# Acoustic Analysis of Soccer Fans in Acute Phonotrauma After the Match

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**Summary: Objectives.** Acute phonotrauma is the result of sound production by shouting or straining one's voice. In this study, we aimed to investigate the acute changes in the vocal folds and voices of soccer fans who voluntarily applied to our clinic after the soccer match where they engaged in acute phonotrauma. There are no other studies in the literature conducted on a similar sample group.

**Study design.** This is a case-control study.

**Methods.** Videolaryngostroboscopic (VLS) examination, acoustic voice analysis, and Voice Handicap Index (VHI) questionnaire were performed on 29 voluntary soccer fans included to the study before the match and at the first hour after the match. The values obtained were compared statistically with each other and with 29 control groups without voice pathology.

**Results.** The jitter, shimmer, and normalized noise energy values measured after the match increased significantly statistically compared with the pre-match level, but harmonic noise ratio value decreased significantly ($P < 0.05$). VHI scores increased significantly after the match according to the pre-match scores ($P < 0.05$). In the VLS examinations, there was no difference in the images before and after the match.

**Conclusions.** It has been concluded that people who are using their voices loudly and intensely by shouting during the match are exposed to sound changes after the match, and if this situation becomes persistent, it may cause permanent voice pathologies. It is thought that VHI and acoustic voice analysis should be done together with VLS for diagnosis and follow-up of voice changes for which the VLS examination alone is not sufficient.

**Key Words:** Acoustic analysis–Phonotrauma–Soccer fans–Videolaryngostroboscopy–Voice Handicap Index.

## INTRODUCTION

Acute phonotrauma is the result of sound production by shouting or straining one's voice. The sudden, unstable, uncontrolled banging of vocal folds with great force to each other leads to this situation. This results in various pathologies such as nodules, polyps, bleeding, inadequate closure of the vocal folds, and damage to the free edges of the vocal folds and, accordingly, functional voice disorders. Fanatic soccer fans shout throughout a match and use their voices loudly and intensively and present to ear-nose-throat outpatient clinics to be treated for various voice problems associated with vocal misuse. Today, videolaryngostroboscopic (VLS) examination is performed in addition to the ear, nose, throat (ENT) physical examination in the examination of patients with voice problems. However, these examination methods are insufficient in evaluating the voice objectively. VLS examination is not meaningful alone unless organic pathologies such as subepithelial hemorrhage, edema, nodules,erythema, edge irregularity etc. Therefore, in addition to these examination methods, computer-assisted acoustic voice analysis should be performed, and questionnaires such as Voice Handicap Index (VHI) should be used in diagnosis and follow-up of patients with voice problems. According to their results, it would be appropriate to plan the treatment and rehabilitation period.

The aim of this study was to assess acute changes in vocal folds of soccer fans who voluntarily presented to our clinic after the soccer match where they engaged in acute phonotrauma. The subjects were examined with VLS, clinical examination, and acoustic voice analysis methods. We investigated the effectiveness of these examination methods in determining the voice pathology, vocal fold structure, function, and planning the treatment. There are no other studies in the literature conducted on a similar sample group. The difference of our study is an evaluation of the voice quality and the change in vocal folds of nonprofessional voice users 1 hour after the phonotrauma.

## MATERIALS AND METHODS

Before this prospective study, approval of the ethics committee was obtained (Eskisehir Osmangazi University Medical Faculty Ethics Committee: Date: 17/09/2014 Number: 80558721/253). Thirty adult male volunteer fans who had no voice-related organic or functional pathology who went to the soccer match, cheered loudly, and were exposed to an environment that promoted phonotrauma were included in the study. People with a history of local or systemic disease, drug use, and operation affecting voice were not included in the study. One volunteer was excluded from the study because he did not come to follow-up after the first examination during the study. The study was conducted on 29 volunteers. The control group included 29 volunteers who had no voice-related organic or functional pathology and

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were not exposed to an environment that promoted phonotrauma. Informed consent documents were obtained before the examination.

The study subjects underwent acoustic voice analysis, VLS examination, and VHI questionnaires before and immediately after the soccer match (at the first hour).

Acoustic voice analyses were performed with *Dr. Speech* software (Drs Tiger Inc., Seattle, WA, USA) using *Vocal Assessment* and *Real Analysis* programs. VLS records were obtained by *Xion 3 CCD CHIP full HD* endostroboscopy system (XION medical, Berlin, Germany). VLS images recorded on the computer were evaluated by three specialist physicians who are not among the authors and had no previous knowledge of the images, using the scale used in Gürbüz et al's study.[1] In the said scale, the reliability of which was investigated in the aforementioned study, vocal cord free edge, amplitude, mucosal wave, vocal cord nonvibratory region, periodicity, ventricular band motion, and anteroposterior contraction parameters were evaluated. The Turkish version of the VHI was completed by the study subjects before and after the match.[2] Acoustic voice analysis and the VHI questionnaire were applied to the control group. The values obtained were compared statistically with each other and those of the control group.

