THE INVESTIGATION OF VOICE ERGONOMICS FACTORS IN THE PROFESSION OF CONDUCTOR

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Abstract
Conductors are professional voice users who need a good voice, and knowledge of voice ergonomics may help prevent voice disorders.
The aim of the study was to investigate the knowledge of voice ergonomics and factors that impact on the voice among choir and ensemble conductors.
An online survey was sent to Latvian choir and ensemble conductors. The survey was operationalised through a Questionnaire of voice ergonomics risk factors, included questions concerning the conductors' working practice and vocal self-assessment scales. The questionnaire was completed by 155 choir and ensemble conductors.
The data concerning general and vocal health, workload, noise, air quality, body and head posture, vocal load, stress, and fatigue during and after rehearsals were obtained and analysed.
The survey outcomes provided valuable information about factors of voice ergonomics amongst choir and ensemble conductors and it highlighted ways for improving vocal health in this group of professional voice users.
Keywords: *voice ergonomics, conductors, vocal symptoms, working practice, online survey*

Introduction

In Latvia, choral music has old and well-established traditions, which are maintained, cherished and handed down, first and foremost, by a choir conductor, artistic leader - a charismatic personality, who is a leader, guide, teacher and advisor of a collective in one person. A choir conductor is responsible not only for the conceptual selection of artistic programs and planning the work of the collective, for technical and artistic rehearsing and performing these programs at the concert, but also for inspiring, guiding and stimulating the collective for a collaborative process of creation, joint artistic communication among themselves and with listeners, and the wider society.

Vocal communication is like an intermediary between human relationships and the development of a personality. Therefore, practitioners and theoreticians from different

fields of activity (music, medicine, psychology, and pedagogy) have always been interested in the possibilities of human voice expression.

Voice is a personality's means of expression since it can betray our deepest feelings. Despite different predispositions and genetic qualities, a personality characterised by a constant, internal subjectively dwelling 'Ego' develops during interpersonal communication. The individuality of any person develops through the interrelations that occur between people, which contend that each person's uniqueness results from being together with others (Eckert, 2008). Though voice properties are anatomically and acoustically determined, the voice reflects an individual's personality and emotional state. At the same time, human voices are unique within the individual context and as a means for conveying the most profound ideas of musical composition and individual emotional experiences. This aspect of voice is in the centre of a choir conductors' and vocal ensemble leaders' attention.

An illustrative example of the reflection of emotions in a voice can be seen in the latent voice messages frequently used in music therapy, for example, "voice betrays my feelings". Under the influence of strong emotions, such as mourning or anxiety, the voice changes, frequency vibrations emerge, and we perceive them as trembling voices. The fact that our voice can betray our feelings becomes evident when the speaker needs to hide his emotions (Paipare, 2021). The human voice is referred to as a performative phenomenon and an aesthetic object. These two concepts express the aesthetic power of the influence of voice.

Aesthetics of voice is tightly related to vocal health. Vocal disorders influence the sounding of voice by changing its tone, loudness, and timbre. In cases of disorder, voices sound tired, expressionless, and sometimes even annoying for other people. In many professions, voice is the primary working tool, as in those of actors, teachers, and the clergy. For these professions, it is essential to address the audience, and arouse their passion and inspire them. The profession for which a charismatic, highly professional voice is almost a compulsory prerequisite is that of a choir conductor.

The development of any profession is based on the skills and competencies necessary for professional activity. The profession of a choir conductor requires deep and comprehensive knowledge of music, special abilities of a conductor, and demands a considerable effort of mind and nerves, and physical strength (Linderbergs, 2012).

However, it is worth noting that choir conductors are one of the voice professions for which the knowledge about how to keep one's voice good and the possibilities of preventing vocal disorders are vital. A healthy conductor's voice is essential because giving the singers instructions can positively affect the singers' voices. Unfortunately, vocal problems are quite a widespread phenomenon among choir conductors. The conductor who has not acquired conducting methods and techniques well enough may harm his/her voice (Smith & Sataloff, 2013).

