

## Vocal Quality, Symptoms, and Habits in Musical Theater Actors

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### SUMMARY

**Purpose:** The purpose of this study was to measure and compare the voice characteristics and vocal complaints and habits of musical theater actors and musical theater students.

**Method:** Thirty participants were included in the study, 18 musical theater students and 12 professional musical theater actors. Vocal quality was measured by the multiparameter indices Dysphonia Severity Index (DSI) and Acoustic Voice Quality Index (AVQI). A perceptual evaluation of the speaking voice was performed using the GRBASI scale. All participants completed the Voice Handicap Index (VHI), the VHI adapted to the singing voice, the Vocal Tract Discomfort (VTD) Scale and the Corporal Pain Scale.

**Results:** Excellent scores for DSI (resp. 7.3, 7.1) and AVQI (resp. 2.6, 2.5) were found in the musical theater actors and students. All participants reported at least two symptoms of VTD and the mean scores for the VHI adapted to the singing voice were located in the clinical zone. Musical theater students reported significantly more VTD and pain symptoms compared to the professionals. No significant differences in perceptual and objective voice characteristics were found between musical theater actors and students. A higher presence of vocal misuse and stress in the students was observed.

**Conclusion:** Musical theater students and actors are elite vocal performers with comparable excellent objective vocal measures (DSI, AVQI). In both groups, an increased number of VTD and complaints of the singing voice were reported. Especially students were vulnerable for stress, vocal misuse, VTD, and pain symptoms. The findings suggest that musical theater actors are a risk group for developing voice disorders requiring multidimensional voice assessment and voice care.

**Key Words:** Musical theater —Singers —Actors —Voice

## INTRODUCTION

Musical theater is a unique performance genre that consists of a variety of vocal styles interchanging with dialogues and diverse physical activities. Musical theater actors typically have a heavy vocal load during rehearsals and performances.<sup>36,28</sup> Performances can be scheduled 6 to 10 times a week for seasons that can last for weeks to years<sup>7, 36</sup>, and many actors combine this work with other assignments in the professional field. In contemporary musical theater productions, different vocally demanding singing styles such as rock, pop, belt, and belt mix are used.<sup>36, 37</sup> Musical theater actors sing and dance during exhausting choreographies and combine it with acting. The dialogues often contain intensive physical exertions and vocally violent behavior like screaming, shouting, crying, or sobbing.<sup>3</sup> Actors must be able to express the full range of human emotions and adjust their phonation to different environmental conditions.<sup>4</sup> On stage, smoke, dust, improper amplification, and restricting or heavy costumes, can negatively impact the vocal quality.<sup>45</sup> Off-stage behavior in performers is sometimes characterized by poor vocal hygiene and a lack of vocal as well as physical rest.<sup>6</sup> Gehling et al,<sup>7</sup> on the other hand, showed that the population of Broadway performers has low rates of deleterious behavior compared with national averages.<sup>7</sup> In the population of musical theater students, a high presence of harmful vocal habits was found.<sup>8,9</sup> The most striking observation was the high prevalence of stress and anxiety (87, 7%).<sup>8</sup> According to Donahue et al<sup>9</sup>, preprofessional musical theater students represent a unique population of students who rely on optimal voice production for educational pursuits and for eventual job opportunities. Musical theater students receive an intensive training in singing, dancing, and acting and are expected to participate in long rehearsals and full performances.

In professional and preprofessional vocal athletes, a slight vocal problem can result in (future) occupational, emotional, and psychosocial problems. Dysphonia can reduce the quality of the performance or result in a cancellation of the show, both having financial implications.<sup>5</sup> Because of the heavy vocal load, musical theater actors are a potential high risk group for developing voice disorders, although there is a lack of controlled studies investigating this assumption<sup>36</sup>. Prevalence data regarding voice disorders in musical theater actors are limited. A survey of Gehling et al<sup>7</sup> in musical theater actors revealed that 25% of the respondents had been diagnosed with a voice disorder. Phylant et al<sup>2</sup> investigated professional opera, musical theater and contemporary singers using a vocal health questionnaire. The occurrence of a diagnosed vocal condition was 44% and 69% of the singers experienced a vocal disability. Despite a high presence of vocal symptoms, the reported number of days missed per year (1.4-4.7) is relatively low in this group of voice users.<sup>7</sup> The most frequently reported symptom in musical theater actors and students is vocal fatigue.<sup>8, 9, 36</sup> Some authors<sup>36</sup> described that vocal fatigue in musical theater actors can possibly be regarded as a work-related symptom that can vary across time and performances. It is currently unknown when vocal symptoms like vocal fatigue are “normal” for performers and when these symptoms are the result of “overload” and may lead to laryngeal pathology.

