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Reflux Symptom Index (RSI) and singing voice handicap index (SVHI) in singing students. A pilot study.

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Corresponding Author:	Andrea Nacci ENT, Audiology and Phoniatrics Unit, University of Pisa, Pisa, Italy Pisa, Italy
First Author:	Andrea Nacci
Order of Authors:	Andrea Nacci
	Luca Bastiani
	Maria Rosaria Barillari
	Massimo Martinelli
	Jerome R Lechien, MD. PhD, MS
	Federica Simoni
	Stefano Berrettini
	Bruno Fattori
Abstract:	Summary Objectives. To correlate, RSI with SVHI, in a group of singing students, by means of a specific anamnestic questionnaire which analyzes the physical, social, emotional and economic impacts of voice problems on their lives. This study is a cross-sectional single-centre observational study. Methods. 42 modern singing students (26F/16M; average age: 24.9±5.7; range: 16-46 years old) were recruited. A self-assessment of the singing-voice (SVHI) and of reflux symptom (RSI) were performed. Results. Using the validated RSI threshold 31% of partecipants were classified as RSI greater than 13 as an indication of suspected LPR. Classifying the SVHI score as proposed in the recent literature (cutoff of 20.35) our sample was a voice disorders prevalence of 71.4%. There was no significant positive or negative relationship between RSI and SVHI total score (rho=0.238, p=0.13). Instead, by considering the relationship between the individual items of the two questionnaires, it is highlighted that the item 1 of SVHI was significantly correlated with most of the RSI items (p=0.0001–0.006). In the same vein, the item 5 of SVHI was correlated to hoarseness and coughing (p=0.005–0.006). The item 20 of SVHI was significantly correlated with hoarseness, excess mucus in the throat or postnasal drip and with the pharyngeal globus sensation (p=0.001–0.005). By aggregating the SVHI item response as a positive response (2 to 4) versus a negative response (0 or 1) between “RSI pathology classification”, a significant association was observed for SVHI item 1 ($p < 0.021$), item 5 ($p < 0.006$), item 20 ($p < 0.042$), item 24 ($p < 0.044$) item 25 ($p < 0.047$). These associations were confirmed by univariate binary logistic. Multivariate binary logistic regression confirms that SVHI Item 1, Item 5 were more associated with RSI positive. Based on results, we propose a questionnaire that combines the most relevant SVHI items correlated to LPRD (SVHI-10-LPRD questionnaire). Cronbach's alpha coefficient for the 10 items selected was 0.87; item-total correlation coefficients for each item were in the range of 0.461-0.670.

	Conclusions. This pilot study shows that, in case of significant RSI for LPR, it is possible to observe a significant association with some symptoms described in SVHI. These results underline that the association of the RSI and SVHI questionnaires administered to singers and singing students, can represent a simple screening to reveal possible alterations of the singing voice correlate to LPR. Moreover, we propose a Singing Voice Handicap Index correlated to LPR (SVHI-10-LPRD). It will be necessary to increase the sample of subjects in the study to confirm these preliminary data.
Response to Reviewers:	

Reflux symptom index (RSI) and singing voice handicap index (SVHI) in singing students. A pilot study.

Nacci Andrea[1,2], Bastiani Luca [3], Barillari Maria Rosaria [2,4], Martinelli Massimo [5], Lechien Jerome R [2,6], Simoni Federica[1], Berrettini Stefano[1,7], Fattori Bruno [1].

[1] ENT Audiology Phoniatric Unit, University of Pisa, Pisa, Italy.

[2] Laryngopharyngeal Reflux Study Group of Young-Otolaryngologists of the International Federations of Oto-Rhino-Laryngological Societies (YO-IFOS), Paris, France.

[3] CNR Institute of Clinical Physiology, Epidemiology Section, Pisa, Italy.

[4] Division of Phoniatrics and Audiology, Department of Mental and Physical Health and Preventive Medicine, Luigi Vanvitelli University, Naples, Italy.

[5] CNR Institute of Information Science and Technologies, Signals & Images Lab, Pisa, Italy

[6] Department of Otolaryngology-Head and Neck Surgery, Foch Hospital, University of Paris Saclay, Paris, France.

[7] Division of ENT Diseases, Karolinska Institutet, Stockholm, Sweden.

Corresponding Author:
Andrea Nacci, MD
ENT, Audiology and Phoniatrics Unit, University of Pisa.
Cisanello Hospital, Via Paradisa, 2
I-56124 PISA, Italy.
Tel: 0039-050-997.518
Fax: 0039-050-997.501
E-mail: a.nacci@med.unipi.it

Summary

Objectives. To correlate, RSI with SVHI, in a group of singing students, by means of a specific anamnestic questionnaire which analyzes the physical, social, emotional and economic impacts of voice problems on their lives. This study is a cross-sectional single-centre observational study. **Methods.** 42 modern singing students (26F/16M; average age: 24.9±5.7; range: 16-46 years old) were recruited. A self-assessment of the singing-voice (SVHI) and of reflux symptom (RSI) were performed. **Results.** Using the validated RSI threshold 31% of partecipants were classified as RSI

greater than 13 as an indication of suspected LPR. Classifying the SVHI score as proposed in the recent literature (cutoff of 20.35) our sample was a voice disorders prevalence of 71.4%. There was no significant positive or negative relationship between RSI and SVHI total score (rho=0.238, p=0.13). Instead, by considering the relationship between the individual items of the two questionnaires, it is highlighted that the item 1 of SVHI was significantly correlated with most of the RSI items (p=0.0001–0.006). In the same vein, the item 5 of SVHI was correlated to hoarseness and coughing (p=0.005–0.006). The item 20 of SVHI was significantly correlated with hoarseness, excess mucus in the throat or postnasal drip and with the pharyngeal globus sensation (p=0.001–0.005). By aggregating the SVHI item response as a positive response (2 to 4) versus a negative response (0 or 1) between "RSI pathology classification", a significant association was observed for SVHI item 1 ($p < 0.021$), item 5 ($p < 0.006$), item 20 ($p < 0.042$), item 24 ($p < 0.044$) item 25 ($p < 0.047$). These associations were confirmed by univariate binary logistic. Multivariate binary logistic regression confirms that SVHI Item 1, Item 5 were more associated with RSI positive. Based on results, we propose a questionnaire that combines the most relevant SVHI items correlated to LPRD (SVHI-10-LPRD questionnaire). Cronbach's alpha coefficient for the 10 items selected was 0.87; item-total correlation coefficients for each item were in the range of 0.461-0.670. **Conclusions.** This pilot study shows that, in case of significant RSI for LPR, it is possible to observe a significant association with some symptoms described in SVHI. These results underline that the association of the RSI and SVHI questionnaires administered to singers and singing students, can represent a simple screening to reveal possible alterations of the singing voice correlate to LPR**.** Moreover, we propose a Singing Voice Handicap Index correlated to LPR (SVHI-10-LPRD). It will be necessary to increase the sample of subjects in the study to confirm these preliminary data.

Key words: Laryngopharyngeal reflux, LPRD, RSI, SVHI, Singing, Self-report, SVHI-10-LPRD questionnaire.