The cases evaluated in the study group were informed about voice hygiene measures and voice therapy, and they were advised to return for a follow-up examination at our outpatient clinic.

## VOICE HANDICAP INDEX

This questionnaire, which is most commonly used in the analysis of patients with voice problems, was developed in 1997 by Jacobson et al.[3] The VHI is a 30-item questionnaire. It has three subgroups, that is, functional, physical, and emotional subgroups, each consisting of 10 items. Each item is given a value in the range of 0–4 by the patient, and the maximum total score is 120. The higher the score, the bigger the problem with the voice.[3] The VHI is a 30-item long and time-consuming questionnaire, so we used the shorter and simpler VHI-10 form. In addition, the reliability and validity of the Turkish version of the VHI-10 questionnaire have been established by Kiliç et al[2] in 2008.

## ACOUSTIC VOICE ANALYSIS

The *Vocal Assessment* and *Real Analysis* sections of *Dr. Speech* software (Tigers Inc.) was used in the voice analysis of the subjects. The subjects were asked to make the /a/ sound for 3 seconds in modal voice (/a/ sustain) from a distance of about 20 cm using *Trust* brand microphone (Dordrecht, Netherlands), and their voices were recorded. Recordings were made in a quiet room with a sampling rate of 44,100 Hz and a resolution of 16 bit in the *Vocal Assessment* program, and a sampling rate of 11,025 Hz and a resolution of 16 bit in the *Real Analysis* program. With the *Vocal Assessment* program, the following parameters were measured in the given order: habitual fundamental frequency (Fo, Hz), jitter (%), shimmer (%), normalized noise energy (NNE, dB), harmonic-to-noise ratio (HNR, dB), hoarse voice, harsh voice, and breathy voice. In this program, voice quality was evaluated in the range of 0 (normal) to 3 (worst) for all three parameters (hoarse, harsh, and breathy voice). With the *Real Analysis* program, percent of voicing time (PVT, %) and percent of voiceless time (PVLESST, %) parameters were measured.

## STATISTICAL ANALYSIS

Paired *t* test was used for the comparison of continuous variables measured before and after the match. Pre-match and post-match continuous measurements were compared with control group measurements using independent-sample *t* test. Categorical variables obtained before and after the match were compared using marginal homogeneity test and compared with the control group measurement using chi-square analysis. The relationships between the variables were evaluated with correlation analysis. IBM *SPSS Statistics* 21.0 (New York, USA) was used for statistical analyses. A *P* value less than 0.05 was considered statistically significant.

## RESULTS

Twenty-nine volunteer fanatic soccer fans and 29 control group volunteers participated in the study. All study subjects were male. Mean age was 25 (18–49) years in the study group and 27 (19–51) years in the control group. Habitual Fo values measured by the *Vocal Assessment* program were compared with pre-match, post-match, and control group; no statistical difference was found ($P > 0.05$) (Table 1). Pre-match jitter (%), shimmer (%), and NNE

**TABLE 1.**
**The Results of Assessment Made by the *Vocal Assessment* Program**

| | Study Group | | | | | | *P* | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pre-match | | Post-match | | Control Group | | | | |
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | A | B | C |
| Habitual Fo | 135.74 | 23.42 | 125.32 | 23.70 | 131.17 | 12.54 | >0.05 | >0.05 | >0.05 |
| Jitter (%) | 0.17 | 0.05 | 0.27 | 0.27 | 0.14 | 0.05 | <0.05 | >0.05 | <0.05 |
| Shimmer (%) | 1.75 | 0.69 | 2.29 | 1.1 | 1.46 | 0.61 | <0.05 | >0.05 | <0.05 |
| NNE (–) | 9.80 | 3.50 | 7.10 | 4.11 | 13.60 | 1.29 | <0.05 | >0.05 | <0.05 |
| HNR | 24.93 | 2.76 | 23.15 | 4.36 | 24.47 | 2.85 | <0.05 | >0.05 | <0.05 |

A: Value obtained as a result of the comparison of pre-match and post-match values ($P < 0.05$ significant).
B: Value obtained as a result of the comparison of pre-match values with the control group ($P < 0.05$ significant).
C: Value obtained as a result of the comparison of post-match values with the control group ($P < 0.05$ significant).