Laryngoscopic evaluations in musical theater actors reveal a high degree of edema, decreased vibratory behavior, decreased mucosal wave, and an hourglass closure pattern.<sup>5</sup> Also in musical theater students, a high presence of inflammatory lesions (26%) and supraglottal constriction during normal phonation (68%) was observed.<sup>8</sup>

The acoustic vocal quality of musical theater actors is an understudied topic in the literature. Multidimensional voice approaches containing objective voice measurements are standard in clinical assessments of voice disorders. However, normative data regarding the musical

theater's voice are lacking. Hoffman-Ruddy et al<sup>5</sup> compared some individual acoustic parameters between musical theater actors, street actors, and choral ensemble and found that, although the worst results were found in street actors, no statistical differences between the three groups were found for the acoustic parameters. A previous study in musical theater students revealed that their objective vocal quality, measured with the Dysphonia Severity Index (DSI), is much better than the normative data.<sup>8</sup> The mean DSI scores for male and female students were respectively 5.3 and 5.7, both corresponding with excellent vocal capacities. Timmermans et al,<sup>6</sup> however, described a reduced vocal quality in musical theater students reflected in a mean DSI score of 2.3. To the best of our knowledge, there are no studies investigating the objective vocal quality of professional musical theater actors using a multiparameter index. This highlights the need for different normative data for musical theater performers. The purpose of this study was to investigate and compare the vocal quality, vocal complaints, and vocal habits of professional musical theater actors and musical theater students. Hypothetically, both groups will show good vocal capacities despite the heavy vocal load. The best results are expected in the more experienced professional musical theater actors.

## **METHODS**

This study was performed according to the Declaration of Helsinki and approved by the Ethics Committee of Ghent University Hospital (registration number: B670201630345). A written informed consent was obtained from each participant.

### **Participants**

Thirty subjects with a mean age of 23.6 y (standard deviation [SD]: 4.5, range: 17-38 y) participated in the study. The group of musical theater students consisted of 14 female and 4 male full-time students in a bachelor musical program in Belgium or The Netherlands (mean age: 21.3y, SD 2.14; range 17-26y). All students succeeded in the entrance test of the musical program. The group of professional musical theater actors consisted of 8 women and 4 men (mean age: 27.1y, SD 4.98; range 20-38). Inclusion criteria for this group were having a bachelor degree in musical theater, and working at least 12 months as a musical theater actor. All participants were in a good physical and mental state of well-being, and reported normal hearing.

### **Voice assessment protocol**

All participants underwent a voice assessment protocol consisting of questionnaires investigating vocal symptoms and their impact on psychosocial functioning (Voice Handicap Index (VHI),<sup>10</sup> VHI adapted to the singing voice,<sup>11</sup> Vocal Tract Discomfort (VTD) Scale,<sup>12</sup> and the Corporal Pain Scale (CPS) (Van Lierde et al), an auditory-perceptual evaluation of the voice, and an objective voice assessment consisting of multiparameter voice quality indices.

#### *Vocal symptoms and habits*

The self-perception of vocal symptoms of the speaking and singing voice was investigated using the Dutch version of the VHI<sup>13,10</sup> and the VHI adapted to the singing voice.<sup>14,11</sup> The VHI and the VHI adapted to the singing voice are self-administered questionnaires consisting of 30 statements. Each statement is evaluated on a 5 point grading scale (0 = never, 1 = almost never, 2 = sometimes, 3 = almost always, 4 = always). The total VHI scores varies between 0 and 120 and the higher the score, the more perceived disability due to voice difficulties of respectively

the speaking and the singing voice is present. Cutoff scores of 20 are used to identify voice related disability.<sup>13</sup> The VHI has been shown to have a high test-retest reliability and construct validity and is statistically robust.<sup>15</sup> To inventory the symptoms of VTD, the Dutch version<sup>31</sup> of the VTD scale was used.<sup>12</sup> The VTD scale quantifies the severity and frequency of throat discomfort by means of qualitative descriptors. This scale is a reliable tool with good sensitivity, specificity, and efficiency.<sup>16</sup> In addition, participants completed the Dutch version of the CPS.<sup>38</sup> This scale investigates the frequency and intensity of self-perceived corporal pain sensations. It consists of 12 corporal pain symptoms of two categories: proximal corporal pain located next to the larynx, neck, and shoulder girdle (ie, temporomandibular joint/mandible pain, tongue pain, sore throat, shoulder pain, neck pain, and diffuse pain), and distal corporal pain located in other regions of the body (ie, headache, back pain, chest pain, arm pain, hand pain, and earache). To inventory the patients' history, the questions of the ELS protocol<sup>34</sup> were used.

### *Voice recordings*

Voice recordings were performed in a quiet room using a Samson Meteor Mic USB condensator microphone, digitalized at a sampling rate of 44.1 kHz using the software program Praat.<sup>17</sup> The mean signal to noise ratio of the recordings was 35.4 with a minimal signal to noise ratio of 22 (median 35.0, SD: 8.05, range: 22-60).