Introduction

The Laryngopharyngeal Reflux Disease (LPRD) is characterized by reflux of gastroduodenal contents at the pharyngolaryngeal level, where it comes into contact with the mucosa of the upper airway-digestive tract [1]. LPRD is associated with hoarseness, throat clearing, cough, dysphagia, globus sensation, postnasal drip, otitis media with effusion, asthma, chronic rhinosinusitis, obstructive sleep apnea syndrome (OSAS) and tooth erosion with oral mucosal changes [2-7]. Moreover, patients with LPRD have significant deterioration of both subjective and objective voice quality and the occurrence of LPR in professional voice users as singers can have a dramatic impact of daily life [8,9]. Singers with LPR may have normal or minimally pathological speaking voice but impaired singing voice (vocal fatigue, hoarseness, and loss of range). LPRD and reflux laryngitis are common in singers because of necessary air support involving higher intra-abdominal pressure, increased stress due to career management and because of their lifestyle (which is often associated with eating late at night, drinking alcoholic and caffeinated beverages, smoking) [9-12].

~~When Lundy and colleagues studied a group of asymptomatic singing students by means of specific anamnestic questionnaires and videolaryngostroboscopy, they found a high incidence of posterior erythema, suggesting possible reflux, in 73.4% of the subjects[11]. Tepe *et al.* also confirmed that there is a high incidence of voice-related problems in young singers who are apparently asymptomatic; the symptoms consistent with reflux (morning hoarseness) appeared to be particularly frequent [13]~~. Some authors found asymptomatic singing students and young singers with a high incidence of posterior erythema and voice problems (morning hoarseness) suggestive of pharyngolaryngeal reflux [11,13]. Other reports have demonstrated that professional singers more frequently show symptoms and signs of laryngeal reflux, vocal cord ~~cordal~~ hemorrhage and chorditis [14-16]. Sataloff (2012) reports an incidence of 72% for laryngeal alterations related to LPR detected on laryngostroboscopy in asymptomatic singing teachers [17]~~. Myint (2016) even reports a prevalence of about 90% due to laryngeal anomalies detected at laryngostroboscopy in opera singing students; such finds included vocal nodules, incomplete glottal closure, vascular anomalies and LPRD's signs [18]~~ , while Myint

even reports a prevalence of about 90% due to laryngeal anomalies (vocal nodules, incomplete glottal closure, vascular anomalies and LPRD's signs) detected at laryngostroboscopy in opera singing students [18].

In one of our works, results of laryngostroboscopy have been described and of specific anamnestic questionnaires related to voice and reflux (reflux symptom index (RSI), voice handicap index (VHI), singing-VHI) administered to a group of singing students and to a control group made up of non-singer subjects, comparable in age and sex. At laryngostroboscopy, 60.7% of students presented pathological findings, versus 20% of controls: organic lesions (bilateral nodules, cysts, sulcus vergeture), posterior erythema and laryngeal edema were more frequent in the students. The most common symptoms in singers were phono-asthenia and mucus sensation. S-VHI showed higher values in students with pathological laryngostroboscopy. Finally, average RSI and RFS were higher in students [12].

Mucosal injury from LPR could cause increased susceptibility of the vocal fold mucosa to injury and subsequent formation of nodules, polyps, or Reinke's edema [19]. ~~The subjects who use the voice for professional artistic reasons present not only a greater LPR prevalence, but also a greater prevalence of organic lesions of the vocal cords for which it is possible that the lesions that are found in the singers are not only correlated to the malmenage and vocal surmenage, but also, at least in part, to LPRD that could favour the development of benign lesions of the vocal folds [12,19].~~ The subjects who use the voice for professional artistic reasons present not only a greater LPR prevalence, but also a greater prevalence of organic lesions of the vocal cords. It is possible that the lesions that are found in the singers are not only correlated to the malmenage and vocal surmenage, but also, at least in part, to LPRD that could favour the development of benign lesions of the vocal folds [12,19].

At present, the literature about the specific LPR symptoms in singers is almost non-existent and ~~. In particular~~ the direct correlations between laryngopharyngeal reflux and the problems of the sung voice have not been studied.

This preliminary study aims to correlate RSI with SVHI, in a group of singing students, by means of

a specific anamnestic questionnaire which analyzes the physical, social, emotional and economic impacts of voice problems on the singers' lives.

Design and setting

This cross-sectional single-center observational study was conducted in the ENT Audiology and Phoniatrics Unit of University of Pisa.

Material and Methods

A group of 42 students of modern singing (26F/16M; average age: 24.9±5.7; range: 16-46 years old) filled out the Italian versions of RSI [20] and SVHI [21,22]. There were no smoker or allergic patients. Patients had no symptoms related to nasal diseases.

RSI

The Reflux Symptom Index (RSI), is a self-administered nine-item questionnaire. For each item, the score range is between 0 (no problem) and 5 (severe problem), with a maximum total score of 45 points [23]. An RSI value greater than 13 is considered as indicative of LPR [23]. The RSI used in this work is also validated for the Italian language [20].

SVHI

To evaluate vocal disability in singers, a specific questionnaire (the Italian version of the Singing-Voice Handicap Index, SVHI) was used with the aim of measuring the physical, social, emotional, and economic impacts of voice problems on the lives of singers [21,22]. The S-VHI is a 36-item self-administered questionnaire, which is able to assess difficulties related to voice health status typical of the singer, as demonstrated by its psychometric properties of reliability and validity [21,22]. The items address symptoms which are frequently reported to laryngologists and speech language pathologists by singers.

Statistical analyses

The categorical variables are expressed as percentages, while all the continuous variables are expressed as mean ± standard deviation. The Chi square or Fischer test was used in order to compare "RSI pathology classification" and categorical variables, while the T-student was used for the continuous variables. For both questionnaires, Reflux Symptom Index and Singing-Voice Handicap Index, questionnaire internal reliability was assessed using Cronbach's alpha coefficient, values above 0.7 indicating desirable levels [24].

Relationship between RSI and SVHI total score and between items was assessed with the Spearman's rank correlation coefficient (rho).

To evaluate the association between SVHI items with RSI pathology classification (>13, suggestive value for LPR), binary logistic models were performed. We defined the "RSI pathology classification" [23] (0= RSI negative ≤13; 1= RSI positive >13) as a dependent variable and the SVHI items as independent variables; both were recoded into binary variables as a positive response (2 to 4) versus a negative response (0 or 1) as suggested in original SVHI validation study [21] (0= Subjects not feeling voice problems; "never + almost never;" 1= subjects recognizing the frequency of voice problems: "sometimes + almost always + always"). In the first step the univariate binary logistic regression we performed to choose the predictive variables and subsequently a multivariate binary logistic regression to test simultaneously the combinations of variables selected by the univariate multinomial logistic (adjusted for sex and age). Results are reported as odds ratio (OR) with a 95 % confidence interval. Statistical analysis was performed by using software (SPSS version 23.0 – STATA13). All p values were two-sided and considered statistically significant when $p < 0.05$.

Results

61.9 % of the sample were female (male 38.1%) with a mean age of 24.9 years and range of 16 to 46. The mean for RSI total score was 9.1 (sd 7.1) and the median was 8 with interquartile range (IQR) 2-14.5. The mean of SVHI total score was 32.3 (sd 20.9) with a median equal to 29 (IQR 14.7-40.2).

Using the validated RSI threshold [23] (0= RSI negative ≤13; 1= RSI positive >13), 31% of participants were classified as RSI greater than 13 as an indication of suspected LPR.

