Interrelationship between subjective and instrumental voice and noise data in vocally demanding workplaces

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Summary
The aim was to investigate how self-rated amount of voice use and perceived disturbing noise relate to instrumental measurements of phonation ratio and environmental noise over time in work and leisure conditions. Participants were 20 patients with work-related voice disorders, and 20 vocally healthy controls matched regarding age, profession and workplace. The participants, all women with vocally demanding jobs, rated estimated speaking time and perceived disturbing noise 4 times per day during 1 week. Instrumental measures of phonation ratio (percent) and of sound pressure level (dBA) of the environmental noise were registered with a portable voice and noise meter from morning to evening during the week. Self-rated speaking time and instrumentally measured phonation ratio, as well as self-rated disturbing noise and instrumentally measured environmental noise, had similar patterns indicating that recurrent self-reports of amount of voice use and disturbing noise can be reliable if done in a structured way.

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1. Introduction

Speaking in high levels of environmental noise for lengthy periods of time is a risk factor for voice disorders [1,2]. Thus, how patients with work-related voice disorders perceive their voice use and environmental noise in daily life, and how it corresponds with instrumental measurements, is of interest both from research and clinical perspectives. The validity and reliability of self-ratings have been questioned, however, since occupational voice users may not be aware of how much they actually talk [3]. Yet, few attempts have been done to collect self-reports of voice use and disturbing noise in a structured way over time. The study aim was, therefore, to investigate how self-rated amount of voice use and perceived disturbing noise relate to instrumental measurements of phonation ratio and environmental noise during one week in work and leisure conditions.

2. Methods

Forty women with vocally demanding jobs participated. Twenty were patients diagnosed with work-related voice disorders; 10 with phonastenia (vocal fatigue) and 10 with vocal nodules. Twenty were vocally healthy controls matched regarding age, profession and workplace. The participants were older than 18 years of age and they did not have any self-reported hearing impairment. Singing professionally or regularly in choirs, or previous voice training, were exclusion criteria.

Four times per day during one week the participants completed subjective ratings of estimated speaking time and perceived disturbing noise on 100 mm visual analogue scales. The participants also

completed short diary notes of daily activities in relation to voice use and if they were at work, at home, or someplace else. With an accelerometer and a microphone attached to a neck collar, instrumental measures of phonation ratio, i.e., the time during which the vocal folds have been vibrating divided by the total recorded time (%), and of sound pressure level (SPL) of the environmental noise (dBA), were registered onto a portable voice and noise monitor (VoxLog, Sonvox AB, Sweden) [2,4], every 5 seconds from morning to evening during the week.

The self-rating scores were measured in millimetres and consisted of 2240 data points (2 parameters x 4 times per day x 7 days x 40 participants), whereof 96% were completed. Voice and noise data registered with VoxLog were analyzed with the software VoxLog Connect 3.1.13 (firmware version 2.2.3, Sonvox AB, Sweden). Data were manually categorized into 4 time intervals per day based on the participants' diary notes. On average 13.5 hours per day were recorded per participant. Because of breaks when some participants did not use VoxLog, e.g., during physical exercise, or due to technical errors, the actual amount of analyzed time was less, on average 12.5 hours per day. Subjective and instrumental measurements were compared between work and leisure conditions and for the two groups of patients and their control groups.

The study was part of a larger project approved by the Research Ethics Committee at Karolinska Institutet, Stockholm, Sweden (Dnr 2012/509-32).

3. Results

3.1. Estimated speaking time

Figure 1 demonstrates variation in estimated speaking time during a workday. Average speaking time ratings were significantly higher during work (i.e., during T2 and T3) compared to the morning (T1) and evening (T4) for all participants groups ($P < 0.001$).

Figure 2 shows variation in estimated speaking time during a work-free day. A more flat pattern of average speaking time ratings emerged during the work-free day compared with the workday. All participant groups rated significantly lower average speaking time in the morning (T1) compared to the rest of the work-free day ($P < 0.01$).

3.2. Phonation ratio

Figure 3 demonstrates variation in phonation ratio during a workday. The average phonation ratio followed the same pattern as the subjective ratings of speaking time (Figure 1), and was significantly higher during work (i.e., during T2 and T3) compared to the morning (T1) and evening (T4) ($P < 0.001$).

Figure 4 shows variation in phonation ratio during a work-free day. There were no significant differences of average phonation ratio between time intervals for any of the participants groups during the work-free day.