### *Auditory-perceptual evaluation*

The voice recordings for the auditory perceptual evaluation consisted of a reading sample of the Dutch phonetically balanced text 'Papa en Marloes'.<sup>18</sup> The continuous speech was rated blindly by two masters in speech-language pathology using the 4 point grading GRBAS scale.<sup>19</sup> The 5 parameters of the scale, G (overall grade of hoarseness), R (rough), B (breathy), A (asthenic), and S (strained quality), were expanded with a sixth parameter I for instability.<sup>20</sup>

### *Multiparametric voice quality indices*

**Dysphonia Severity Index.** The DSI is a multiparametric approach designed to establish an objective and quantitative correlate of the perceived vocal quality.<sup>21</sup> It is based on a weighted combination of 4 voice parameters: maximum phonation time (MPT, s), highest frequency (F-high, Hz), lowest intensity (I-low, dB), and jitter (%). The DSI is constructed as  $0.13 \text{ MPT} + 0.0053 \text{ F-high} - 0.26 \text{ I-low} - 1.18 \text{ jitter} + 12.4$ . The index ranges from -5 to +5 for severely dysphonic to normal voices but values higher than +5 are possible in subjects with excellent vocal capacities. The cutoff score between normophonic and dysphonic voices is 1.6.<sup>22</sup> The MPT was determined by asking the subjects to sustain the vowel /a:/ at habitual pitch and loudness after a maximal inspiration. Participants were instructed to reach their highest and lowest frequency and intensity by producing a glissando on the vowel /a:/.<sup>23</sup> The best result was selected out of 3 trials. For the determination of the jitter, a recording of the vowel /a:/ at habitual pitch and loudness was used.

**Acoustic Voice Quality Index.** The Acoustic Voice Quality Index (AVQI) is a robust and valid method to quantify the severity of overall dysphonia based on both continuous and sustained vowel recordings.<sup>24,25</sup> This multiparameter index consists of a weighted combination of six voice parameters: smoothed cepstral peak prominence, harmonics-to-noise ratio, shimmer local, shimmer local dB, general slope of the spectrum (slope), and tilt of the regression line through the spectrum (tilt). The formula is constructed as  $9.072 - 0.245 \times$

smoothed cepstral peak prominence  $- 0.161 \times$  harmonics-to-noise ratio  $- 0.470 \times$  shimmer local  $+ 6.158 \times$  shimmer local dB  $- 0.071 \times$  Slope  $- 0.170 \times$  Tilt and ranges from zero to 10. The higher the score of the AVQI, the worse is the overall vocal quality. The cutoff score between normal and dysphonic voices is 2.95.<sup>24</sup>

### Statistical analysis

SPSS Statistics (SPSS Corporation Chicago, IL) version 26.0 was used for the analysis of the data. The Mann-Whitney *U* test was used for the comparison of continuous voice parameters between musical theater students and musical theater actors. For the comparison of ordinal variables (GRABSI) between both groups, the Kruskal Wallis test was used. Nominal data in both groups were compared using the Fisher's Exact test. Analyses were conducted at  $\alpha = 0.05$ . Cohen's  $\kappa$  was run to determine the interrater reliability for the subjective vocal measurements.

## RESULTS

### Vocal symptoms and habits

The results of the VHI and the VHI adapted to the singing voice are presented in Table 1. No significant differences were found between the musical theater students and the musical theater actors for the VHI ( $P = 0.851$ ) and the VHI-adapted to the singing voice ( $P = 0.884$ ). The majority of the musical theater students ( $n = 13$ , 72.2%) and musical theater actors ( $n = 10$ , 83.3%) scored below the clinical threshold for psychosocial impact of voice symptoms for the speaking voice. The mean scores for the VHI- adapted to the singing voice in both groups are located in the clinical zone. Respectively 61.1% ( $n = 11/18$ ) and 58.3% ( $n = 7/12$ ) of the musical theater students and actors scored above the clinical threshold for the VHI-adapted to the singing voice.

**TABLE 1.**  
**Results of the VHI and the VHI Adapted to the Singing Voice**

	Musical Theater Students					Musical Theater Actors				
	Mean	Median	SD	Min	Max	Mean	Median	SD	Min	Max
VHI	13.6	10.0	10.6	0	32	12.8	13.0	7.0	1	24
VHI-adapted to the singing voice	24.1	22.5	14.2	4	48	23.9	23.0	12.2	10	44