Classifying the SVHI score as proposed in the recent literature review of Sobol *et al.* (2018) with a cutoff of 20.35 (95% confidence levels 10.6 to 30.1), our sample was a voice disorders prevalence of 71.4%. The prevalence was 47.6% with a SVHI score ≥ 30.1 [25].

The average age and gender percentage does not differ in the two groups RSI and S-VHI.

~~However, by correlating the individual RSI items and the individual items of S-VHI (Spearman's rho), we achieved interesting results. In particular, item 1 of the SVHI (It takes a lot of effort to sing) was highly significant correlated with most of the RSI items (RSI 1, 2, 3, 4, 7, 8 and 9; p = 0.0001 - 0.006). This shows that the presence of one of these symptoms correlated with the sensation of exertion during singing.~~ Both the questionnaires were found to have an acceptable internal reliability (RSI: α= 0.823; CI, 0.730–0.893; SVHI: α= 0.945; CI, 0.918–0.966).

There was no significant positive or negative relationship between RSI and SVHI total score (rho=0.238, p=0.130) (Figure 1).

However, by correlating the individual RSI items and the individual items of S-VHI (Spearman's rho), we achieved interesting results (Table 1). Instead, by considering the relationship between the individual items of the two questionnaires, it is highlighted that the item 1 of SVHI (It takes a lot of effort to sing) was significantly correlated with most of the RSI items (RSI 1, 2, 3, 4, 7, 8 e 9; p=0.0001–0.006). The item 2 of SVHI (My voice cracks and breaks) was correlated respectively with hoarseness, troublesome or annoying cough and feeling of something blocked or mass in the throat (p=0.005–0.009). In the same vein, the item 5 of SVHI (My ability to sing varies day to day) was correlated to hoarseness and coughing (p=0.005–0.006). Item 6 of SVHI (My voice "gives out" on me while I am singing) and the item 12 (My speaking voice is not normal) are significantly correlated with hoarseness and difficulty in swallowing food, liquids, or pills (p=0.004–0.007). The item 20 of SVHI (I have trouble controlling the raspiness in my voice) was significantly correlated with hoarseness, excess mucus in the throat or postnasal drip and with the pharyngeal globus sensation

(p=0.001–0.005). At last, the items 24, 25 26 e 30 of SVHI were related to some RSI items (p=0.0001–0.008).

~~Table 1~~ Table 2 shows the association between SVHI item response and "RSI pathology classification"; only for the 5th item a statistical significance ($p < 0.010$, Fisher test) was observed.

As suggested by Choen, by aggregating the SVHI item response as a positive response (2 to 4: "sometimes + almost always + always") versus a negative response (0 or 1; "never + almost never") between "RSI pathology classification", a significant association was observed for SVHI item 1 ($p < 0.021$, Fisher test), SVHI item 5 ($p < 0.006$, Fisher test), SVHI item 20 ($p < 0.042$, Fisher test), SVHI item 24 ($p < 0.044$, Fisher test) and SVHI item 25 ($p < 0.047$, Fisher test).

These associations were confirmed by univariate binary logistic (~~Table 2~~ Table 3), which also shows the strength of the association. The results showed that, in the subjects who affirm "My ability to sing varies day to day", SVHI Item 5 were more associated with RSI+ (OR 8.750; CI 1.903–32.235). Statistically significant associations with RSI+ were also observed for the SVHI Item 1 "It takes a lot of effort to sing" (OR 6.769; CI 1.268–31.139), for SVHI Item 25 "My speaking voice is hoarse after I sing" OR 5.417; CI 1.055–27.814) and for SVHI Item 20 and 24. No statistically significant association was observed for all other SVHI items.

Multivariate binary logistic regression performed with the significant variables selected by the univariate model (Figure 2 and Table 4) confirms that SVHI Item 1 "It takes a lot of effort to sing" (OR 13.357; CI 1.178–51.047) and SVHI Item 5 "My ability to sing varies day to day" (OR 11.917; CI 1.605–48.509) were more associated with RSI+. Statistically significant associations were also observed for SVHI Item 20 "I have trouble controlling the raspiness in my voice" and for the age. No statistically significant association was observed for the gender.

Based on results described above, we propose a questionnaire that combines the most relevant SVHI items correlated to LPRD, in order to reduce their number (Table 5). The psychometric properties for the chosen items were good. Cronbach's alpha coefficient for the 10 items selected was 0.87, indicating good internal consistency. Item-total correlation coefficients for each item were in the

range of 0.461-0.670 (Table 6). All the item-total correlation coefficients were found to be higher than 0.40, which is the suggested minimum level. For each item, if it was removed, the alpha coefficients of Cronbach were slightly lower than the overall alpha coefficient of Cronbach (Table 6). This finding indicates that all the 10 items selected could be well integrated into the SVHI-10-LPRD reduced questionnaire.

Stata's power command calculation (STATA 13) for logistic regression models was used to perform the Posteriori Power Analysis for Odds Ratios (OR).

Based on the Odds Ratios emerged from the binary logistic regression with 42 subjects the Posteriori Power Analysis for SVHI-n.1 was 0.89, for SVHI-n.5 was 0.81, and for SVHI-n.20 was 0.75 .

Discussion

LPRD related symptoms impair quality of life and the studies support that patients with LPRD have significant deterioration of voice quality [9,26]. Clinical and experimental studies reported that LPRD leads to the development of significant histological changes in the mucosa of the vibratory margin of the vocal folds. Indeed, many alterations of vocal cords (epithelial cell dehiscence and epithelial thickening, Reinke's space modifications, inflammatory infiltrates, mucosal drying), are associated with LPRD [19]. These histological changes may modify the biomechanical properties of the vocal fold tissue leading to hoarseness.

Alterations of perceptual voice quality (primarily grades of dysphonia and roughness) and of acoustic voice assessments (standard deviation of fundamental frequency, noise to harmonic ratio phonatory fundamental frequency range, percent jitter, pitch perturbation quotient, percent shimmer, smoothed amplitude perturbation quotient, peak-to-peak amplitude variation) are associated with LPRD [9,27]. Besides, the self-assessment of the voice is altered in case of LPRD, with pathological values of VHI [27].

Singers with LPRD may have normal speaking voice but impaired singing voice (vocal fatigue,

hoarseness, and loss of range), with a dramatic impact on theirs daily life [8]. A specific questionnaire, the SVHI, has been created aimed to measure the physical, social, emotional and economic impacts of voice problems on the singers' lives. The SVHI is a valid tool for assessing self-perceived handicap associated with singing problems and is more reliable than the VHI to assess the singer's voice problems [12,21,22].

