each group revealed that there was a greater negative significant correlation in the diseased group (r_p: -0.68, p: 0.001) than in the healthy group (r_p: -0.37, p: 0.049).

Conclusion: Hospitalized COVID-19 patients experience deviations in the voice quality and acoustic-aerodynamic features of their voice. Also, the results of this study showed the patient group had higher perceptual dysphonia and lower voice quality compared to the healthy group. Further studies are recommended to determine the relationship between objective and subjective voice evaluation in patients with COVID-19 after recovery.

Keywords: COVID-19, dysphonia, Dysphonia severity index (DSI), Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V), Voice
Introduction

COVID-19 is a high-risk infectious disease caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-COV-2) which has been affecting the world since 2019. It has been becoming one of the most challenging problems the world has faced in the recent decade (1-3). Among all of the COVID-19 symptoms, 57.4% of infected patients experience destructive effects on structures that are involved in voice production such as the lung, larynx, nose, and throat (4-6). According to previous studies, voice complaints especially dysphonia can be present in about 43.7% of COVID-19 patients; this prevalence was reported at 71.4% in hospitalized patients (7, 8).

Optimal voice requires precise coordination and interaction between all subsystems of phonation, including the power system, voice source, and sound resonator (Herbst, 2017)(9-12). COVID-19 can cause voice disorders in three possible ways (13, 14). The first theory is about the direct entry of the SARS-COV-2 pathogens into the larynx tissue and connecting to a specific receptor which can lead to tissue inflammation (15-17). The second theory minds the patients who need to be intubated due to COVID-19 and the injury and irritation of vocal folds after intubation is one of the consequences (8). The last theory states that the viral neuropathies that have been seen in patients infected with COVID-19 that impact both the recurrent laryngeal nerve and the superior laryngeal nerve, so as a result dysphonia can be expected (18). So that due to the mentioned hypothesizes, COVID-19 can cause direct damage to the vocal tract, larynx, and vocal cords, and leading to changes in their functioning (5, 10, 15-18). As a result, dysphonia, limitation in loudness, pitch, harshness, and breathiness occur; therefore, voice quality deteriorates in COVID-19 patients (5, 10). The impact of COVID-19 on the

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1 Severe Acute Respiratory Syndrome Coronavirus 2
respiratory system can include lung infection, pneumonia, and reduced respiratory volume, as well as acute respiratory distress syndrome (19, 20). Changes in lung function secondary to respiratory tract infections commonly seen in patients with COVID-19 can lead to reduced respiratory support for voice and speech; This impact on voice production is recognized in mild-to-severe cases of COVID-19 and is evidenced by the voice assessment outcomes performed in this and similar studies (21-23). For instance, inadequate airflow increased aperiodicity, and signal perturbation are examples of these affected aspects (24).

Voice production and subsequent vocal quality are influenced by many factors (25, 26). Neurological, medical, and structural deviations in the vocal tract, larynx and respiratory function, inappropriate use of voice, and also psychological issues are the factors that can cause voice disorder (27). The mentioned factors are evaluated with the diagnostic assessments such as interview, medical examination, self-evaluation, auditory perceptual assessments, aerodynamic-acoustic, and vocal folds’ functional evaluation (27). In studies related to COVID-19 the voice of the patients assessed with different voice evaluations; such as auditory-perceptual assessments (CAPE-V1 and GRBAS2) (24, 28, 29), self-report voice questionnaires such as VTD3 and VHI-104 (28, 30), aerodynamic assessments(S/Z ratio and MPT5) (31), and acoustic voice analyses like shimmer, HNR, H1H2, CPP, and jitter(12, 32). The use of complimentary voice assessments, e.g., auditory-perceptual and acoustic-aerodynamic measurements, improves the quality of clinical information and allows for a more comprehensive treatment plan (33, 34).