Symptoms of VTD are presented in Table 2. All participants reported at least two symptoms of VTD. The most frequently reported symptoms in musical theater students were a dry (100%), tight (94.4%), and tickling (88.9%) sensation. In the group of the musical theater actors, dry (83.3%), tickling (83.3%), and tight (66.7%) sensations were most frequently reported. The frequency of an irritable VTD sensation was significantly higher in musical theater students ( $P = 0.028$ ). The intensity of a burning ( $P = 0.017$ ), tight (0.039) and irritable sensation ( $P = 0.039$ ) was also significantly higher in the group of students. Table 3 presents the corporal pain symptoms in both groups. The CPS revealed that headache (100%-83.3%), sore throat (94.4%-91.7%), neck pain (77.8%-91.7%), shoulder pain (77.8%-83.3%), and back pain (89.9-91.7) are frequently reported pain symptoms in musical theater students and actors. Musical theater students reported significantly more pain symptoms when the total score of pain symptoms was compared between the students (mean 9.3, SD 32, range 3-16) and the professionals (mean: 7.2, SD:3.3, range: 2-15) ( $P = 0.043$ ).

**TABLE 2.**  
**Vocal Tract Discomfort Symptoms in Musical Theater Students and Actors**

	Frequency	Never		Seldom		Sometimes		More than Sometimes		Often		Very often		Always	
		%	n	%	n	%	n	%	n	%	n	%	n	%	n
Musical theater students	Burning	22.2	4	38.9	7	16.7	3	22.2	4	0.0	0	0.0	0	0.0	0
	Tight	5.6	1	16.7	3	22.2	4	33.3	6	16.7	3	5.6	1	0.0	0
	Dry	0.0	0	33.3	6	16.7	3	22.2	4	27.8	5	0.0	0	0.0	0
	Aching	77.8	14	16.7	3	5.6	1	0.0	0	0.0	0	0.0	0	0.0	0
	Tickling	11.1	2	16.7	3	38.9	7	22.2	4	11.1	2	0.0	0	0.0	0
	Sore	55.6	10	16.7	3	22.2	4	5.6	1	0.0	0	0.0	0	0.0	0
	Irritable	16.7	3	22.2	4	22.2	4	33.3	6	5.6	1	0.0	0	0.0	0
	Lump	22.2	4	38.9	7	5.6	1	16.7	3	5.6	1	11.1	2	0.0	0
Musical theater actors	Burning	50.0	6	16.7	2	33.3	4	0.0	0	0.0	0	0.0	0	0.0	0
	Tight	33.3	4	16.7	2	8.3	1	33.3	4	8.3	1	0.0	0	0.0	0
	Dry	16.7	2	16.7	2	50.0	6	8.3	1	8.3	1	0.0	0	0.0	0
	Aching	83.3	10	16.7	2	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
	Tickling	16.7	2	41.7	5	25.0	3	16.7	2	0.0	0	0.0	0	0.0	0
	Sore	91.7	11	8.3	1	0.0	0	0	0	0.0	0	0.0	0	0.0	0
	Irritable	50.0	6	25.0	3	16.7	2	8.3	1	0.0	0	0.0	0	0.0	0
	Lump	50.0	6	16.7	2	16.7	2	16.7	2	16.7	2	0.0	0	0.0	0

  

	Intensity	no perceptions		almost no perception		Limited perception		More than limited perception		Moderate perception		More than moderate perception		Severe perception	
		%	n	%	n	%	n	%	n	%	n	%	n	%	n
Musical theater students	Burning	22.2	4	16.7	3	22.2	4	33.3	6	5.6	1	0.0	0	0.0	0
	Tight	5.6	1	11.1	2	22.2	4	33.3	6	22.2	4	0.0	0	5.6	1
	Dry	0.0	0	22.2	4	11.1	2	38.9	7	22.2	4	0.0	0	5.6	1
	Aching	77.8	14	0.0	0	5.6	1	11.1	2	0.0	0	5.6	1	0.0	0
	Tickling	11.1	2	11.1	2	33.3	6	16.7	3	22.2	4	5.6	1	0.0	0
	Sore	55.6	10	0.0	0	22.2	4	0.0	0	11.1	2	11.1	2	0.0	0
	Irritable	16.7	3	5.6	1	33.3	6	33.3	6	11.1	2	0.0	0	0.0	0
	Lump	22.2	4	16.7	3	33.3	6	16.7	3	5.6	1	5.6	1	0.0	0
Musical theater actors	Burning	58.3	7	16.7	2	25.0	3	0.0	0	0.0	0	0.0	0	0.0	0
	Tight	41.7	5	8.3	1	16.7	2	25.0	3	8.3	1	0.0	0	0.0	0
	Dry	25.0	3	8.3	1	33.3	4	8.3	1	25.0	3	0.0	0	0.0	0
	Aching	83.3	10	16.7	2	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
	Tickling	25.0	3	0.0	0	50.0	6	25.0	3	0.0	0	0.0	0	0.0	0
	Sore	91.7	11	0.0	0	8.3	1	0.0	0	0.0	0	0.0	0	0.0	0
	Irritable	50.0	6	8.3	1	25.0	3	16.7	2	0.0	0	0.0	0	0.0	0
	Lump	58.3	7	8.3	1	8.3	1	16.7	2	8.3	1	0.0	0	0.0	0