**TABLE 2.**
**The Results of Voice Quality Assessment Made by the *Vocal Assessment* Program**

| | Study Group | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Hoarse Voice | | Harsh Voice | | Breathy Voice | | Control Group | | |
| | Pre-match | Post-match | Pre-match | Post-match | Pre-match | Post-match | Hoarse Voice | Harsh Voice | Breathy Voice |
| 0 | 15(n) | 7(n) | 26(n) | 24(n) | 8(n) | 2(n) | 25(n) | 28(n) | 20(n) |
| 1 | 12(n) | 17(n) | 3(n) | 1(n) | 8(n) | 5(n) | 4(n) | 1(n) | 7(n) |
| 2 | 2(n) | 4(n) | 0(n) | 2(n) | 4(n) | 4(n) | 0(n) | 0(n) | 1(n) |
| 3 | 0(n) | 1(n) | 0(n) | 2(n) | 9(n) | 18(n) | 0(n) | 0(n) | 1(n) |

n: the number of volunteer fans.

(–) values increased after the match, and this increase was statistically significant ($P < 0.05$) (Table 1). Pre-match HNR (db) values decreased after the match and this decrease was statistically significant, too ($P < 0.05$) (Table 1).

With the *Vocal assessment* program, pre-match hoarse voice and breathy voice values were found to increase after the match and such increase was statistically significant ($P < 0.05$), whereas harsh voice values did not show any significant difference ($P > 0.05$) (Table 2, 3). Figure 1 and 2 show the differences in pre-match and post-match "Voice Quality Estimates" parameters of a study subject.

**TABLE 3.**
***P* Values of the Results of Voice Quality Assessment Made by the *Vocal Assessment* Program**

| | A | B | C |
|---|---|---|---|
| Hoarse voice | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ |
| Harsh voice | $P > 0.05$ | $P > 0.05$ | $P > 0.05$ |
| Breathy voice | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ |

A: *P* value obtained as a result of the comparison of pre-match and post-match voice quality values of the study group.
B: *P* value obtained as a result of the comparison of pre-match voice quality values between the study group and the control group.
C: *P* value obtained as a result of the comparison of post-match voice quality values between the study group and the control group.

Similarly, when post-match hoarse voice and breathy voice values of the study group were compared with those of the control group, a statistically significant difference was found ($P < 0.05$) (Tables 2, 3).

In the study group, pre-match PVT values obtained by the *Real Analysis* program significantly decreased after the match ($P < 0.05$), whereas PVLESST values significantly increased ($P < 0.05$) (Table 4).

VHI questionnaire scores of the study group increased statistically significantly after the match, compared with pre-match scores ($P < 0.05$). In the same questionnaire, post-match values were significantly higher than those of the control group ($P < 0.05$) (Table 5).

No significant difference was found in the comparison of VHI questionnaire scores with hoarse, harsh, and breathy voice values measured in the *Vocal Assessment* program ($P > 0.05$) (Table 6).

VLS examination records of the study group made before and after the match were evaluated by three individual ear-nose-throat specialists who are not among the authors. When pre-match records were compared with post-match records, no change was found in any of the parameters assessed.

## DISCUSSION

ENT physical examination, VLS examination, and acoustic voice analyses are performed in the examination of patients with voice