3.3. Perceived disturbing noise

Figure 5 demonstrates variation in perceived disturbing noise during a workday. The group of patients with vocal nodules (green line in Figure 5) and their controls (purple line) rated significantly higher degree of disturbing noise during work (i.e., during T2 and T3) than the group of patients with phonasthenia (blue line) and their controls (red line) ($P < 0.01$). For the patients with vocal nodules and their controls, there was a significant increase in average ratings of disturbing noise during work (T2 and T3) compared to the morning (T1) and evening (T4) ($P < 0.001$). This was not the case for the patients with phonastenia and their controls who rated about the same level of disturbing noise throughout the day.

Figure 6 demonstrates variation in perceived disturbing noise during a work-free day. There were no significant differences in average ratings of disturbing noise between the participant groups, nor between time intervals during the work-free day.

3.4. Noise sound pressure level

Figure 7 demonstrates variation in noise SPL during a workday. The instrumental measures of noise SPL corresponded with the subjective ratings of disturbing noise (Figure 5). During work (T2 and T3) the patients with vocal nodules and their controls were exposed to significantly higher environmental noise SPL compared to the patients with phonasthenia and their controls ($P < 0.01$). During morning (T1) and evening (T4) there were no significant differences between the participant groups. The average noise SPL during T1 was significantly lower than T2, T3 and T4 ($P < 0.01$)

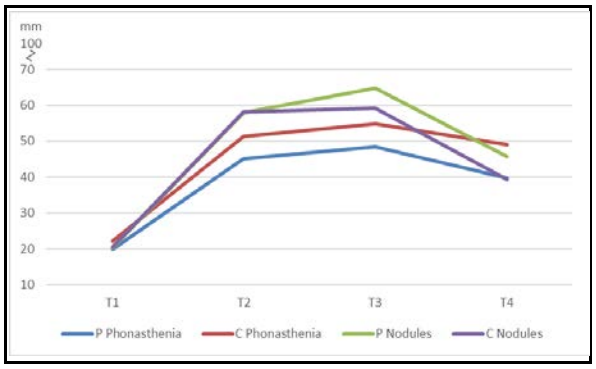

Figure 1. Variation in self-rated *speaking time* for 4 time intervals during a *workday* based on average measures from 5 workdays. The y-axis shows the rating on a 100 mm VAS (0 = "not at all", 100 = "a lot"). T1, 1st time interval (morning until the beginning of the workday; T2, 2nd time interval (from the beginning of the workday until lunch time); T3, 3rd time interval (after the lunch break until the end of the workday); T4, 4th time interval (from the end of the workday until bedtime). P Phonasthenia, patients with phonasthenia; C Phonasthenia, controls to patients with phonasthenia; P Nodules, patients with vocal nodules; C Nodules, controls to patients with vocal nodules.

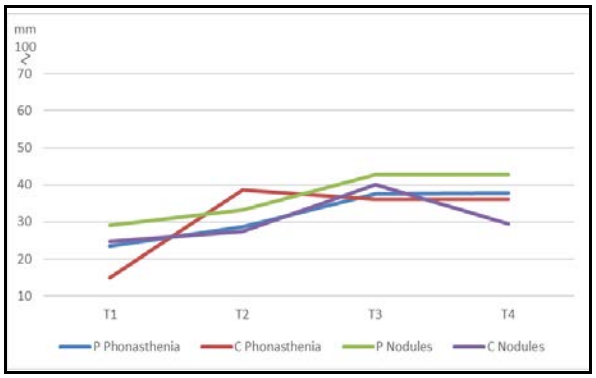

Figure 2. Variation in self-rated *speaking time* for 4 time intervals during a *work-free day* based on average measures from 2 work-free days. The y-axis shows the rating on a 100 mm VAS (0 = "not at all", 100 = "a lot"). T1, 1st time interval (morning including breakfast; T2, 2nd time interval (after breakfast until lunch time); T3, 3rd time interval (after lunch until late afternoon); T4, 4th time interval (before dinner until bedtime). P Phonasthenia, patients with phonasthenia; C Phonasthenia, controls to patients with phonasthenia; P Nodules, patients with vocal nodules; C Nodules, controls to patients with vocal nodules.

for the patients with vocal nodules and their controls, while there were no significant differences in average noise SPL between time intervals for patients with phonasthenia and their controls.