Voice is the conductor's work tool with universal application features. The requirements set for a conductor's voice are specific – it should be ready for rapid changes in functions, namely, for the transition from speaking to singing, from a low compass to a high compass, from soft dynamics to loud dynamics, from one style of singing to a different style of singing, for the development of clear diction a. o. The conductor's vocal load is closely related to the auditory load. When working with a choir, the conductor tries to hear clear chords, intonation, correct voice leading, diction, pronunciation of different languages, changes in timbral nuances and dynamics of choir sounding, and in listening to music

performed by the choir, the conductor's vocal folds show motor activities (Davidova & Sersnova, 2012). Additionally, during the rehearsal, such changes in activities – explanation (speaking voice), demonstration (singing voice), careful listening, repetition of a musical thought – take place innumerable times (Rehder & Behlau, 2008).

For a significant number of choral singers, the conductor is an essential vocal teacher, and they expect the conductor to be their authority on singing, the art of choral singing and the fundamentals of music (Smith, 2018). The research done in Finland, involving a survey of 319 choral singers, revealed that 63.2% of singers obtained their knowledge of voice and its use from their choir conductors (Ravall & Simberg, 2020). The task of a conductor requires not only teaching choral music but also demonstrating healthy ways to create it through one's singing voice (Webb, 2007). The choir conductor is required to know the basic principles of developing a free and natural vocal sound, risk factors for voice disorders, the development of a vocal apparatus. Furthermore, the conductor should be aware of the singers' voice problems, peculiarities, and specificity. This means that a conductor has to perfectly know and study the anatomy of the voice producing system and physiology of singing voice to train singers' voice and bear in mind their vocal health.

Voice ergonomics has been developed for improving voice and speech as tools for communication. It consists of all factors and measures that increase the possibilities of good voice and speech production. Voice ergonomics is concerned with personal and environmental factors (Sala et al., 2019). In choir conductors and choirmasters, factors of voice ergonomics involve conductors' knowledge about voice and different aspects of its use, vocal load (duration, continuity, and intensity of using the voice), acoustics and air quality in the rehearsal rooms. Such ergonomic factors as satisfaction with work and stress are also of great importance, since they are closely related to the internal microclimate of the choir (mutual understanding, creative atmosphere, discipline at rehearsals, a. o.).

The scientific literature has provided research on voice ergonomics in different representative vocal professions (teachers, call centre operators, fitness trainers, etc.). However, factors of voice ergonomics among different styles of singers have not yet been studied extensively, and within the context of the profession of conductors, these issues have been studied even less. Self-assessment questionnaires, where the respondents describe their subjective feelings and objective measurements of the room acoustics and vocal load, can be used to explore issues of voice ergonomics (Hom, 2013; Phyland, 2015; Rezende et al., 2015; Renk et al., 2017; Ravall & Simberg, 2020). Studies on occupational voice disorders emphasise the necessity to adopt a more bio-psycho-social approach, with a particular focus on addressing the current gap in our knowledge that would support the existence of the link between voice disorders and environmental conditions (Behlau et al., 2014). An excessive vocal load is one of the principal factors responsible for functional dysphonia (Whitling et al., 2017; Zabret et al., 2018). Work environment, workload, and psycho-emotional state are ergonomic factors which leave their imprint on the voice.

Since the research on choir conductor's vocal health and conditions of using voice has not yet been done in Latvia, **the aim** was to elucidate the conductors' knowledge about voice ergonomics and factors impacting voice.

Methods

The research was carried out within the frame of the project "Choir Conductors' Vocal Load within the Context of Voice Ergonomics" (Nr. lzp-2020/2-0250). The resolution from the Clinical Investigation Ethics Committee of The Development Association at the Pauls Stradiņš Clinical University Hospital was received for the implementation of this research.

This study was a cross-sectional study utilising an online questionnaire survey. The Questionnaire of voice ergonomics risk factors (Sala et al., 2019) was supplemented by questions that complied with the specificity of choir conductor profession to clarify the state of respondents' vocal health and factors of voice ergonomics. The questionnaire included the following blocks of questions:

- Demographic information (age, education, work experience, type of voice etc.);
- Health (laryngeal pathologies, general health condition);
- Knowledge about voice ergonomics;
- Workload (the number of rehearsals, concerts, length of rehearsals, the number of choir participants a. o.);
- Factors of environment (noise and reverberation, quality of the air);
- Body posture and the position of the head during the rehearsal;
- Working practices;
- Stress.

Three self-assessment scales were also included in the questionnaire.