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1 Consensus Auditory-Perceptual Evaluation of Voice  
2 Grade, Roughness, Breathiness, Asthenia, Strain  
3 Vocal Tract Discomfort  
4 Voice Handicap Index-10  
5 Maximum Phonation Time
The Dysphonia Severity Index (DSI\(^1\)) is a popular objective voice assessment tool among voice therapists because it measures multiple parameters of voice production. (35-37). On the other hand, the auditory-perceptual assessment tools are known as the commonly methods that are done quickly and are available such as the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) or GRBAS (26, 38). These voice assessments are auditory-perceptual subjective judgments of voice quality based on the opinion of voice therapists (38). CAPE-V seems to be more sensitive to small changes compared to the GRBAS (39, 40). However, rater’s experience is a crucial element for increasing accuracy of auditory voice assessments. Consequently, the use of objective instruments such as multi-parametric voice formulas is suggested to cover the limitations of auditory-perceptual evaluation of voice (38, 41). Some studies confirmed the correlation between objective with subjective voice assessments in patients with voice disorders and healthy speakers (35, 42-44).

The previous studies revealed a significant difference between various aspects of voice quality in COVID-19 patients and healthy people (10, 12, 24, 30). All of them have shown that the disease could damage various dimensions of voice after recovering from the COVID-19 infection (10, 32, 45-47), but few studies were conducted during the bedridden period of these patients in the hospital (24, 28, 29). In this study, we intend to examine the effect of COVID-19 infection on the different aspects of voice by implementing DSI and CAPE-V in patients during their bedridden time in the hospital. Then, we would determine DSI and CAPE-V in the COVID-19 patients versus healthy subjects. This is the first study to investigate the correlation between subjective (CAPE-V) and objective voice analysis (DSI) in

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\(^1\) Dysphonia Severity Index
hospitalized patients with COVID-19 infection that can hold a remarkable contribution to the various voice assessments utilized for these patients.

MATERIALS AND METHODS

Ethical consideration

This study was a cross-sectional analytic study. All participants completed the consent form before data collection. The study was approved by the Ethics Committee affiliated with the Rehabilitation Faculty at Tehran University of Medical Sciences (IR.TUMS.FNM.REC.1399.169).

Participants

Eighty subjects, 40 patients with positive laboratory-confirmed COVID-19 (with a mean age of 41.2±5.41), and 40 healthy subjects (with a mean age of 44.50±3.50) participated in the present study. Each group had 27 men and 13 women. The inclusion criteria for the subjects were as follows: adults who have no previous history of voice disorders, no history of respiratory disorders, and no history of allergy, hearing loss, endocrine diseases, neurologic disorders, and addiction. Moreover, getting a COVID-19 diagnosis (mild to moderate) in the patients' group and negative results for healthy subjects was required. Individuals who were not willing to participate in voice assessment, females who had menstrual periods, and patients with severe COVID-19 who could not cooperate because they were in the ICU at the time of the study were excluded. COVID-19-positive patients in this study were those who were admitted to the Shahid Beheshti and Amiralam hospitals in Iran. Patients were evaluated after being in the hospital for at least three to five days (with a mean of 4.3±1.8 days) and being able to participate in the study. The current study only included patients with mild to moderate COVID-19. To be more exact,
the clinical symptoms of these patients vary from mild complications, negative pneumonia signs in imaging, to vocal tract infection, pneumonia symptoms, and fever in moderate patients (48). Also, the COVID-19 patients did not experience failure in respiration; so, they did not need mechanical ventilation. A PCR and a chest computed tomographic (CT\(^1\)) scans are typical tests for diagnosing COVID-19, according to the World Health Organization's (WHO) guidelines. The CT scan is usually the first diagnosis technique that is performed for patients suspicious of COVID-19 is performed for and a positive PCR result validated the COVID-19 diagnosis following the CT scan. All of the COVID-19 participants had positive PCR test after getting CT results suspicious of COVID-19. Healthy subjects matched according to age and gender were volunteers from the staff of Amiralam hospital and Tehran University of medical sciences.