**TABLE 3.**  
**Results of the Corporal Pain Scale**

		Never		Sometimes		Ofter		Almost always		Always		
		%	n	%	n	%	n	%	n	%	n	
Musical theater students	Headache	0.0	0	61.1	11	38.9	7	0.0	0	0.0	0	
	Mandible pain	66.7	12	22.2	4	11.1	2	0.0	0	0.0	0	
	Tongue pain	83.3	15	0.0	0	16.7	3	0.0	0	0.0	0	
	Sore throat	5.6	1	61.1	11	33.3	6	0.0	0	0.0	0	
	Neck pain	22.2	4	27.8	5	50.0	9	0.0	0	0.0	0	
	Shoulder pain	22.2	4	27.8	5	44.4	8	0.0	0	0.0	0	
	Back pain	11.1	2	27.8	5	55.6	10	0.0	0	5.6	1	
	Diffused pain	50.0	9	33.3	6	16.7	3	0.0	0	0.0	0	
	Earache	44.4	8	55.6	10	0.0	0	0.0	0	0.0	0	
	Hand pain	83.3	15	16.7	3	0.0	0	0.0	0	0.0	0	
	Chest pain	61.1	11	38.9	7	0.0	0	0.0	0	0.0	0	
	Arm pain	94.4	17	5.6	1	0.0	0	0.0	0	0.0	0	
	Musical theater actors	Headache	16.7	2	66.7	8	16.7	2	0.0	0	0.0	0
		Mandible pain	58.3	7	25.0	3	16.7	2	0.0	0	0.0	0
Tongue pain		100.0	12	0.0	0	0.0	0	0.0	0	0.0	0	
Sore throat		8.3	1	61.1	11	16.7	2	0.0	0	0.0	0	
Neck pain		8.3	1	58.3	7	33.3	4	0.0	0	0.0	0	
Shoulder pain		16.7	2	66.7	8	8.3	1	8.3	1	0.0	0	
Back pain		8.3	1	75.0	9	16.7	2	0.0	0	0.0	0	
Diffused pain		75.0	9	25.0	3	0.0	0	0.0	0	0.0	0	
Earache		58.3	7	33.3	4	0.0	0	0.0	0	8.3	1	
Hand pain		100.0	12	0.0	0	0.0	0	0.0	0	0.0	0	
Chest pain		83.3	10	16.7	2	0.0	0	0.0	0	0.0	0	
Arm pain		100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	

Voice influencing factors and participant's characteristics are presented in Table 4. A significant presence of vocal misuse ( $P = 0.040$ ) and stress ( $P = 0.004$ ) was observed in the group of musical theater students compared to the professionals. In professional musical theater actors, a significantly higher consumption of alcohol was present ( $P = 0.013$ ).

**TABLE 4.**  
**Voice Influencing Factors**

	Musical Theater Students		Musical Theater Actors		P- value
	n	%	N	%	
Vocal complaints	1	5,6	1	8,3	0.683
History of voice therapy	4	22,2	1	8,3	0.267
Vocal misuse during performance	10	55,6	3	25,0	<b>0.055</b>
Vocal misuse outside performance	9	50,0	2	16,7	<b>0.040</b>
Smoking	2	11,1	1	8,3	0.071
Upper airway infections	3	16,7	0	0,0	0.611
GERD	4	22,2	0	0,0	0.089
Allergy	7	38,9	3	25,0	0.268
Stress	15	83,3	5	41,7	<b>0.004</b>
	mean	SD (range)	mean	SD (range)	
Number of alcoholic drinks per week	1.2	0.9 (0-3)	3.2	2.8 (0-10)	<b>0.013</b>

### Auditory-perceptual evaluation

The results of the auditory-perceptual evaluations are presented in Table 5. Concordance values of the ratings were 75.6%. In respectively 44.4% and 33.3% of the musical theater students and actors, a mild roughness was observed. Breathiness was present in 11.1% ( $n = 2$ ) of the musical theater students and a strained vocal quality was perceived in 5.6% and 8.3% of the musical theater students ( $n = 1$ ) and actors ( $n = 1$ ). No significant differences in GRBASI scores were found between the students and the professional musical theater actors.