Vocal Symptoms Scale (VSS) (Simberg, 2004) was a screening tool for voice disorders, it included seven vocal symptoms, and the respondents were supposed to answer how often they have experienced them during the recent year. Two or more weekly or more often occurring vocal symptoms might testify to having voice disorders.

The Voice Handicap Index (VHI-10) (Rosen et al., 2004) consisted of ten statements characterising the impact of voice disorders on the person's physical, functional, and emotional state. By applying the five-point Likert scale, the respondent evaluated to what extent each of these statements applied to their own experience of using voice. The Singing Voice Handicap Index (SVHI-10) was developed on the example of the Voice Handicap Index and included ten statements related to singing voice (Cohen et al., 2009).

The questionnaire was sent electronically to 700 addressees, included in the register of Latvian amateur choirs and vocal ensembles. Unfortunately, there was no information on how many addressees had received the invitation to participate in the study and how many of those addressees who received the invitation to participate in the study were conductors. Thereby, it is impossible to establish the response rate. The questionnaires were filled by choir and vocal ensemble leaders – conductors and choirmasters. A total of one hundred fifty-five completed questionnaires were received.

Software SPSS 16.0 for Windows was used for the statistical processing of data. Methods of descriptive statistics were applied to establish the distribution of different voice ergonomics factors in conductors. The research data did not correspond to the normal distribution; therefore, non-parametric data analysis methods were used. A Mann-Whitney test was applied to compare the two independent groups. The Chi-square test was used to compare dichotomous values. The correlation between the parameters was established by using Spearman's correlation analysis.

Results

In Latvia, there are 418 choirs registered in the Latvian culture database (LR Ministry of Culture, 2021). Questionnaires were received from 155 respondents, out of which 115 were women (74.2%). The distribution of respondents by age is shown in Table1. Out of all respondents, 19 were smokers (12.3%). In addition, conductors with different lengths of service participated in the research: the length of service of 17 respondents (11.0%) was less than five years, for 20 respondents (12.9%) – 6 to 10 years, for 30 (19.4%) from11 to 20 years, 42 (27.1%) from 21 to 30, 29 (18.7%) – from 31 to 40 years, and for 17 (11.0%) longer than 41 years.

Table 1. Respondents' mean age in female and male groups

CRITERION	n (%)	M	SD	Min	Max
All respondents	155 (100)	47.4	13.8	17	75
Gender					
Females	115 (74.2)	48.0	13.3	20	75
Males	40 (25.8)	45.5	15.1	17	75

Most of the respondents (88%) had higher levels of education in music, including those with a doctoral degree (n = 2). Sixty per cent of respondents had obtained their education in the profession of a conductor, and 56% - in the profession of music teachers. The respondents' responses testified to the fact that higher education was also received in such professions as vocalists, instrumentalists, musicologists, and conductors of symphonic or wind orchestra. During the process of higher education, most respondents had obtained several professions.

The analysis of conductors' involvement with a choir showed that most of them work with mixed choirs (72.3%), whilst those who worked with boys' choirs were in the minority. Almost thirty-five per cent of respondents were conductors of vocal ensembles (see Table 2). The obtained data indicated that in 57.4% of cases, one conductor worked with two or even more collectives.

Table 2. Types of choirs conducted by the respondents (female, male)

TYPE OF A CHOIR	TOTAL (N = 155)	FEMALE (n = 115)	MALE (n = 40)
	N (%)	n (%)	n (%)
Mixed choir	112 (72.3)	73 (63.5)	39 (97.5)
Vocal ensemble	54 (34.8)	43 (37.4)	11 (27.5)
Female choir	45 (29.0)	41 (35.7)	4 (10.0)
Children mixed choir	36 (23.2)	25 (21.7)	11 (27.5)
Girls' choir	24 (15.5)	22 (19.1)	2 (5.0)
Male choir	21 (13.5)	7 (6.1)	14 (35.0)
Boys' choir	15 (9.7)	9 (7.8)	6 (15.0)

Respondents represented different voice groups. In the female voice group, 40% were sopranos, 24% - mezzo-soprano, 35.7% - altos; in the male voice group, 25% were tenors, 57.5% - baritones, and 17.5% - basses. Along with conducting, 79% of conductors sing in different music collectives themselves - in choirs, ensembles or solo.