**Procedure and Assessments**

In the first, demographic data and medical history were gathered by interview. After detecting subjects with inclusion criteria in the COVID-19 group and also in the healthy group, voice sampling was done in a quiet room with a noise level lower than 40 dB (49). We used a Zoom H5 microphone (frequency response 5 Hz to 20 kHz) for voice sampling (24 bits, and 44.1 kHz sampling rate). The microphone was placed at a distance of 5 to 10 cm at a 45° angle from the patient’s mouth. The necessary explanation for data gathering was explained orally and the sampling procedure was performed considering health protocols to avoid SARS-COV2 transmission. Before the initiation of recording the voice samples, an examiner that was an SLP modeled the tasks for the subjects. Finally, the recorded voice samples,

\(^1\) Computed Tomographic
which were collected for analyses of auditory-perceptual, acoustic, and aerodynamic assessments, were transferred to a laptop (Acer Aspire E 14). These data were analyzed with Praat software (version 6.0.39).

**Acoustic-aerodynamic assessment**

Another voice sampling was performed for evaluating the acoustic and aerodynamic measures to determine the DSI score (35). DSI is a multi-parametric voice assessment that can be an indicator of voice quality as it is affected by acoustic and aerodynamic characteristics. After analyzing the voice samples, acoustic and aerodynamic features including the highest frequency\(^1\) (Hz), lowest intensity\(^2\) (dB), MPT (seconds), and jitter (%) were extracted according to the instructions of the DSI scale. All acoustic and aerodynamic measures were assessed and analyzed with the Praat software version 6.0.39 (50). To perform all of these analyses, each task was performed three times and the best result was selected and reported by Praat software.

For obtaining MPT, the patients were asked to produce /a/ continually after a deep inhalation for as long as possible in the sitting position as a part of the aerodynamic examination. For calculating F\(_0\)-High, we explain the instructions to the patients; to produce /a/ sustainably by raising the frequency from normal to as high as possible without changing the intensity of their voice for 5 seconds. The patients performed the maneuver, and then we recorded the voice sample and analyzed them. Finally, for I-Low and Jitter, we first ask them to produce sustained vowel /a/ as comfortable and soft as possible for 5 seconds. After recording the samples, the first second of every sample was extracted and the middle 3 seconds of each voice sample were analyzed with Praat software. The best result of each

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1. F\(_0\)-High
2. I-Low
acoustic and aerodynamic assessment in three trials of a patient was placed in the DSI formula: \[ DSI = 0.13 \times MPT + (0.0053 \times F_0 \text{ High}) - (0.26 \times I \text{ Low}) - (1.18 \times Jitter \%) + 12.4 \] and ultimately the overall score was determined. According to the study by Wuyts et al. (2000) the score of DSI is between +5 to -5 and the score of +5 represents the normal voice and -5 determines severe dysphonia (35, 51).

**Auditory-perceptual assessment**

In this study, an auditory-perceptual assessment of voice was performed using the Persian version of CAPE-V\(^1\) (52). This questionnaire is a perceptual clinician-based judgment of voice quality. According to the CAPE-V\(_P\) protocol, three tasks including producing sustained vowels /a/ and /i/ for 3 to 5 seconds, reading six valid sentences, and narrative speech were assessed (52). The audio files were gathered and transferred to the laptop. The files were randomized and then sent to two experienced voice therapists with more than 7 years of experience in voice therapy and familiar with CAPE-V\(_P\) scoring, who determined CAPE-V\(_P\) evaluation points in total and subtest of them blindly. The raters gave 6 scores from 0 to 100 for CAPE-V\(_P\) subtests including overall severity, roughness, loudness, pitch, strain, and breathiness of voice quality. A score of 0 indicates normal voice, and the level of dysphonia increases as the CAPE-V\(_P\) points rise (1-9 mild dysphonia, 10-59 moderate dysphonia, 60-100 severe dysphonia) (24). The evaluators marked a dot on a one-hundred-millimeter horizontal line, the closer the mark was to the end of the line and 100, the more severe the dysphonia was. The raters gave scores to each participant in a quiet room using headphones set at a comfortable volume level of 40 dB hearing level. As we noted above, scoring in this section was done blindly. After determining the scores of all parts of CAPE-V\(_P\) by two evaluators; 25% of the samples were randomized and sent to themselves again to score, and in this way, we