**TABLE 5.**  
**Results of the GRBASI Scale in Musical Theater Students and Actors**

	Musical Theater Students					Musical Theater Actors					P - value	Cohen's kappa
	Mean	Median	SD	Min.	Max.	Mean	Median	SD	Min	Max		
Grade	0.56	1	0.51	0	1	0.33	0	0.49	0	1	0.240	0.474
Roughness	0.44	0	0.51	0	1	0.33	0	0.49	0	1	0.550	0.533
Breathiness	0.11	0	0.32	0	1	0.00	0	0.00	0	1	0.240	0.526
Asthenic	0.00	0	0.00	0	0	0.00	0	0.00	0	0	1.000	–
Strain	0.06	0	0.24	0	1	0.08	0	0.29	0	1	0.769	1
Instability	0.00	0	0.00	0	0	0.00	0	0.00	0	0	1.000	–

### Multiparametric voice quality indices

The results of the objective voice parameters in both groups for male and female participants are presented in Table 6. The mean DSI for musical theater students and actors was respectively 7.1 (SD: 1.74, range 2.8-9.9) and 7.4 (SD: 2.1, range: 2.9-10.5). For the AVQI, the mean scores for musical theater students and actors were respectively 2.5 (SD 0.65, range: 1.5-4.0) and 2.6 (SD: 0.52, range 1.8-3.4). No significant differences in DSI ( $P = 0.755$ ) and AVQI ( $P = 0.439$ ) were found between the students and the actors.

### DISCUSSION

The purpose of this study was to investigate and compare the vocal habits, vocal complaints and vocal quality of professional musical theater actors and musical theater students. The objective vocal quality was measured using the DSI and AVQI reflecting respectively the vocal capacities and acoustic vocal quality of the subjects. Students as well as professionals demonstrated high DSI values corresponding with excellent vocal capacities. The mean scores of 7.1 and 7.4 exceed the maximum DSI levels of +5 and are much higher than the normative data of the Belgian Study Group on Voice Disorders.<sup>26</sup> None of the participants scored below the pathological threshold of 1.6.<sup>22</sup> The excellent vocal capacities of musical theater students correspond with the results of a previous study in Belgian musical theater students.<sup>8</sup> No significant differences in multiparameter indices were found between the professionals and the students. The results of this study are in contrast with the findings of Timmermans et al<sup>6</sup> who found rather poor vocal quality, reflected in much lower DSI values, in professional and preprofessional stage and musical actors. The different results in the study of Timmermans et al<sup>6</sup> can possibly be related to the heterogeneity of the study population or a lack of vocal hygiene or education in musical theater more than a decade ago. In a previous study,<sup>1</sup> acoustic analysis in theater actors showed a mean AVQI of 3.48 corresponding with a mild dysphonia. Compared to theater actors,<sup>1</sup> musical theater performers tend to display better acoustic vocal quality. In clinical practice, the ELS protocol is widely used for the multidimensional assessment of vocal pathology.<sup>20</sup> Normative data for the multiparameter indices and acoustic analyses of speech are developed by different research groups.<sup>20,24</sup> Given the present results, it is clear that for elite vocal performers like musical theater actors, different norms should be applied.



**TABLE 6.**  
**Results of the Objective Voice Parameters in Musical Theater Students and Actors**

		Musical Theater Students										Musical Theater Actors									
		Women					Men					Women					Men				
		Mean	Median	SD	Min.	Max.	Mean	Median	SD	Min.	Max.	Mean	Median	SD	Min.	Max.	Mean	Med.	SD	Min.	Max.
<b>DSI</b>		7.47	7.5	1.5	4.5	9.9	5.8	6.2	2.3	2.8	8.1	8.0	7.9	1.4	6.5	10.5	6.1	5.7	3.2	2.9	10.2
	MFT	18.9	19.7	4.6	11.8	28.5	19.2	20.9	7.5	8.6	26.3	17.5	17.7	5.1	10.0	27.1	20.8	20.1	6.1	14.2	28.9
	Jitter	0.2	0.2	0.1	0.1	0.3	0.2	0.2	0.2	0.1	0.5	0.2	0.2	0.1	0.1	0.3	0.2	0.2	0.1	0.1	0.4
	I-low	47.5	46.0	3.4	45.0	56.8	47.4	45.3	4.4	45.0	53.9	46.5	45.0	2.6	45.0	52.4	49.5	47.3	6.4	45.0	58.6
	F-high	1031.7	1052.8	204.1	620.3	1278.6	779.6	726.9	186.7	623.9	1040.5	1093.2	1123.2	176.5	726.7	1270.3	769.3	689.2	229.4	592.7	1106.0
<b>AVQI</b>		2.6	2.5	0.7	1.5	4.0	2.2	2.2	0.5	1.8	2.7	2.7	2.7	0.5	1.9	3.4	2.6	2.5	0.7	1.8	3.34
	CPPS	13.7	13.8	1.4	10.8	15.7	13.9	13.9	1.7	12.1	15.6	13.8	13.8	0.4	13.0	14.4	15.4	15.3	2.7	12.2	18.7
	HNR	18.3	17.3	2.6	15.0	22.3	17.6	18.3	2.5	14.1	19.8	18.9	18.7	1.5	17.2	21.1	18.0	18.0	2.6	15.1	21.0
	Shimmer	5.5	5.4	1.3	3.3	8.2	6.4	6.6	2.1	4.1	8.4	4.6	4.5	1.6	2.5	6.9	5.0	5.3	1.6	2.8	6.5
	Slope of LTAS	-18.4	-18.5	2.4	-22.3	-11.7	-18.4	-18.0	1.7	-20.6	-16.8	-15.0	-15.2	3.4	-21.1	-9.7	-17.6	-18.0	6.3	-24.8	-9.6
	Tilt of trendline	-11.5	-11.6	0.8	-12.7	-10.3	-12.1	-12.3	0.6	-12.6	-11.3	-11.3	-10.9	1.0	-13.0	-10.3	-10.4	-11.0	2.4	-12.5	-7.0