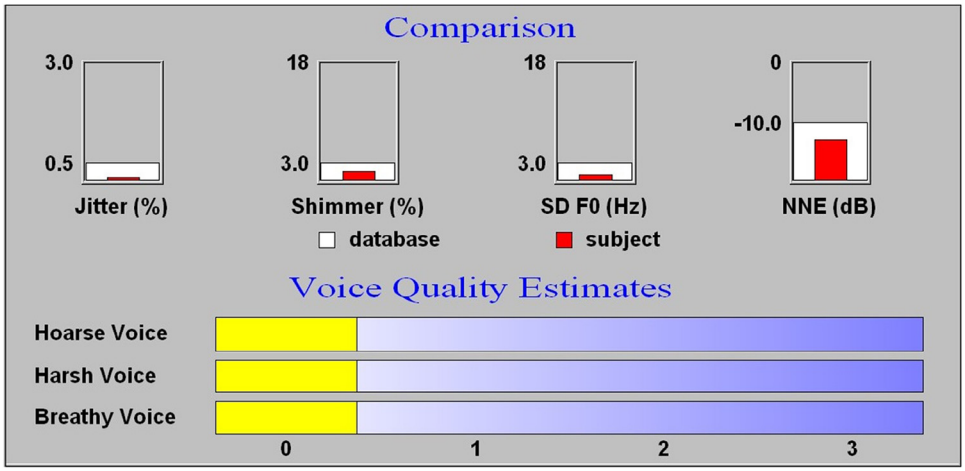


**FIGURE 1.** Pre-match "Voice Quality Estimates" parameters of a study subject.

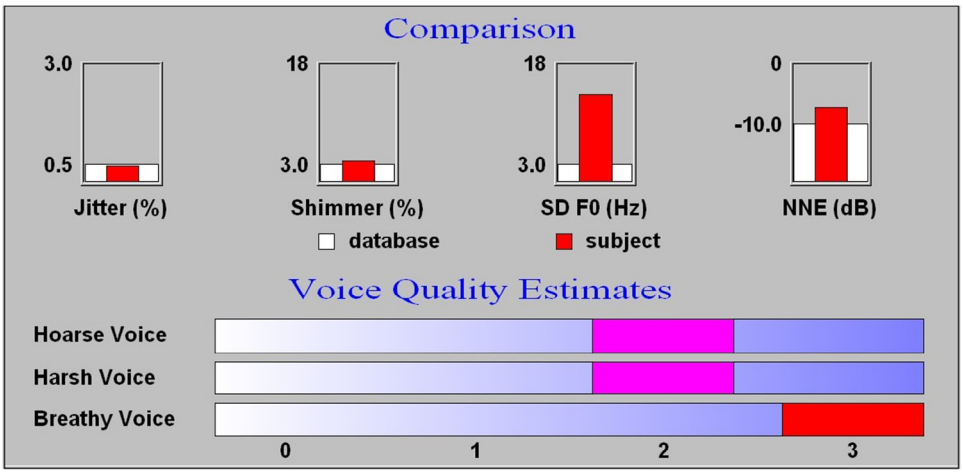


**FIGURE 2.** Post-match "Voice Quality Estimates" parameters of the same study subject.

problems. In addition, various questionnaires are used to determine the effects of voice complaints on the quality of life of the patients. The most frequently used questionnaire for this purpose is the VHI.[2,3] In this questionnaire, the higher the score, the bigger the problem with the voice. In two individual studies, it is emphasized that the 10-item simple form, which is the modified version of the VHI questionnaire and the Turkish version of which we used in the current study, is a reliable questionnaire that can be easily implemented in a short time.[2,4] In the literature, it is observed that this questionnaire is frequently used especially in studies conducted on singers.[5] In our study, in the questionnaires conducted on the study group after the match where they were exposed to an environment that promoted phonotrauma, the scores were significantly higher than those before the match.

Another method used in the study of patients with voice problems is acoustic voice analysis. These analyses are made using various computer programs. The *Vocal Assessment* and *Real Analysis* sections of *Dr. Speech* software was used in our study.

Habitual Fo is the number of sound vibrations per second. It is expressed in Hz. Normal values are 100–150 Hz for males and 180–250 Hz for females.[6] In pathologies of vocal folds that cause increased mass, the Fo decreases.[7] In one study, it was found that the Fo increased significantly after polyp excision from vocal folds.[8] The subjects in our study were all male. Mean Fo decreased minimally after the match; however, such decrease was not statistically significant. This suggested that acute phonotrauma did not have the effect of increased mass in vocal folds.

**TABLE 4.**
**The Results of Assessment Made by the *Real Analysis* Program**

| | Study Group | | | | | | *P* | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pre-match | | Post-match | | Control Group | | | | |
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | A | B | C |
| PVT (%) | 98.017 | 5.56 | 92.603 | 7.90 | 99.769 | 0.62 | <0.05 | >0.05 | <0.01 |
| PVLESST (%) | 1.982 | 5.56 | 7.396 | 7.90 | 0.230 | 0.62 | <0.05 | >0.05 | <0.01 |

A: Value obtained as a result of the comparison of pre-match and post-match values ($P < 0.05$ significant).
B: Value obtained as a result of the comparison of pre-match values with the control group ($P < 0.05$ significant).
C: Values obtained as a result of post-match values with the control group ($P < 0.05$ significant).

**TABLE 5.**
**The Results of the Voice Handicap Index (VHI) Assessment**

| | Study Group | | | | | | *P* | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pre-match | | Post-match | | Control Group | | | | |
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | A | B | C |
| VHI | 1.17 | 1.67 | 11.27 | 8.51 | 0.65 | 1.11 | <0.01 | >0.05 | <0.01 |

A: Value obtained as a result of the comparison of pre-match and post-match values ($P < 0.05$ significant).
B: Value obtained as a result of the comparison of pre-match values with the control group ($P < 0.05$ significant).
C: Values obtained as a result of post-match values with the control group ($P < 0.05$ significant).