General and vocal health

The analysis of the data obtained on the general state of health showed that the most significant number of conductors complained about shoulder and neck muscle pains (59.6%), lower back pains - (35.1%) and about carpal channel syndrome, which appeared as numbness of palms and fingers (22.8%) (see Fig. 1). Furthermore, a Spearman's correlation analysis indicated a statistically significant correlation between shoulder and neck muscle pains and sense of vocal effort during rehearsals and tiredness after rehearsals (r_s = 0.181, P = 0.024; r_s = 0.218, P = 0.006); also a statistically significant association between lower back pain and vocal effort during the rehearsals was found (r_s = 0.254, P = 0.001).

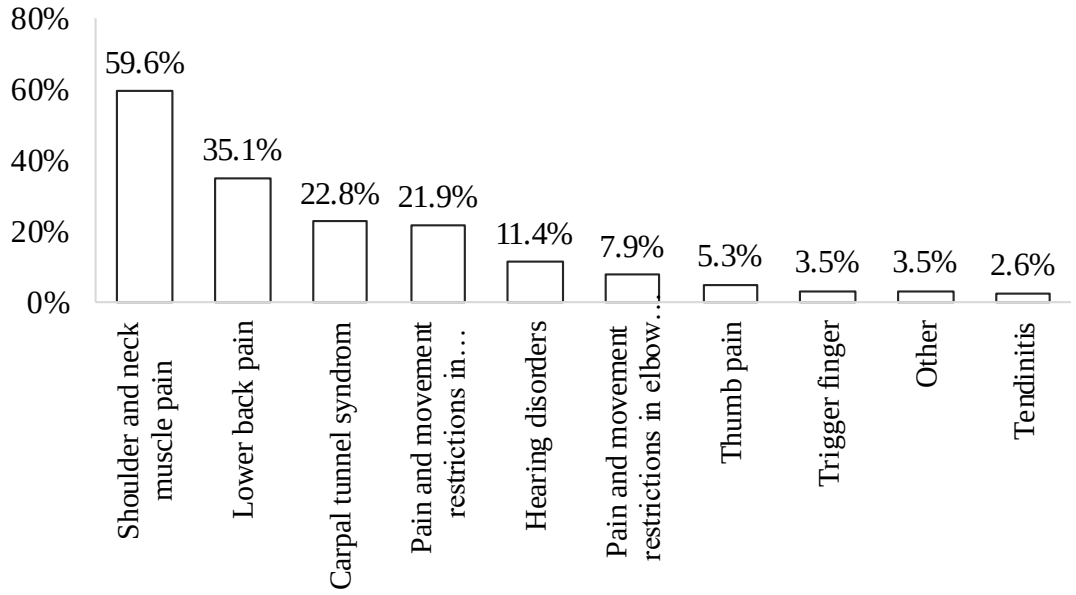

Figure 1. Health problems in conductors

The scores of the Vocal Symptom Scale indicated that 41% of conductors had marked two or more vocal symptoms, which occur weekly or more often and might testify to voice disorders (Simberg, 2004). However, only 19.4% of conductors marked laryngeal diseases in anamnesis (vocal nodules, polyps, phonasthenia, and dysphonia). The mean score of the VHI-10 was 8.6 points (SD = 6.0) in the whole group of respondents, the mean score of the SVHI-10 was 12.2 points (SD = 6.5). A statistically significant strong correlation between the scores of the VSS and VHI-10 (r_s = 0.471, P < 0.001) as well as between the scores of the VSS and SVHI-10 (r_s = 0.448, P < 0.001) were observed.

Conductor's workload

A conductor's workload assessment included collecting data about the number of rehearsals per week, the number of singers in the choir, and gathering information about the number of concerts a year, since the preparation and performing at concerts involve an increased physical and psychological load. Most respondents (70%) worked as choir or ensemble conductors and teachers at schools; therefore, the mean number of hours per week in the schools was clarified.