The results of the auditory-perceptual evaluations revealed a more nuanced view on vocal quality compared to the objective indices. In respectively 44.4% and 33.3% of the musical theater students and actors a mild roughness was observed. For actors, an optimal perceptual voice quality of the speaking voice is important to be maximally intelligible and to be able to project the voice.<sup>1</sup> The reliability of the auditory-perceptual evaluations might be influenced by experience or professional background.<sup>27</sup> The raters in this study were master students in SLP and had rather low experience. Perceptual tasks involve comparing voices to internal standards which can be influenced by their professional experiences with mainly elite vocal performers. The perceptual ratings are in accordance with the results of Timmermans et al<sup>6</sup> who found a mean G-score of  $0.64 \pm 0.12$  in the group of stage and musical actors. In this study, no differences were found between the students and the professionals. A perceptual evaluation of the singing voices however was lacking which is a shortcoming of this study that should be addressed in future research. Maxfield et al<sup>28</sup> investigated and compared the perceptual differences in the singing voices using a belt, legit, and mix vocal style of novice and professional musical theater singers and found that although differences were small, professional singers were somewhat more successful in producing voicing styles that matched the perceptual expectations of casting directors.

To investigate the presence of vocal habits and vocal symptoms in the speaking and singing voice, different questionnaires were used. Only one musical theater student (5.6%) and one musical theater actor (8.3%) reported having vocal complaints. The VHI revealed low scores in both students and professionals reflecting a low impact of voice symptoms on daily functioning. It is well known that the VHI is not sensitive enough for singers with vocal complaints.<sup>29</sup> Therefore, the Dutch version<sup>14</sup> of the VHI- adapted to the singing voice of Morsomme et al<sup>11</sup> was used to investigate the psychosocial impact of singing voice complaints. The majority of the musical theater students (61.1%) and actors (58.3%) scored above the clinical threshold for the VHI-adapted to the singing voice. Vocal complaints in both groups are mainly noticed in the singing voice and relatively low in the speaking voice. Phyland et al<sup>35</sup>, however, criticized the use of VHI scales in healthy singers without an overt vocal pathology as these instruments do not provide a sensitive measure of the more subtle or transient physical changes to the vocal mechanism that may have more variable impacts on the singer and their performances. Therefore, she developed the (Evaluation of the Ability to Sing Easily) (EASE), which is a more sensitive instrument to measure vocal function in musical theater actors.<sup>35</sup> Nevertheless, the EASE is not yet translated and validated for Dutch musical theater actors. A study of Pacheco and Behlau<sup>30</sup> in 264 Brazilian musical theater singers revealed a low number of vocal symptoms and low scores on the EASE-BR. The presence and intensity of VTD symptoms in this study was investigated using the VTD scale. Compared to the normative data of subjects without voice problems,<sup>31</sup> the high presence of VTD symptoms in musical theater students and actors is striking. The most frequently reported symptoms were a dry, tight, and tickling sensation in the vocal tract. VTD can be a result of increased vocal load and may eventually lead to maladjustments in voice production<sup>31</sup> or vocal fatigue. Also general pain symptoms, investigated by the CPS, like headache, sore throat, neck pain, shoulder pain, and back pain are frequently reported. In musical theater students, the frequency and intensity of an irritable sensation, and the intensity of a burning, irritable, and tight sensation was significantly higher. The students also reported significantly more pain symptoms compared to the professionals. An education program in musical theater as well as the profession itself requires heavy physical demands. The training program and the physical acts during highly exhausting choreographies in rehearsals and performances may possibly lead to increased physical pain symptoms in this group. It is possible that professionals have better coping skills protecting them from general pain and VTD related to the heavy vocal load. Possible

differences in coping skills and the influence of experience in the field in professionals and preprofessionals should be further investigated. The increased amount of pain and VTD in the musical theater students might also be explained by a higher amount of vocal misuse in this group compared to the professionals. In the literature, the same trend of increased VTD and pains symptoms was observed in stage actors.<sup>1</sup> Whether the higher prevalence of general pain symptoms in actors is related to the physical demands of their profession, the presence of (stage) anxiety or stress, or higher sensitivity to pain symptoms is subject for further research.