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\(^1\) CAPE-V\(_P\)
calculated the intra-rater reliability for each evaluator separately. This process was done to ensure the accuracy of the auditory perceptual evaluation data and the reliability of the auditory-perceptual assessment. In the end, the results of the evaluator who had the highest intra-rater reliability index were selected as the final score of the CAPE-V_p assessment (r: 0.86%). The results were analyzed by Pearson’s correlation coefficient in SPSS software.

**Statistical analysis**

In this study, descriptive statistical analysis has utilized for the determination of the frequency, standard deviation, and mean of the variables. To evaluate the normal distribution of the variables the *Kolmogorov Smirnov* test was used. An independent Sample T-Test was used to compare the results of CAPE-V and DSI between the two groups. *Pearson* correlation coefficient was used for determining of correlation between the total score of DSI and CAPE-V_p in both groups. The *SPSS* software (version 22; *SPSS* Inc, Chicago, IL) was used for statistical analysis and the level of significance was set at $p \leq 0.05$ with a 95% interval confidence which is considered statistically significant.

**Results**

In this study, we assessed eighty subjects (with a mean age of 42.76± 4.88 years) in two groups including COVID-19 and healthy subjects. Also, the *Kolmogorov Smirnov* test demonstrated the normal distribution of data in two groups ($p > 0.05$). The demographic data are presented in Table 1.

Table 1 here.

Considering Table 1, Participants were matched in the age and sex in both groups by an independent t-test.
Furthermore, the analysis results of the DSI score and its components in the two groups of this study are shown in table 3 in detail and compared between COVID-19 patients and healthy subjects.

In table 2 the mean± SD of the total score of DSI was 0.40±0.94 in COVID-19 patients and 3.65±0.86 in healthy subjects. As presented in Table 3, the mean scores of the F0-high, MPT, and DSI were lower in the COVID-19 patients than in the healthy group. Also, I-low and jitter were higher in the COVID-19 patients than in healthy subjects (p≤0.00). As we see, there was a significant difference between the participants of the two groups regarding the DSI and its components (p≤0.00).

The results of subtests and total score of CAPE-V_p assessment were analyzed by independent sample T-test and reported in Table 3 in two groups separately.

The result of Table 3, showed that the overall score of CAPE-V_p in COVID-19 patients and healthy participants were 62.7±17.94 and 24.65±6.86 (mean± SD) respectively. In conclusion, as shown in Table 2, there was a significant difference in the results of the overall CAPE-V_p score and its subtests including roughness, loudness, pitch, strain, and breathiness between the two groups of patients with COVID-19 and healthy individuals (p<0.005).

Finally, the correlation between the total scores of DSI and CAPE-V_p was assessed in two groups separately. Pearson correlation analysis revealed a significant correlation between the DSI and severity of CAPE-V_p in the COVID-19
infected group ($r_{Pearson} = -0.68, \ p = 0.001$); on the contrary, the correlation in the healthy group between DSI score and total score of CAPE-\(V_p\) was relatively lower ($r_{Pearson} = -0.37, \ p = 0.049$).

**Discussion**

In this study, we investigated the effect of COVID-19 on acoustic and perceptual voice assessment with the DSI formula and CAPE-\(V_p\) scale. Also, we intended to determine the correlation between these objective and subjective voice assessments in COVID-19 patients and healthy subjects. After analyzing the tests’ results it was evident that SARS-COV-2 affected DSI and CAPE-\(V_p\) scores notably in the patients’ group in comparison to the healthy group. Moreover, a remarkable correlation was illustrated between the total scores of DSI and CAPE-\(V_p\) in both groups of study, although the COVID-19 group had a greater negative relationship comparing the healthy group.