Table 3. Workload factors

WORKLOAD FACTORS	M	SD	Min	Max
Choir rehearsals per week (n)	3.3	2.6	1	20
Mean number of choir singers (n)	29.7	12.0	9	84
Number of concerts per year (n)	12.9	12.9	0	80
Pedagogical work per week (h)	15.4	14.0	0	46

Knowledge about voice ergonomics and application of this knowledge in everyday life

Respondents were asked to assess their knowledge about voice ergonomics by using four options – "very good", "almost good", "almost poor", "very poor". The assessment received from 7.7% of respondents was "very good", from 54.2% respondents - "almost good", from 33.5% respondents – "almost poor", but 4.5% of respondents assessed their knowledge about voice ergonomics as "very poor". Though female knowledge about voice ergonomics was better than male, statistically significant differences between the gender groups were not observed (Z = -0.6, P = 0.548, Mann-Whitney test). In assessing the application of knowledge relating to voice ergonomics in everyday situations, 18.1% of respondents responded that they did not use voice ergonomics knowledge in everyday life, 36.8% of respondents answered that they occasionally used it, but 45.2% stated that they used knowledge about voice ergonomics in everyday situations. Similarly, to the previous results, statistically significant differences between males and females concerning the use of knowledge about ergonomics were not observed (Z = -1.194, P = 0.233, Mann-Whitney test).

Noise and reverberation in rehearsal rooms

Respondents answered questions concerning the noise in rehearsal rooms. Fifty-two per cent of conductors maintained that the noise coming from different engineering-technical systems (ventilation, air-conditioners, and lamps) was heard in rehearsal rooms. In addition, the noise coming from outside was mentioned by 62.6% of conductors, saying that the noise coming from traffic, adjoining rooms or corridors was the most frequent one. Thirty-one per cent of respondents had noticed reverberation in rehearsal premises.

Air quality in rehearsal rooms

The respondents' highlighted three principal factors related to inner air quality: dry air during the heating season (63.9%); the presence of objects gathering dust – long curtains of the hall, hangings (36.8%); too high or too low temperature in the rehearsal premises (25.2%). Nineteen per cent of respondents mentioned heavy and stuffy air in the rehearsal premises, but 17% noted the presence of draughts. A statistically significant correlation was found between objects gathering dust in the rehearsal rooms and throat clearing and coughing when speaking (r_s = 0.227, P = 0.005).

Body and head posture

However, most of the respondents (81.3%) evaluated their body posture during the rehearsal as being comfortable. During the rehearsal, conductors were usually in an upright position (75%). Forty-two per cent of conductors noted that their bodies are relaxed during conducting, but 54% of conductors indicated strain and tension in shoulders, hands, or legs. The correct body posture during conducting - a stable standing position on both feet, distributing the weight equally between both feet was observed in

48% of conductors. The survey results demonstrated that such body positions as an extension of neck muscles, keeping head in a turned position and tensed and risen shoulders, which are harmful for voice production, were frequent in the practice of the conductors.

Vocal load during the rehearsal

The responses from the questionnaire revealed that 65.8% of respondents considered that they speak in a loud voice, but 22.6% stated that they speak in a loud voice even when not working with the choir, for 9% of conductors it was challenging to speak in a soft voice. The participants were asked to assess the average loudness of their voice during the rehearsal by applying the five-point Likert scale where the minimal value corresponded to a relaxed and quiet voice and the maximal value to a very loud voice. The mean loudness of voice during the rehearsal appeared to be 3.36 points (SD = 0.63). In the same way, by using the Likert scale, the vocal effort during the rehearsal was assessed (minimal value – not at all, maximal value – very much). The conductors evaluated the mean vocal effort with 3.53 points (SD = 0.98). A statistically significant moderate correlation between the voice loudness and vocal effort during rehearsals was found (r_s = 0.376, P < 0.001) (see Table 4). Previous studies have shown that voice loudness is related to activity noise; therefore, the respondents were asked to evaluate the activity noise during rehearsals using a five-point scale where the maximal value corresponded to very loud noise and minimal to a very silent. The activity noise created by choir singers was scored as 2.39 points (SD = 0.8). A statistically significant weak correlation between the activity noise during rehearsals and conductors' voice loudness (r_s = 0.269, P = 0.001), as well as a moderate correlation between the activity noise and vocal effort (r_s = 0.339, P < 0.001), was found. (See table 4).

The second component characterising a vocal load was the voice using duration. The excessive and continuous voice use during the day was mentioned by 58.7% of conductors. Pauses, allowing the voice to have a rest, were taken by 78.7% of conductors. The data obtained showed that the average duration of rehearsals was 133 minutes (SD = 32.4). The length of rehearsals was within the range of 60 to 240 minutes. During the rehearsal, the break was made by 64% of conductors.