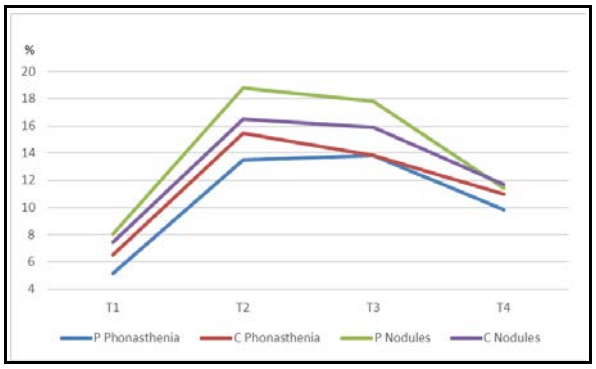

Figure 3. Variation in *phonation ratio* for 4 time intervals during a *workday* based on average measures from 5 workdays. T1, 1st time interval (morning until the beginning of the workday; T2, 2nd time interval (from the beginning of the workday until lunch time); T3, 3rd time interval (after the lunch break until the end of the workday); T4, 4th time interval (from the end of the workday until bedtime). P Phonasthenia, patients with phonasthenia; C Phonasthenia, controls to patients with phonasthenia; P Nodules, patients with vocal nodules; C Nodules, controls to patients with vocal nodules.

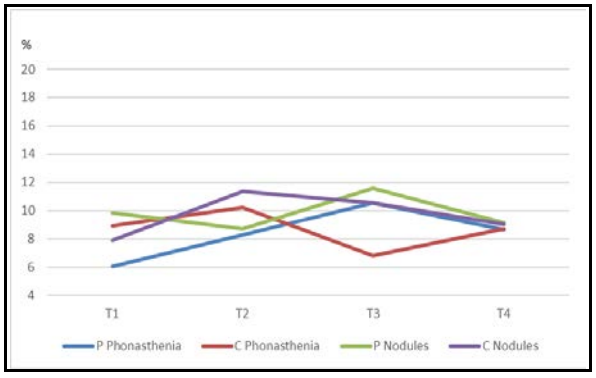

Figure 4. Variation in *phonation ratio* for 4 time intervals during a *work-free day* based on average measures from 2 work-free days. T1, 1st time interval (morning including breakfast; T2, 2nd time interval (after breakfast until lunch time); T3, 3rd time interval (after lunch until late afternoon); T4, 4th time interval (before dinner until bedtime). P Phonasthenia, patients with phonasthenia; C Phonasthenia, controls to patients with phonasthenia; P Nodules, patients with vocal nodules; C Nodules, controls to patients with vocal nodules.

Figure 8 shows variation in noise SPL during a work-free day. The instrumental measures of noise SPL corresponded with the subjective ratings of disturbing noise (Figure 6) during work-free days; there were no significant differences between participants groups, nor between intervals.

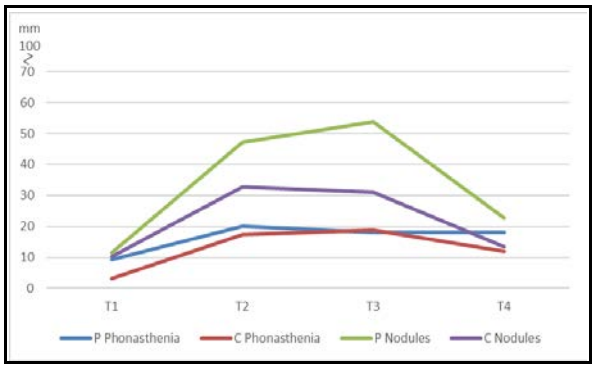

Figure 5. Variation in self-rated *disturbing noise* for 4 time intervals during a *workday* based on average measures from 5 workdays. The y-axis shows the rating on a 100 mm VAS (0 = "not at all", 100 = "a lot"). T1, 1st time interval (morning until the beginning of the workday; T2, 2nd time interval (from the beginning of the workday until lunch time); T3, 3rd time interval (after the lunch break until the end of the workday); T4, 4th time interval (from the end of the workday until bedtime). P Phonasthenia, patients with phonasthenia; C Phonasthenia, controls to patients with phonasthenia; P Nodules, patients with vocal nodules; C Nodules, controls to patients with vocal nodules.

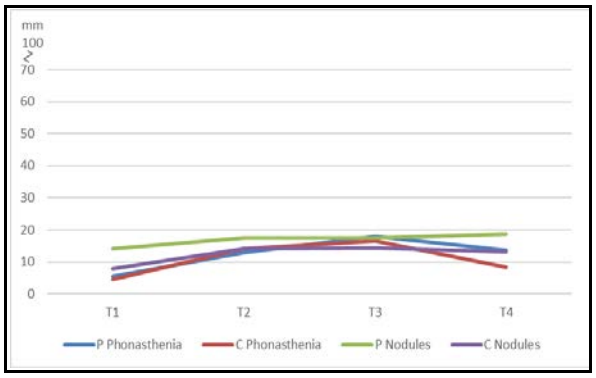

Figure 6. Variation in self-rated *disturbing noise* for 4 time intervals during a *work-free day* based on average measures from 2 work-free days. The y-axis shows the rating on a 100 mm VAS (0 = "not at all", 100 = "a lot"). T1, 1st time interval (morning including breakfast; T2, 2nd time interval (after breakfast until lunch time); T3, 3rd time interval (after lunch until late afternoon); T4, 4th time interval (before dinner until bedtime). P Phonasthenia, patients with phonasthenia; C Phonasthenia, controls to patients with phonasthenia; P Nodules, patients with vocal nodules; C Nodules, controls to patients with vocal nodules.