In this study, the DSI formula was used as a multi-parametric measurement of acoustic and aerodynamic features of voice. As mentioned before, this multi-parametric measurement is a score that represents objective voice quality as it combines acoustic and aerodynamic parameters (35, 53). This study showed that the total score of DSI and its components (MPT, F0-high, I-low, jitter) were harmed statistically significant ($P \leq 0.05$) during the infection period in the COVID-19 inpatient group (DSI: -0.40±0.94) in contrast of the healthy group (DSI: 3.65±0.86) ($P \leq 0.05$). To be more precise due to SARS-COV-2 infection, unlike the healthy group, in the diseased group I-low and jitter increased, MPT duration and the highest F0 decreased. As we mentioned, jitter was lower in the patients' group (0.56±0.21) compared with the healthy ones (0.19±0.12) and this may be explained based on the hypothesis of inflammation, uneven weighing, incomplete glottis closure, and deterioration of vocal folds' tissue leading to aperiodicity and irregularity in vocal
fold vibration after recurrent coughs and virus tissue entry (12, 54). MPT duration in the COVID-19 patients (9.90±2.54 Sec) was shorter than healthy group (17.24±3.92 Sec) because of the reduced respiratory support, and also may be due to disturbed glottal closure after possible larynx inflammation, and insufficient coordination between respiratory and phonatory subsystems of speech (12, 19, 20), and maybe because of the hypothesis regarding nerve damage and sensory neuropathy caused by COVID-19 (55). It seems that inadequate control of the larynx and airflow pressure and increased glottal muscle tension during vocalization due to the COVID-19 infection leads to free edge alteration and finally changes vibratory rates of vocal folds or decreased F0-high (345.82±46.33 in patients and 420.45±50.07 in healthy people) (12, 32). Furthermore, we observed that I-low was greater in the patient group (55.55±3.26), and it can be due to increased glottal resistance that necessitates more pressure to initiate vocalization than healthy subjects (49.90±1.90) (35). Almost similar assessments were reported by the other studies assessing other aerodynamic and acoustic features in COVID-19 patients such as S/Z ratio, MPT, shimmer, HNR, H1H2, CPP1, and jitter (10, 12, 24, 54). Based on the study of Asiaee (12) et al. the results of acoustic assessments such as jitter, shimmer, and MPT were significantly different between the COVID-19 and the healthy subjects (12). Also, the same results were reported by Saki et al.in evaluating MPT in two groups of COVID-19 and healthy ones (24). Moreover, Shahpasand et al. mentioned in their poster presentation that there were pathological values for DSI in COVID-19 patients but there wasn’t any published data (54). Contrary to our results in this study, Göląc et al. did not find any difference in the acoustic assessments' results such as HNR, jitter, and shimmer; the logical explanation of these results includes the time of sampling in the Göląc study (10). It

1 Cepstral Peak Prominence
seems that these diverse results are due to that patients in Gölaç study were assessed about 8 months after recovery and not during the bedridden time; however, our results were in line with the MPT values (10). Ultimately, it appears that discoordination between the lung as a source of airflow and the larynx as a vocalization box for voice production can increase muscle tension in the larynx and affect each parameter of DSI and consequently the total score of DSI.