Stress and fatigue

The participants were asked to evaluate stress during rehearsals and vocal and general fatigue after rehearsals by applying a five-point Likert scale where one point corresponds to the minimal display of the factor, while 5 points – to the maximal expression of the factor. The mean stress assessment score was 2.2 points (SD = 1.06), the mean vocal fatigue score was 3.29 points (SD = 1.10), and the mean assessment score for general fatigue after rehearsal was 3.25 points (SD = 0.98). Spearman's correlation indicated a statistically significant strong correlation between vocal and general fatigue after rehearsals and between vocal fatigue and vocal effort (see Table 4). In addition, the analysis of the data indicated that stress had a significant correlation with vocal and general fatigue, vocal effort, and activity noise during rehearsals (see Table 4).

Table 4. The correlation of stress and fatigue with the voice loudness, vocal effort, and activity noise (Spearman's correlation)

CRITERION	(1)	(2)	(3)	(4)	(5)
Stress during rehearsals (1)					
Vocal fatigue after rehearsals (2)	0.480**				
General fatigue after rehearsals (3)	0.450**	0.570**			
Voice loudness during rehearsals (4)	0.153	0.266**	0.228**		
Vocal effort during rehearsals (5)	0.440**	0.659**	0.379**	0.376**	
Activity noise during rehearsals (6)	0.264**	0.344**	0.144	0.269**	0.399**

** $P \leq 0.001$

The knowledge of voice ergonomics and vocal symptoms

Two respondents' groups were formed based on the Vocal Symptom Scale scores. Conductors with two or more vocal symptoms occurring weekly or more often were included in the voice disorders' group (41%). The voice disorders' group participants had higher scores on the VHI-10 and the SVHI-10 than respondents without self-assessed voice disorders (Z = -5.8, P < 0.001; Z = 5.514, P <0.01 *Mann-Whitney test*).

A Chi-square test showed a significant difference between conductors with and without voice disorders in knowledge about voice ergonomics. A more significant number of conductors with voice disorders indicated their knowledge of voice ergonomics as "very poor" and "almost poor" in contrast to conductors without voice disorders, the majority of whom evaluated their voice ergonomics knowledge as "very good" and "almost good" (χ^2 = 6.587, P = 0.01) (see Fig. 2).

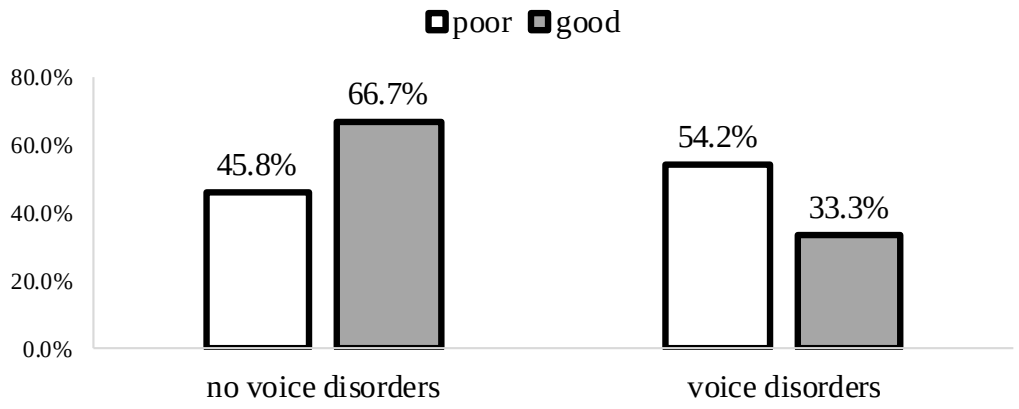

Figure 2. Knowledge of voice ergonomics in conductors with and without voice disorders

Risk factors of voice disorders among conductors

The demographic and voice ergonomics risk factors (N = 90) were compared in both respondents' groups using Chi-square test analysis. The results indicated that female conductors had voice disorders more frequently than males (χ^2 = 4.229, P = 0.04). Self-assessed voice disorders were observed in 46.1% of female and 27.5% of males. Table 5 demonstrates factors that were found to have a statistically significant impact on the conductors' voices. The data analysis indicated that self-assessed voice disorders in conductors were related to medical factors, body and head posture during rehearsals, prolonged and excessive voice use, and dust in rehearsal premises. Moreover, we found

that voice disorders were related to the stress (Z = -4.756, P < 0.001), to vocal effort (Z = -5.678, P < 0.001), and to activity noise during rehearsals (Z = -3.157, P = 0.002). Voice disorders were rarer among the conductors who used knowledge of voice ergonomics in daily practice and rested voice during breaks (See Table 5).