In this study, the RSI and SVHI were given to a group of 42 singing students in order to correlate the suggestive symptomatology of LPRD with the problems related to vocal performance studied with SVHI. The internal consistency of the instrument was satisfied with Cronbach's alpha greater than 0.8 for both questionnaires. The RSI mean value in the study group was less than the cut off of 13 (9.1±7.1), but the 31% of students showed an RSI higher than 13, that is suggestive for an LPR. This data, characteristic of a high prevalence of symptomatology related to reflux in singing students, was consistent with the data present in the literature and with the results of one of our recent studies [11,12,18]. The SVHI mean value resulted 32.3±20.9 with a median equal to 29. Classifying the SVHI score as proposed by Sobol et al (2018) with a 20.35 of cut off and a a 95% confidence interval between 10.6 and 30.1, the 71.4% presented voice disorders in our study group (if a cut off of 20.35 is considered) [25] . Instead, when the upper confidence limit 30.1 was considered as the cut off, then the prevalence of a voice disorders dropped to 47.6%. SVHI measures several components related to vocal issues (physical, social, emotional and economic) and how these different elements impact on the lives of singers. In our study group, the average age was less than 25 years with an age range between 16 and 46 years; only one student was over 40 and only 5 students were over 30 years old. In other words, in our study group the singing students evaluated were young and in the compilation of the SVHI may have affected, both a poor vocal technique and psychological components and habits of life and incorrect food. These elements could explain the high prevalence of voice disorders in young singing students when evaluated with specific scores [12].

Considering the scores of the single questionnaires as ordinal values and comparing the RSI with the SVHI in each individual patient, we did not obtain a significant correlation (Figure 1). Relationship

between RSI and SVHI total score, and between items was assessed with the Spearman's rank correlation coefficient; there was no significant positive or negative relationship between RSI and SVHI total score (p= 0.13). The fact that there is no significant association between RSI and SVHI scores is interesting, but it should be confirmed with a larger and different (age and gender) study cohort. SVHI is an anamnestic questionnaire that analyzes many components, including the physical, social, emotional and economic impacts of voice problems on the singers' lives. For this reason, probably not all the 36 items of the SVHI can be correlated with a PLR-related voice disorder. We propose a questionnaire that combines the most relevant SVHI items - LPRD correlated, in order to reduce the number of items. This SVHI-10-LPRD correlated questionnaire could also be useful for monitoring treatment's results (Table 5). For the items chosen, the psychometric properties were good. Cronbach's alpha coefficient for the 10 items selected was 0.87, indicating a good internal consistency (Table 6). Although the results in our study are satisfactory it will be necessary to conduct other research to evaluate the factorial structure in a larger sample.

However, by correlating the individual RSI items and the individual items of S-VHI (Spearman's rho), we achieved interesting results. In particular, item 1 of the SVHI (It takes a lot of effort to sing) was highly significant correlated with most of the RSI items (RSI 1, 2, 3, 4, 7, 8 and 9; p = 0.0001 - 0.006). This shows that the presence of one of these symptoms is correlated with the sensation of exertion during singing. One of the symptoms related to LPR in non-singer subjects is phonastenia, so it is not surprising that in singing students the effort is one of the symptoms most closely related to the individual RSI items. The SVHI item 2 (My voice cracks and breaks) was also correlated respectively with hoarseness, troublesome or annoying cough and feeling of something blocked or mass in the throat (p = 0.005 – 0.009). In addition to item 2, also item 5 of the SVHI (My ability to sing ~~various days~~ varies day to day) was related to hoarseness and cough (p = 0.005 - 0.006). LPR determines dryness of the mucosa, epithelial cell dehiscence, and inflammatory infiltrates, for which it is understandable how the voice can crack and break. Moreover, the effects of reflux on the vocal

cords are not constant, and the degree of reflux can vary depending on various factors, among which the most important is certainly the type of feeding during evening meals. The degree of dysphonia from LPR has a non-constant course and varies more than the organic lesions of the glottic plane (nodules, cysts, polyps), so it is not surprising that in the pupils, reflux episodes can cause considerable variability (even from day to day) in singing skills. The item 6 of the SVHI (My voice "gives out" on me while I am singing) and the item 12 (My speaking voice is not normal) are significantly correlated with hoarseness and difficulty in swallowing food, liquids, or pills ($p = 0.004 - 0.007$). The item 6 confirms the instability of the sung voice characteristic of the LPR, while the correlation of the item 12 highlights that the singers presenting LPR have a dysfunction of both the spoken and the sung voice.

Item 20 of SVHI (I have trouble controlling the raspiness in my voice) is significantly correlated with hoarseness, excess mucus in the throat or postnasal drip and with the pharyngeal globe ($p = 0.001 – 0.005$). Among the features of the item, in the case of LPR, we recall roughness and increase in the noise to harmonic ratio, so the association between item 20 of SVHI and LPR appears to be consistent. Also items 24, 25 26 e 30 of SVHI are related to some items of RSI ($p = 0.0001 – 0.008$), confirming that hoarseness, excess mucus and cough are associated with alteration of the sung voice in the case of LPR.

To evaluate the strength of the association between the SVHI items with the RSI ones, we performed a monovariate and multivariate binary logistics with a step wise procedure. According to our results, in case of significant RSI for LPR, singing students are 13 times more likely to perceive effort to sing, 12 times greater than having an ability to variably sing from day to day and 3 times higher than having trouble controlling the breathiness in voice.

Conclusions

Performed on a sample of singing students, this pilot study shows that, in case of significant RSI for LPR, it is possible to observe a significant association with some symptoms described in SVHI.

These results underline that the association of the RSI and SVHI questionnaires administered to singers and singing students, can represent a simple screening to reveal possible alterations of the singing voice correlate to LPR. In particular, in the case of RSI suggestive for LPR, in the presence of effort to sing, ability to sing variable from day to day and trouble controlling the raspiness in my voice it will be useful to plan further investigations, to perform a phoniatric examination and a videolaryngostroboscopy. It will be necessary to increase the sample of subjects in the study to confirm these preliminary data.

Conflict of interest: None

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	RSI-1	RSI-2	RSI-3	RSI-4	RSI-5	RSI-6	RSI-7	RSI-8	RSI-9	SVHI-1	SVHI-2	SVHI-5	SVHI-6	SVHI-12	SVHI-20	SVHI-24	SVHI-25	SVHI-26	SVHI-30
RSI-1	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RSI-2	**0.547****	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RSI-3	**0.573****	**0.597****	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RSI-4	**0.522****	**0.379***	0.208	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RSI-5	**0.320***	**0.581****	0.234	**0.494****	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RSI-6	0.077	**0.398****	0.212	**0.445****	**0.353***	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-
RSI-7	**0.443****	0.202	**0.393***	**0.413****	0.265	0.171	**1**	-	-	-	-	-	-	-	-	-	-	-	-
RSI-8	**0.500****	**0.507****	**0.496****	**0.443****	**0.373***	-0.021	**0.482****	**1**	-	-	-	-	-	-	-	-	-	-	-
RSI-9	**0.346***	**0.523****	**0.370***	0.259	0.287	-0.127	0.303	**0.681****	**1**	-	-	-	-	-	-	-	-	-	-
SVHI-1	**0.578****	**0.416****	**0.572****	**0.557****	**0.334***	0.258	**0.528****	**0.501****	**0.485****	**1**	-	-	-	-	-	-	-	-	-
SVHI-2	**0.423****	0.287	**0.369***	**0.319***	-0.018	0.108	**0.400****	**0.375***	**0.407****	**0.514****	**1**	-	-	-	-	-	-	-	-
SVHI-5	**0.427****	0.277	0.254	**0.418****	**0.427****	0.207	0.260	0.162	0.252	0.282	0.248	**1**	-	-	-	-	-	-	-
SVHI-6	**0.418****	0.176	**0.346***	**0.431****	0.003	0.133	**0.318***	**0.368***	**0.319***	**0.417****	**0.577****	**0.484****	**1**	-	-	-	-	-	-
SVHI-12	**0.416****	-0.089	0.057	**0.409****	-0.082	-0.078	0.166	0.126	-0.034	0.142	**0.365***	**0.492****	**0.533****	**1**	-	-	-	-	-
SVHI-20	**0.446****	0.095	**0.485****	0.202	-0.138	-0.158	0.217	**0.230****	0.297	**0.324***	**0.439****	0.258	**0.448****	**0.316***	**1**	-	-	-	-
SVHI-24	**0.487****	0.178	**0.401****	0.234	-0.076	-0.010	0.289	0.255	0.266	0.265	**0.474****	**0.349***	**0.315***	**0.377***	**0.772****	**1**	-	-	-
SVHI-25	**0.307***	0.164	**0.649****	0.080	-0.048	0.053	0.262	**0.333***	0.238	**0.337***	0.212	**0.313***	**0.480****	0.247	**0.597****	**0.489****	**1**	-	-
SVHI-26	**0.322***	-0.016	**0.310***	0.201	0.133	0.072	**0.490****	0.242	**0.329***	**0.505****	**0.356***	**0.670****	**0.326***	0.225	**0.437****	**0.547****	**0.402****	**1**	-
SVHI-30	0.200	0.072	**0.390***	0.171	0.088	0.011	**0.447****	0.256	0.201	**0.396****	**0.394****	0.175	**0.498****	0.022	**0.369***	0.182	**0.364***	**0.431****	**1**