CAPE-$V_p$ is a perceptual clinician-based judgment questionnaire of voice quality that determines the severity of dysphonia perceptually. In this study, the total score and subtests scores of CAPE-V were affected and deteriorated significantly due to COVID-19 in the patient group compared to the healthy group. The worsened voice quality in auditory-perceptual assessment in these patients might be probably due to the changes after tissue inflammation of the larynx (52). Based on Lee et al. neuropathy in vague nerve, specifically recurrent laryngeal nerve can cause recurrent cough which is in line with COVID-19 hypothesis mentioned before (56). Frequent coughing in COVID-19 patients irritates vocal folds and leads to tension and hard closure of the folds, therefore dysphonia is not unexpected (12, 18). Based on the given reasons, it is evidently demonstrated in the severity score, for it shows the severity and grade of dysphonia in these patients. Moreover, due to the insufficient air pressure and insufficient respiratory capacity caused by COVID-19, and alteration in vocal folds’ vibrating pattern and closure (12, 30, 57), patients vocalize with more strain, roughness, and breathiness; and also their voice loudness and pitch deteriorate (30). Moreover, another reason for the findings of this study can be the fact that patients were assessed during the acute phase of COVID-19 infection who were hospitalized in the ward. Our results were in line with former studies done by Saki et al. and Tahir et al. regarding CAPE-$V_p$ results in assessing the voice of COVID-19 patients (24, 30). In another study by Tohidast et al. (2020), the voice
quality of COVID patients was evaluated by the GRBAS scale and the impact of Covid-19 on these aspects of the patient’s voice was also declared to be statistically significant (28) that was parallel with our study.

Moreover, the correlation between DSI as an objective evaluation scale and CAPE-V_p as a subjective evaluation tool in each group showed there was a notable relationship between the total scores of CAPE-V_p and DSI in the COVID-19- group; although, the correlation between them in the healthy group was lower than patients’ group. These voice assessment tools including DSI and CAPE-V_p are generally used for distinguishing dysphonic and healthy individuals (58). Both DSI and CAPE-V_p reflect the severity of dysphonia based on an objective and subjective manner respectively (58, 59). As mentioned by Nemr et al. patients who have dysphonia and get lower scores in voice quality assessments, also tend to have significantly lower scores in DSI (60). It seems, in COVID-19 dysphonic patients a significant correlation between the measures depicts that the DSI can be a good predictor of auditory-perceptual voice quality evaluated by the CAPE-V_p scale (44). These findings can show that although acoustic-aerodynamic measurements (DSI) and auditory-perceptual assessments (CAPE-V_p) evaluate different voice dimensions, they can be related and support the results each other in COVID-19 patients and healthy subjects. Deeming that voice is a multidimensional phenomenon, it is not surprising that the various aspects of voice evaluations especially in dysphonic patients confirm each other. Some studies have assessed the correlation between these two voice assessment tools, but as far as we searched none of them were performed on COVID-19 patients, and there wasn’t any data comparing these assessments in COVID-19 (42, 44). In fact, former articles that were done by Ataee et al. and Nemr et al. assessed the relation between DSI and CAPE-V_p and revealed
consistent results with ours regarding the overall scores in other dysphonic patients (42, 44).

This study had some limitations. Firstly, it was performed during the acute time of the pandemic era which limited further investigations such as laryngo-video-stroboscopy, so we had no data about the structure or function of the vocal cords of the subjects. Secondly, transferring the patients to a quiet and appropriate room for recording voice samples was difficult due to the limitations of distancing protocols. Data gathering was performed during 3 to 5 days after hospitalization. Therefore, defining the exact phase of the disease was not feasible. Furthermore, to perform a thorough investigation, Inflammation and sensory neuropathy can only be evaluated by direct imaging or tissue sampling, and an EEG respectively; which we could not perform in the study. Moreover, it is suggested that these limitations should be addressed in future research on these patients after recovery from COVID-19 infection and later stages as follow-up with different assessment tools to determine the quality of voice.

Conclusion

This study suggests that hospitalized COVID-19 patients experience difficulties in their voice. They experience more roughness, breathiness and strain, and inappropriate pitch and loudness during their infection period. Also, the aerodynamic and acoustic feature of their voice deteriorates during the disease and should be considered during assessments. Finally, the DSI scale can be used for assessing aerodynamic and acoustic parameters and predicting the overall quality of voice and it can reflect the severity of dysphonia based on an objective manner.

Acknowledgments
We would like to appreciate the participants of the study both COVID-19 patients and healthy individuals who helped us perform this study.