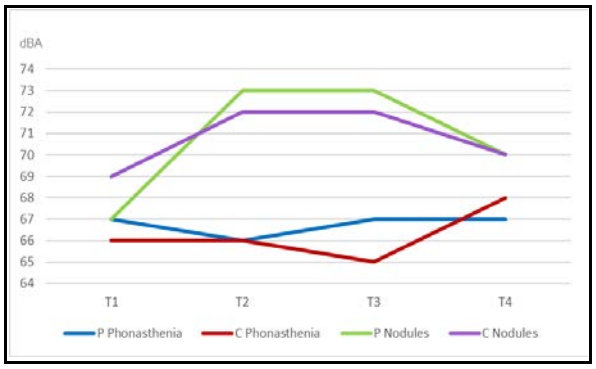

Figure 7. Variation in *noise SPL* for 4 time intervals during a *workday* based on average measures from 5 workdays. T1, 1st time interval (morning until the beginning of the workday; T2, 2nd time interval (from the beginning of the workday until lunch time); T3, 3rd time interval (after the lunch break until the end of the workday); T4, 4th time interval (from the end of the workday until bedtime). P Phonasthenia, patients with phonasthenia; C Phonasthenia, controls to patients with phonasthenia; P Nodules, patients with vocal nodules; C Nodules, controls to patients with vocal nodules.

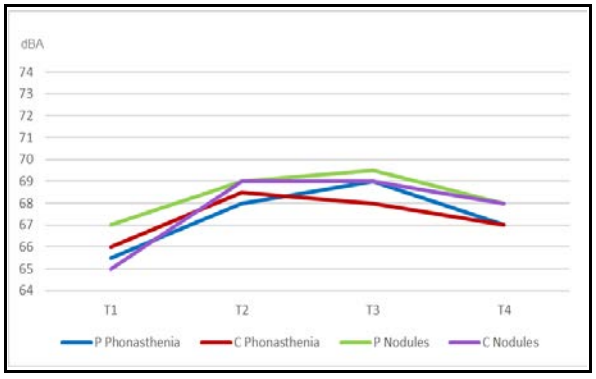

Figure 8. Variation in *noise SPL* for 4 time intervals during a *work-free day* based on average measures from 2 work-free days. T1, 1st time interval (morning including breakfast; T2, 2nd time interval (after breakfast until lunch time); T3, 3rd time interval (after lunch until late afternoon); T4, 4th time interval (before dinner until bedtime). P Phonasthenia, patients with phonasthenia; C Phonasthenia, controls to patients with phonasthenia; P Nodules, patients with vocal nodules; C Nodules, controls to patients with vocal nodules.

4. Discussion

The aim of this week-long field study was to explore variations of self-rated estimated speaking time and perceived disturbing environmental noise in women with vocally demanding professions, with and without voice disorders, and to examine interrelationships with related instrumental measurements of phonation ratio and environmental noise. According to the results, it

seems that patients and vocally healthy controls from the same workplace are well aware of how much time they spend talking and the amount of disturbing environmental noise, since subjective ratings and instrumental measurements had similar patterns during both workdays and work-free days. It is, however important to note that behind the variation in subgroup averages, there was large inter-individual variability.

The findings are in agreement with a recent study where the same voice and noise meter as in the present study was used on music teachers who seemed to have a good perception of how much they used their voices [6]. Overall, the present results are encouraging since reliable patient reports of amount of voice use and environmental noise are useful for understanding the origin of occupational voice disorders [5].

A concern that needs to be further addressed from a voice ergonomics point of view is that the patients with vocal nodules and their controls were exposed to higher noise levels at work, and they were also disturbed by the noise to a larger extent, compared with the patients with phonasthenia and their controls.

5. Conclusions

Individuals who are asked to reflect on how much they use their voices, and the amount of disturbing environmental noise, and rate those several times a day, can deliver a consistent pattern of the variation of those variables over time, in comparison with instrumental measurements of phonation ratio and noise SPL.

Acknowledgement

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