****. Correlation is significant at the 0.01 level (2-tailed).**

***. Correlation is significant at the 0.05 level (2-tailed).**

Table 1. Spearman's rho correlation table between the RSI items and the most related SVHI questions.

		RSI negative ≤13	RSI positive >13	Fisher's Exact Test
Negative response (-) =0 or 1; "never + almost never Positive response (+) = 2 to 4: "sometimes + almost always + always")	**SVHI (-) (+)**	%	%	P value
1. It takes a lot of effort to sing	-	55.2%	15.4%	0.021
	+	44.8%	84.6%	
2. My voice cracks and breaks	-	58.6%	46.2%	0.516
	+	41.4%	53.8%	
3. I am frustrated by my singing	-	58.6%	46.2%	0.516
	+	41.4%	53.8%	
4. People ask ''What is wrong with your voice?'' when I sing	-	86.2%	76.9%	0.657
	+	13.8%	23.1%	
5. My ability to sing varies day to day	-	72.4%	23.1%	0.006
	+	27.6%	76.9%	
6. My voice ''gives out'' on me while I am singing	-	86.2%	61.5%	0.107
	+	13.8%	38.5%	
7. My singing voice upsets me	-	79.3%	92.3%	0.405
	+	20.7%	7.7%	
8. My singing problems make me not want to sing/perform	-	79.3%	76.9%	0.962
	+	20.7%	23.1%	
9. I am embarrassed by my singing	-	69.0%	76.9%	0.722
	+	31.0%	23.1%	
10. I am unable to use my ''high voice''	-	51.7%	61.5%	0.739
	+	48.3%	38.5%	
11. I get nervous before I sing because of my singing problems	-	86.2%	76.9%	0.657
	+	13.8%	23.1%	
12. My speaking voice is not normal	-	75.9%	69.2%	0.713
	+	24.1%	30.8%	
13. My throat is dry when I sing	-	79.3%	69.2%	0.697
	+	20.7%	30.8%	
14. I've had to eliminate certain songs from my singing	-	75.9%	61.5%	0.463
	+	24.1%	38.5%	
15. I have no confidence in my singing voice	-	75.9%	76.9%	0.966
	+	24.1%	23.1%	
16. My singing voice is never normal	-	89.7%	84.6%	0.637
	+	10.3%	15.4%	
17. I have trouble making my voice do what I want it to	-	51.7%	53.8%	0.899
	+	48.3%	46.2%	
18. I have to ''push it'' to produce my voice when singing	-	62.1%	84.6%	0.278
	+	37.9%	15.4%	
19. I have trouble controlling the breathiness in my voice	-	75.9%	69.2%	0.713
	+	24.1%	30.8%	
20. I have trouble controlling the raspiness in my voice	-	75.9%	46.2%	0.042
	+	24.1%	53.8%	
21. I have trouble singing loudly	-	79.3%	76.9%	0.863
	+	20.7%	23.1%	
22. I have difficulty staying on pitch when I sing	-	72.4%	92.3%	0.232
	+	27.6%	7.7%	
23. I feel anxious about my singing	-	65.5%	46.2%	0.314
	+	34.5%	53.8%	
24. My singing sounds forced	-	75.9%	46.2%	0.044
	+	24.1%	53.8%	
25. My speaking voice is hoarse after I sing	-	89.7%	61.5%	0.047
	+	10.3%	38.5%	
26. My voice quality is inconsistent	-	75.9%	69.2%	0.713
	+	24.1%	30.8%	
27. My singing voice makes it difficult for the audience to hear me	-	89.7%	92.3%	0.783
	+	10.3%	7.7%	
28. My singing makes me feel handicapped	-	96.6%	100.0%	0.503
	+	3.4%	0.0%	
29. My singing voice tires easily	-	58.6%	61.5%	0.858
	+	41.4%	38.5%	
30. I feel pain, tickling, or choking when I sing	-	96.6%	84.6%	0.541
	+	3.4%	15.4%	

31. I am unsure of what will come out when I sing	- +	44.8% 55.2%	38.5% 61.5%	0.748
32. I feel something is missing in my life because of my inability to sing	- +	82.8% 17.2%	76.9% 23.1%	0.686
33. I am worried my singing problems will cause me to lose money	- +	93.1% 6.9%	92.3% 7.7%	0.827
34. I feel left out of the music scene because of my voice	- +	82.8% 17.2%	92.3% 7.7%	0.647
35. My singing makes me feel incompetent	- +	72.4% 27.6%	84.6% 15.4%	0.466
36. I have to cancel performances, singing engagements, rehearsals, or practices because of my singing	- +	96.6% 3.4%	84.6% 15.4%	0.540

Table 2. Association of Singing Voice Handicap Index frequency (Negative response = 0 or 1; "never + almost never"; Positive response = 2 to 4: "sometimes + almost always + always") and RSI pathology classification (RSI+ vs RSI-).

		OR	(95% - CI)		Sign.
SVHI 1	It takes a lot of effort to sing	6.769	1.268	31.139	0.025
SVHI 5	My ability to sing varies day to day	8.750	1.903	32.235	0.005
SVHI 20	I have trouble controlling the raspiness in my voice	3.667	1.020	14.617	0.046
SVHI 24	My singing sounds forced	3.667	1.002	14.617	0.047
SVHI 25	My speaking voice is hoarse after I sing	5.417	1.055	27.814	0.043

Table 3. Univariate binary logistic regression: relation between SVHI Items and among RSI pathology classification (RSI+ vs RSI-).

		OR	(95% - CI)		Sign.
SVHI 1	It takes a lot of effort to sing	13.357	1.178	51.047	0.036
SVHI 5	My ability to sing varies day to day	11.917	1.605	48.509	0.015
SVHI 20	I have trouble controlling the raspiness in my voice	3.138	1.023	21.947	0.011
Age	As a continuous variable	1.256	1.002	14.617	0.047
Gender	Female vs Male	1.444	0.265	7.871	0.671

Table 4. Multivariate binary logistic regression: relation between SVHI items and among RSI pathology classification (RSI+ vs RSI-).