The questionnaires investigating vocal habits revealed a high presence of on and off stage vocal misuse (55%-50%) especially in musical theater students. Professional musical theater actors report significantly less vocal misuse compared to students. During rehearsal and performance, voice production is often accompanied by vocal abuse or misuse.<sup>4</sup> Vocally violent behavior, like yelling, screaming, hard glottal attack, and speaking outside acceptable physiologic range, may contribute to voice disturbances<sup>32</sup> and is also reported in other types of actors.<sup>3,6,1</sup> The results of a study by Roy et al<sup>3</sup> showed prudent evidence that vocal training in professional actors defends the laryngeal system from vocal changes related to vocally violent behavior. Whether the amount of experience has a positive impact on vocal habits is a question for future research.

In accordance to the findings of Gehling et al,<sup>7</sup> the prevalence of smokers (8.3%-11%) in both groups in this study is lower than the national average of 23%<sup>41</sup>. A positive evolution in smoking habits is noticed compared to the results of Timmermans et al<sup>6</sup> more than a decade ago. The presence of stress on the other hand, is extremely high. Musical theater is a profession that often goes along with financial insecurity. Especially today, where federal grants for the Belgian cultural sector are limited. Raphael<sup>39</sup> stated that the profession of actor is often associated with financial worries, stress, and anxiety. In Belgium, actors having a commission can work as an employee and actors who don't can fall back on unemployment benefits, the so-called "status of the artist". However, temporary jobs with financial insecurity can possibly lead to increased stress and anxiety. Literature has shown that stress-inducing and challenging conditions change vocal quality and vocal performance.<sup>33,40</sup> In stress-inducing situations the voice can be characterized by a more breathy or strained quality, a lower objective vocal quality and changes in fundamental frequency, frequency, and intensity ranges and aerodynamic capacity.<sup>41,33</sup> In this study the prevalence of stress in musical theater students (83.3%) is even higher compared to the professionals and is comparable with the results of a previous study in musical theater students.<sup>8</sup> Meeting the high standards of the education, participating in professional plays, and competition between the students are hypothetical factors that can increase the amount of stress and anxiety in this population. In professional musical theater actors, a significantly higher consumption of alcohol was present ( $P = 0.013$ ). It is clear that in educational programs as well as in the professional field of musical theater, more attention should be paid to vocal hygiene, psychosocial, and physical health. The high presence of vocal misuse, stress, and complaints of the singing voice indicates that musical theater actors and students are at risk for developing voice disorders. Voice care and regular medical and logopaedic follow-up is necessary in this group of elite vocal performers.

This study provides data concerning multiparameter objective measures (DSI, AVQI), subjective complaints regarding the speaking and singing voice, VTD and pain in musical theater actors and students that can be used in clinical practice. Although both groups had excellent scores in the DSI and AVQI, all participants had at least two symptoms for VTD and scores in the VHI singing voice were within a clinically significant zone. These findings highlight the need of an extensive multidimensional voice assessment in clinical practice

including objective as well as subjective measurements in musical theater actors. The study design however, has some shortcomings. In future research, a control group of other elite vocal performers must be included to compare the vocal quality between different groups of elite vocal performers. Future studies must include a higher number of musical theater actors, include detailed information about singing characteristics and differentiate between different musical theater singing styles, vocal stamina, and vocal load. Moreover, videolaryngostroboscopy, perceptual, and acoustic analysis of the different singing styles in musical theater should be included in the protocol. Lastly, a longitudinal study can provide a better insight in the risk factors and varying symptoms of vocal load or overload in vocal performers.

## **CONCLUSION**

The results of this study show that musical theater actors and students have an excellent speaking vocal quality (AVQI) and vocal capacities (DSI). The mean DSI values of students (7.1) and professionals (7.4) exceed the maximum scores for DSI and correspond with outstanding vocal capacities. These different normative data should be applied in clinical practice when a musical theater actor presents with vocal complaints. The VHI revealed low scores in both students and professionals reflecting a low impact of speaking voice symptoms on daily functioning. The VHI adapted to the singing voice showed a high presence of complaints of the singing voice. Yet, the singing itself was not tested as to any cause of vocal fatigue or disturbance. Other questionnaires, however, revealed a high presence of stress, VTD, and general pain symptoms. Musical theater students reported significantly more VTD, pain symptoms, stress, and vocal misuse compared to the professionals. In professional musical theater actors, on the other hand, a significantly higher consumption of alcohol was present. These findings confirm the assertion that musical theater actors are a risk group for developing voice disorders and that especially students are vulnerable for stress, general pain, and VTD symptoms. Therefore, speech-language pathologists and ENT specialists have a critical role in the care of the professional voice<sup>5</sup> and in the development of prevention programs for the musical theater field.

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