Table 5. Factors impacting on voice disorders (Chi-square test)

FACTORS	NO VOICE DISORDERS n (%)	VOICE DISORDERS n (%)	$X(1)$	P
Laryngeal diseases in anamnesis	10 (33.3)	20 (66.7)	9.882	0.002
Lower back pain	17 (42.5)	23 (57.5)	5.844	0.016
Hearing disorders	4 (30.8)	9 (69.2)	4.570	0.033
Girls' choir conducting	7 (29.2)	17 (70.8)	10.224	0.001
Solo singing	26 (78.8)	7 (21.2)	6.972	0.008
Good knowledge of voice ergonomics	64 (66.7)	32 (33.3)	6.587	0.01
Use of the knowledge of voice ergonomics in daily practice	50 (71.4)	20 (28.6)	9.009	0.011
Interior decoration materials collecting dust	26 (45.6)	31 (54.4)	6.378	0.012
Head tilted forwards	18 (43.9)	23 (56.1)	5.042	0.025
Head in a turned position	26 (46.4)	30 (53.6)	5.455	0.02
Tensed body during conducting	1 (16.7)	5 (83.3)	13.147	0.001
Prolonged and excessive voice using	45 (49.5)	46 (50.5)	7.794	0.005
Breaks during rehearsals	65 (65.0)	35 (35.0)	4.6	0.032

Discussion

The study allowed an insight into the daily life of choir and vocal ensemble conductors and highlighted the problems of vocal health and working conditions in this professional group. Like that of teachers, the conductor's voice quality may be impacted by different risk factors, such as neglecting voice ergonomics, indoor acoustic and air environment factors, and medical psycho-social factors (Trinite, 2017).

Previous studies have shown that an increased vocal load is one of the main factors of voice problems (Behlau et al., 2014; Trinite, 2017; Whitling et al., 2017). An increased vocal load may be caused by the conductors' working schedule, repertoire, and indoor environment where the rehearsals take place. Our study indicated that a considerable number of conductors worked as music teachers or lecturers in schools and universities, choral rehearsals usually took place in the afternoons or evenings, and performances were organised on weekends. Furthermore, the study showed differences in the intensity of conductors' work; for example, the number of rehearsals per week varied from 1 to 20, and some choirs had concerts very often (up to 80 concerts a year). The number of singers in choirs and ensembles was also different – from nine to 84. The diversity of working

conditions leads to the conclusion that the working load of Latvian conductors varies. Our study did not find associations between self-assessed voice disorders and the number of rehearsals, concerts and singers in choir or ensembles. However, associations between voice problems and prolonged and excessive voice use were found and, quite possibly, strongly related to the conductor's duties in the choir and pedagogical work.

One-fifth of respondents maintained that they had laryngeal illnesses diagnosed by otorhinolaryngologists. However, we observed that a considerably larger number of conductors (41%) had two or more vocal symptoms that occurred weekly or more often. Furthermore, the Vocal Symptom Scale scores had a good correlation with the scores of the VHI-10 and the SVHI-10, which implies that vocal symptoms essentially impact speaking and singing voice as well as on individuals' physical and emotional well-being. This tendency is alarming since it shows that voice disorders among conductors have not been adequately studied and identified, and the present minor problems might develop into severe disorders in future.

Neck, shoulder and lower back muscle pains, syndrome of carpal channel and pains in shoulder and elbow joints are common in the conductor's profession, along with sensorineural and conductive auditory disorders (Smith & Sataloff, 2013). Our research revealed that these specific health problems are not unfamiliar to Latvian conductors. The three most frequently mentioned health problems were shoulder and neck muscle pains, lower back pain and syndrome of a carpal channel. Data analysis indicated that illnesses relating to shoulder, elbow or palm problems do not impact voice quality. The number of vocal symptoms was more significant for those conductors whose body posture during conducting was tense, and head position was inappropriate from an ergonomic point of view. A statistically significant correlation between lower back pain and vocal effort during rehearsals and between shoulder muscle pains and vocal fatigue after rehearsal was also identified. Several studies showed that a muscular imbalance caused by a wrong body position inflicts pains in skeletal muscles and affects voice production (Rubin et al., 2006). Our study confirmed these statements - conductors working in non-ergonomic postures for a longer time had complaints about pathological tension in body muscles that inflicted pains. Singing and speaking with poor body and head posture during the rehearsal increase vocal fatigue and increase the vocal effort necessary for achieving the intended result. Thereby, an increased vocal load could be a potential risk factor for voice disorders. Our study indicated that conductors with hearing disorders have a more significant number of vocal symptoms than those without. This finding agrees with Sataloff and Linville's statement that hearing disorders cause voice tension and a louder voice when speaking (2005). Consequently, this is another additional factor creating vocal load and potential risks to vocal health.