How frequently you have had the same experience in the last month?	Never	Almost never	Sometimes	Almost always	Always
It takes a lot of effort to sing	0	1	2	3	4
My voice cracks and breaks					
My ability to sing varies day to day					
My voice "gives out" on me while I am singing					
My speaking voice is not normal					
I have trouble controlling the raspiness in my voice					
My singing sounds forced					
My speaking voice is hoarse after I sing					
My voice quality is inconsistent					
I feel pain, tickling, or choking when I sing					

Table 5. Singing Voice Handicap Index correlated to LPR (SVHI-10-LPRD)

How frequently you have had the same experience in the last month?	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha 95% Confidence Interval
It takes a lot of effort to sing	0.501	0.860	
My voice cracks and breaks	0.560	0.850	
My ability to sing varies day to day	0.560	0.854	
My voice "gives out" on me while I am singing	0.670	0.844	
My speaking voice is not normal	0.514	0.858	**0.870 (0.794-0.918)**
I have trouble controlling the raspiness in my voice	0.666	0.844	
My singing sounds forced	0.662	0.844	
My speaking voice is hoarse after I sing	0.564	0.853	
My voice quality is inconsistent	0.603	0.850	
I feel pain, tickling, or choking when I sing	0.461	0.861	

Table 6. Psychometric properties of Singing Voice Handicap Index correlated to LPR (SVHI-10-LPRD)

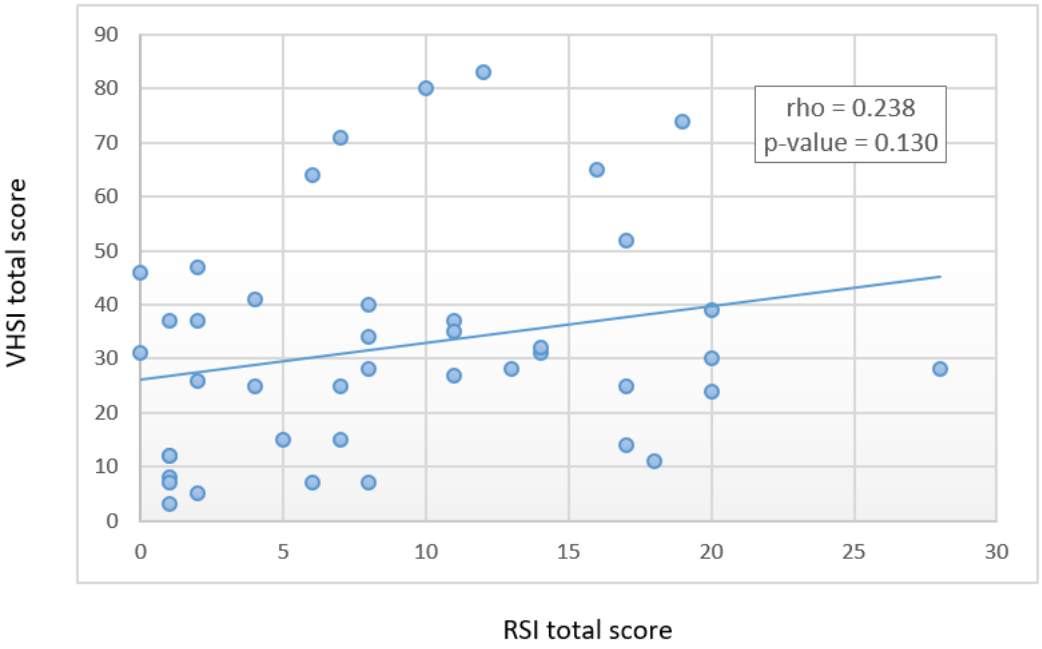


Figure 1 Spearman's rank correlation coefficient (rho) between RSI and SVHI total score