**TABLE 6.**
**Comparison of VHI Questionnaire Scores With Hoarse, Harsh, and Breathy Voice Values**

| | Pre-match VHI | | Post-match VHI | |
|---|---|---|---|---|
| | r | *P* | r | *P* |
| Hoarse voice | 0.347 | >0.05 | 0.237 | >0.05 |
| Harsh voice | 0.309 | >0.05 | 0.241 | >0.05 |
| Breathy voice | 0.222 | >0.05 | -0.023 | >0.05 |

r: Pearson correlation value, $P < 0.005$: significant.

Jitter and shimmer are parameters that are related to irregularities in frequency and amplitude, respectively. These parameters are expressed in percentage (%), and any increase in these parameters was reported to have caused rough voice quality.[6,9] A jitter value below 1% and a shimmer value below 3% are considered normal.[6] Studies on patients with benign masses in vocal folds have shown that there is a significant decrease in postoperative jitter and shimmer values, which is attributed to the reduction of vocal fold mass.[10,11] In our study group, we think that the increase in post-match jitter and shimmer values is related to the change in vibration characteristics of the vocal folds, rather than increased mass.

HNR is the ratio of harmonic total energy to noise energy. Its unit is decibel (dB). High values indicate that the rate of noise in sound is low.[6] In our study, it was determined that pre-match "HNR" values decreased statistically significantly after the match. NNE is obtained by subtracting total energy from harmonic energy. Its value is negative and its unit is decibel. As the noise rate in sound increases, its value increases and approaches 0 (zero).[6] In our study, it was determined that pre-match "NNE" values increased after the match, approached zero, and this was statistically significant. The decrease in HNR values and increase in NNE values after the match show that the rate of noise after the acute phonotrauma increases and thus the voice quality deteriorates.

Auditory-perceptual evaluation of voice is generally performed with Grade, Roughness, Breathiness, Asthenia, Strain and similar scales in a subjective manner.[6] However, perceptual evaluation of voice can be done objectively using the "Voice Quality Estimates" section of the *Vocal Assessment* analysis program, which was used in our study. In fact, in our study, hoarse voice and breathy voice values increased significantly after the match, whereas there was no statistically significant difference in harsh voice values. These findings explain the deterioration of voice that can occur after acute phonotrauma.

The *Real Analysis* program was used to measure PVT and PVLESST parameters. PVLESST is the percentage of voiceless time within total phonation time.[7] This ratio is expected to be "0%" for people without any voice problem. In our study, it was determined that pre-match "PVLESST" values increased after the match ,and such increase was statistically significant. This was ascribed to short-term losses of vibration (voice break) in vocal folds resulting from acute phonotrauma.

The comparison of VHI questionnaire scores with "Voice Quality Estimates" parameters revealed no correlation between the questionnaire and the acoustic voice analysis. This suggested that the VHI questionnaire is subjective and is not significant on its own in the diagnosis of patients with voice problem. It was concluded that this questionnaire could be used in the follow-up to identify the quality of life of the people with voice problems, and that acoustic voice analyses should also be performed with the questionnaire.

Another method used to diagnose patients with voice problems is VLS. VLS is an endoscopic method that evaluates the morphological structure and vibrational properties of epithelial and subepithelial layers of vocal folds under intermittent light.[12–14] In a study, Mann et al[15] have found edema, erythema, and edge irregularity in the vocal folds in VLS examinations of long-term vocal misuse. In our study, pre-match and post-match VLS records were evaluated by three individual ear-nose-throat specialists who are not among the authors and have no previous knowledge of the images using the scale recommended by Gürbüz et al.[3] When pre-match records were compared with post-match records, no change was found in any of the parameters. Therefore, it was concluded that in the case of acute phonotrauma, VLS examination performed in patients shortly after trauma is not meaningful alone unless organic pathologies such as subepithelial hemorrhage, edema, etc have occurred and that acoustic voice analyses should be performed in addition to VLS examination.

People who shout and use their voices loudly and intensively during a match are exposed to post-match voice changes. With this condition becoming persistent, organic pathologies may develop in vocal folds, and permanent voice pathologies may occur.

## CONCLUSION

The acoustic analysis parameters were changed in the early period of acute phonotrauma, but VLS findings were not changed after the acute phonotrauma. It was concluded that in diagnosis and follow-up of voice changes because of acute phonotrauma, VLS, VHI questionnaire, and acoustic voice analyses should be performed so that treatment and therapies are based on the evaluation of the findings obtained therefrom. Moreover, this study is the first study in this sample group, so further studies should be conducted with a higher number of volunteers.

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