References:


<table>
<thead>
<tr>
<th>TABLE 1.</th>
<th>Demographic Characteristics of the Participants in Patients with COVID-19 (n= 40) and Healthy Subjects (n= 40).</th>
</tr>
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<tbody>
<tr>
<td>Age</td>
<td>Gender</td>
</tr>
<tr>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Male</td>
<td>Female</td>
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<tr>
<td>Patients with COVID-19</td>
<td>41.2</td>
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<tr>
<td>Healthy subjects</td>
<td>44.50</td>
</tr>
</tbody>
</table>

*P value

*P < 0.05

* Independent Sample t-test
Comparison of DSI Score and its Components Between Patients with COVID-19 (n= 40) and Healthy subjects (n= 40).

<table>
<thead>
<tr>
<th>Self-assessment scores</th>
<th>Groups</th>
<th>Mean ± SD</th>
<th>*P value</th>
</tr>
</thead>
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<tr>
<td><strong>Acoustic and Aerodynamic Components (DSI)</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>MPT</td>
<td>patients with COVID-19</td>
<td>9.90±2.54</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>healthy subjects</td>
<td>17.24±3.92</td>
<td></td>
</tr>
<tr>
<td>F0-high</td>
<td>patients with COVID-19</td>
<td>345.82±46.33</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>healthy subjects</td>
<td>420.45±50.07</td>
<td></td>
</tr>
<tr>
<td>I-low</td>
<td>patients with COVID-19</td>
<td>55.55±3.26</td>
<td>0.00*</td>
</tr>
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<td></td>
<td>healthy subjects</td>
<td>49.90±1.90</td>
<td></td>
</tr>
<tr>
<td>Jitter</td>
<td>patients with COVID-19</td>
<td>0.56±0.21</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>healthy subjects</td>
<td>0.19±0.12</td>
<td></td>
</tr>
<tr>
<td>DSI</td>
<td>patients with COVID-19</td>
<td>-0.40±0.94</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>healthy subjects</td>
<td>3.65±0.86</td>
<td></td>
</tr>
</tbody>
</table>

**DSI**: Dysphonia Severity Index; **SD**: Standard Deviation. **MPT**: Maximum Phonation Time.

*Independent Sample T-test.
### TABLE 3.

Comparison of the CAPE_Vp and its Components Between Patients with COVID-19 (n: 40) and Healthy Subjects (n: 40).

<table>
<thead>
<tr>
<th>Self-assessment scores</th>
<th>Groups</th>
<th>Mean ± SD</th>
<th><em>P</em> value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPE-Vp Component</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Roughness</td>
<td>patients with COVID-19</td>
<td>40.90±12.54</td>
<td>0.00*</td>
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<td></td>
<td>healthy subjects</td>
<td>17.24±3.92</td>
<td></td>
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<tr>
<td>Breathiness</td>
<td>patients with COVID-19</td>
<td>49.82±19.33</td>
<td>0.00*</td>
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<tr>
<td></td>
<td>healthy subjects</td>
<td>15.45±5.07</td>
<td></td>
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<tr>
<td>Strain</td>
<td>patients with COVID-19</td>
<td>35.15±18.26</td>
<td>0.00*</td>
</tr>
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<td></td>
<td>healthy subjects</td>
<td>9.91±3.90</td>
<td></td>
</tr>
<tr>
<td>Pitch</td>
<td>patients with COVID-19</td>
<td>37.56±18.21</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>healthy subjects</td>
<td>18.19±6.12</td>
<td></td>
</tr>
<tr>
<td>Loudness</td>
<td>patients with COVID-19</td>
<td>24.90±12.54</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>healthy subjects</td>
<td>4.24±2.92</td>
<td></td>
</tr>
<tr>
<td>Overall Severity</td>
<td>of patients with COVID-19</td>
<td>62.7±17.94</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>healthy subjects</td>
<td>24.65±6.86</td>
<td></td>
</tr>
</tbody>
</table>

*CAPE-V: Consensus Auditory-Perceptual Evaluation of Voice; SD: Standard Deviation, numbers (%)

*Independent Sample T-test.