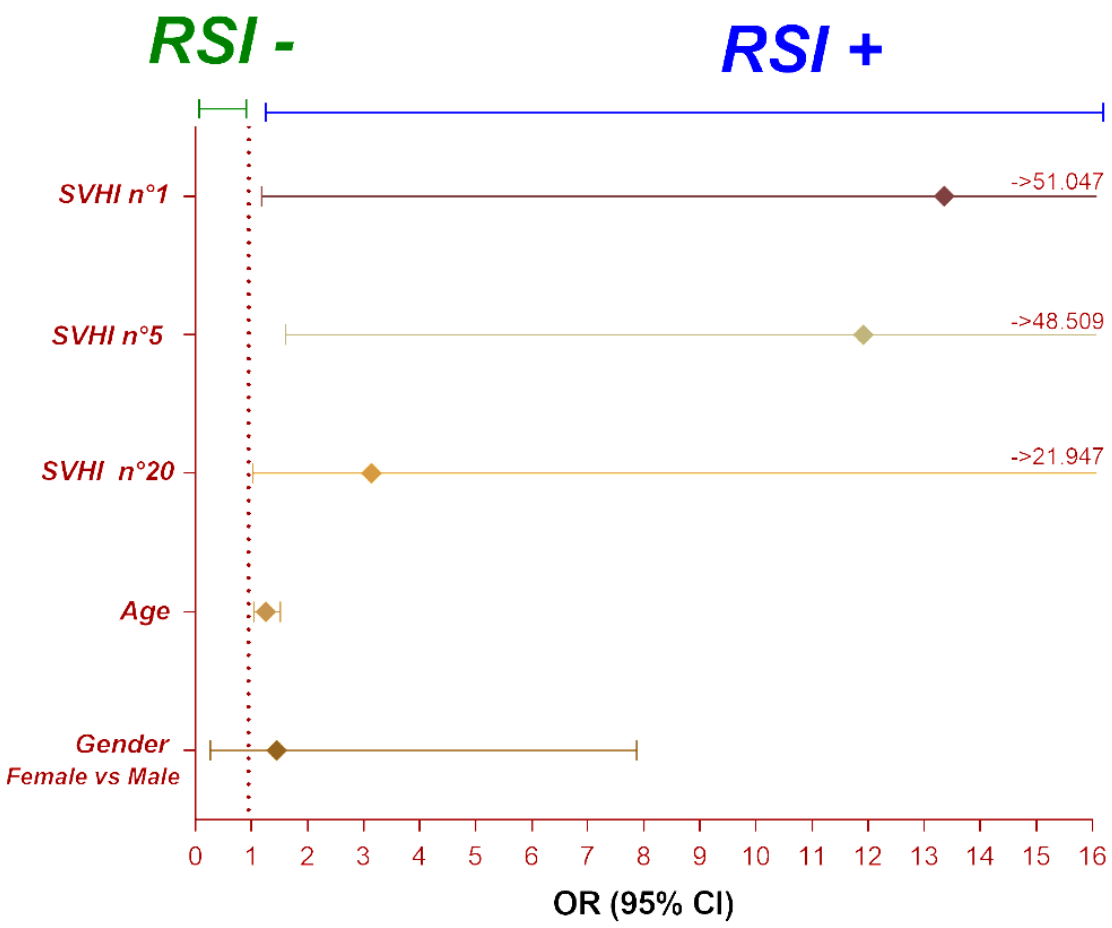
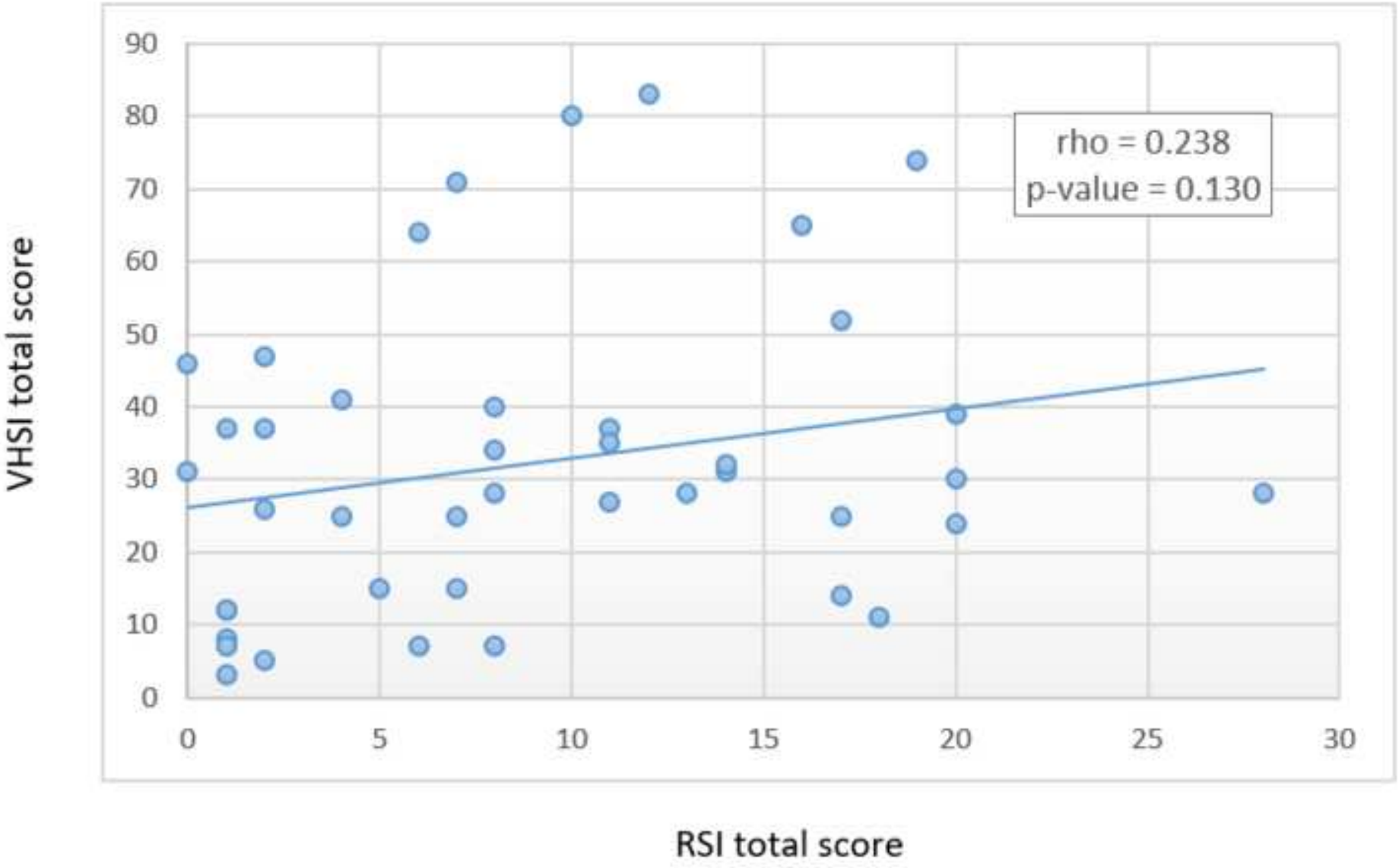


Figure 2. Multivariate binary logistic regression: relation between SVHI Items and among RSI pathology classification (RSI+ vs RSI-).

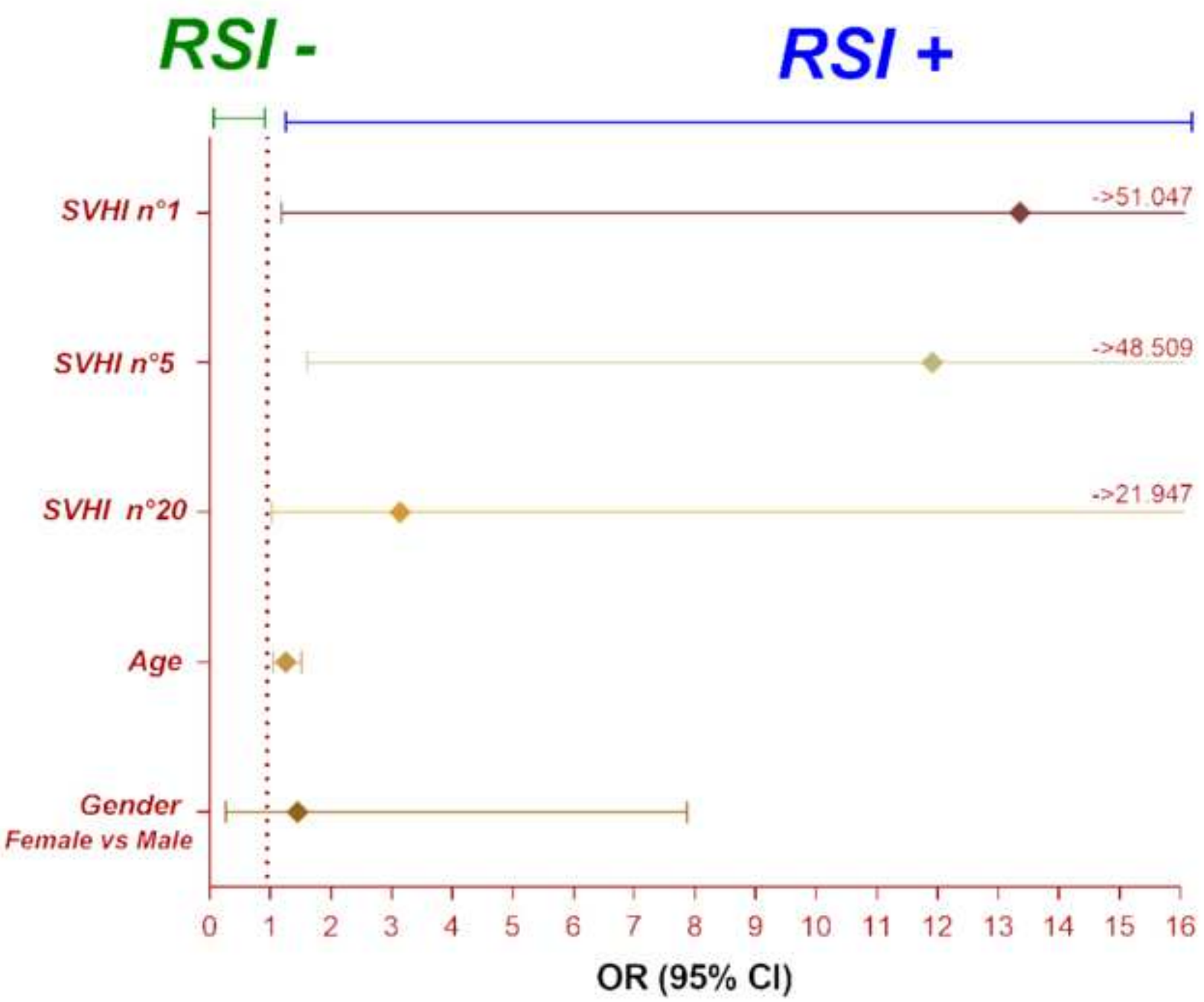
Figure

Click here to access/download;Figure;REVISED_RSI and SVHI in singing students_FIGURE 1.tif



Figure

Click here to access/download;Figure;REVISED_RSI and SVHI in singing students_FIGURE 2.tif



Table

	RSI-1	RSI-2	RSI-3	RSI-4	RSI-5	RSI-6	RSI-7	RSI-8	RSI-9	SVHI-1	SVHI-2	SVHI-5	SVHI-6	SVHI-12	SVHI-20	SVHI-24	SVHI-25	SVHI-26	SVHI-30
RSI-1	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RSI-2	**0.547****	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RSI-3	**0.573****	**0.597****	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RSI-4	**0.522****	**0.379***	0.208	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RSI-5	**0.320***	**0.581****	0.234	**0.494****	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RSI-6	0.077	**0.398****	0.212	**0.445****	**0.353***	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-
RSI-7	**0.443****	0.202	**0.393***	**0.413****	0.265	0.171	**1**	-	-	-	-	-	-	-	-	-	-	-	-
RSI-8	**0.500****	**0.507****	**0.496****	**0.443****	**0.373***	-0.021	**0.482****	**1**	-	-	-	-	-	-	-	-	-	-	-
RSI-9	**0.346***	**0.523****	**0.370***	0.259	0.287	-0.127	0.303	**0.681****	**1**	-	-	-	-	-	-	-	-	-	-
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16. My singing voice is never normal	-	89.7%	84.6%	0.637
	+	10.3%	15.4%	
17. I have trouble making my voice do what I want it to	-	51.7%	53.8%	0.899
	+	48.3%	46.2%	
18. I have to ''push it'' to produce my voice when singing	-	62.1%	84.6%	0.278
	+	37.9%	15.4%	
19. I have trouble controlling the breathiness in my voice1	-	75.9%	69.2%	0.713
	+	24.1%	30.8%	
20. I have trouble controlling the raspiness in my voice	-	75.9%	46.2%	0.042
	+	24.1%	53.8%	
21. I have trouble singing loudly	-	79.3%	76.9%	0.863
	+	20.7%	23.1%	
22. I have difficulty staying on pitch when I sing	-	72.4%	92.3%	0.232
	+	27.6%	7.7%	
23. I feel anxious about my singing	-	65.5%	46.2%	0.314
	+	34.5%	53.8%	
24. My singing sounds forced	-	75.9%	46.2%	0.044
	+	24.1%	53.8%	
25. My speaking voice is hoarse after I sing	-	89.7%	61.5%	0.047
	+	10.3%	38.5%	
26. My voice quality is inconsistent	-	75.9%	69.2%	0.713
	+	24.1%	30.8%	
27. My singing voice makes it difficult for the audience to hear me	-	89.7%	92.3%	0.783
	+	10.3%	7.7%	
28. My singing makes me feel handicapped	-	96.6%	100.0%	0.503
	+	3.4%	0.0%	
29. My singing voice tires easily	-	58.6%	61.5%	0.858
	+	41.4%	38.5%	
30. I feel pain, tickling, or choking when I sing	-	96.6%	84.6%	0.541
	+	3.4%	15.4%	

31. I am unsure of what will come out when I sing	- +	44.8% 55.2%	38.5% 61.5%	0.748
32. I feel something is missing in my life because of my inability to sing	- +	82.8% 17.2%	76.9% 23.1%	0.686
33. I am worried my singing problems will cause me to lose money	- +	93.1% 6.9%	92.3% 7.7%	0.827
34. I feel left out of the music scene because of my voice	- +	82.8% 17.2%	92.3% 7.7%	0.647
35. My singing makes me feel incompetent	- +	72.4% 27.6%	84.6% 15.4%	0.466
36. I have to cancel performances, singing engagements, rehearsals, or practices because of my singing	- +	96.6% 3.4%	84.6% 15.4%	0.540

Table 2. Association of Singing Voice Handicap Index frequency (Negative response = 0 or 1; "never + almost never"; Positive response = 2 to 4: "sometimes + almost always + always") and RSI pathology classification (RSI+ vs RSI-).

Table

		OR	(95% - CI)		Sign.
SVHI 1	It takes a lot of effort to sing	6.769	1.268	31.139	0.025
SVHI 5	My ability to sing varies day to day	8.750	1.903	32.235	0.005
SVHI 20	I have trouble controlling the raspiness in my voice	3.667	1.020	14.617	0.046
SVHI 24	My singing sounds forced	3.667	1.002	14.617	0.047
SVHI 25	My speaking voice is hoarse after I sing	5.417	1.055	27.814	0.043

Table 3. Univariate binary logistic regression: relation between SVHI Items and among RSI pathology classification (RSI+ vs RSI-).

Table

		OR	(95% - CI)		Sign.
SVHI 1	It takes a lot of effort to sing	13.357	1.178	51.047	0.036
SVHI 5	My ability to sing varies day to day	11.917	1.605	48.509	0.015
SVHI 20	I have trouble controlling the raspiness in my voice	3.138	1.023	21.947	0.011
Age	As a continuous variable	1.256	1.002	14.617	0.047
Gender	Female vs Male	1.444	0.265	7.871	0.671

Table 4. Multivariate binary logistic regression: relation between SVHI items and among RSI pathology classification (RSI+ vs RSI-).

Table

Table 5. Singing Voice Handicap Index correlated to LPR (SVHI-10-LPRD)

How frequently you have had the same experience in the last month?	Never	Almost never	Sometimes	Almost always	Always
It takes a lot of effort to sing	0	1	2	3	4
My voice cracks and breaks					
My ability to sing varies day to day					
My voice "gives out" on me while I am singing					
My speaking voice is not normal					
I have trouble controlling the raspiness in my voice					
My singing sounds forced					
My speaking voice is hoarse after I sing					
My voice quality is inconsistent					
I feel pain, tickling, or choking when I sing					

Table

Table 6. Psychometric properties of Singing Voice Handicap Index correlated to LPR (SVHI-10-LPRD)

How frequently you have had the same experience in the last month?	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha 95% Confidence Interval
It takes a lot of effort to sing	0.501	0.860	
My voice cracks and breaks	0.560	0.850	
My ability to sing varies day to day	0.560	0.854	
My voice "gives out" on me while I am singing	0.670	0.844	
My speaking voice is not normal	0.514	0.858	**0.870 (0.794-0.918)**
I have trouble controlling the raspiness in my voice	0.666	0.844	
My singing sounds forced	0.662	0.844	
My speaking voice is hoarse after I sing	0.564	0.853	
My voice quality is inconsistent	0.603	0.850	
I feel pain, tickling, or choking when I sing	0.461	0.861	