Body posture has a vital role in the profession of conductors since choir singing is conducted not only by moving hands but by the whole body. Our study aimed to explore to what extent factors of voice ergonomics are considered in the practice of conductors. However, exploring the causes of identified problems would be another task for future studies. Why do conductors use non-ergonomic body posture? Is it possible to look for the cause in the work environment (location of the choir, stage height, position of the piano) or among psychological and emotional factors since stress can also cause muscle tension in the body?

The analysis of ergonomic factors related to noise and acoustics demonstrated that though the conductors mentioned the noise heard in the room or outside it during the rehearsal, it does not affect the appearance of vocal problems much. These results

partially correspond with the conclusions drawn from the research on voice ergonomic factors among teachers. Like conductors, teachers identified background noise during a lesson, but unlike conductors, the association between noise and voice problems was found in teachers (Trinite, 2017, 2019). We can therefore hypothesise that these differences could be attributed to the fact that when the singers fill the room with the sound of singing, background noises seem insignificant, and the conductor does not perceive them as an obstacle. The research showed that the activity noise, i.e., the noise created by singers during rehearsals, affects the conductor's voice quality. Increased activity noise could occur in song learning when all conductors's attention is given to one voice group, but all others are bored. Following other studies, activity noise is closely related to the number of singers in the room – the more singers, the higher the level of activity noise. In such situations, the Lombard effect is observed, i.e., the conductor's voice becomes louder as the activity noise increases. It is clear that speaking or singing in a noisy environment requires more vocal effort. Such a problem could be eliminated by improving work organisation, i.e., dividing a choir into voice groups and working with each group separately. Such a practice is common in female, male, and mixed choirs, but not always in children's choirs. Conductors of children choirs should find a way how to involve all children to avoid noise-provoking situations. We found that voice disorders were more common in girls' choir conductors. This is probably because the average number of singers in the girls' choirs was higher than in all other choirs ($M = 35.3$, $SD = 16.8$). In addition, the mean score of activity noise during rehearsals was higher in girls' choirs than in other choirs ($M = 2.5$, $SD = 1.0$).

Surprisingly, only 31% of respondents noted the presence of reverberation in the rehearsal rooms. Reverberation enhances music perception and is one of the most critical acoustic criteria for rehearsal rooms and music halls. Although the recognition of reverberation is independent of the existence of any respondent's background in acoustics (Giron et al., 2020), i.e., the assessment of the subjective perception of reverberation can be provided by any user of the room, we consider that conclusions about the acoustics of a rehearsal room and its suitability for choir singing should be based on objective measurements of reverberation. The impact of room acoustics, especially reverberation time, on conductors' vocal load should be investigated further in the future.

The vibratory capacity of vocal folds is directly impacted by the indoor air quality and relative humidity in rehearsal rooms. Dry air in a room increases the concentration of dust, especially if rooms have many dust collecting interior items. We found that conductors who work in dusty rooms more likely had a cough and had more vocal symptoms. These results were in line with other studies stating that a dust concentration in the air is strongly associated with the number of negative vocal symptoms (Simberg et al., 2005). In addition, dust promotes coughing, injuring the mucous membrane of the vocal folds and reducing secretion, causing dryness of the mucous and contributing to inflammation (Marcelino & Oliveira, 2005).

One of the aims of this study was to investigate the knowledge of voice ergonomics in conductors. Most of the respondents (61.9%) stated that their knowledge about voice ergonomics was good. A pretty similar questionnaire study about voice ergonomics in choir singers was carried out in Finland. Results obtained from the survey demonstrated that 55.9% of choir singers had basic knowledge about voice ergonomics (Ravall & Simberg, 2020). Responding to the question concerning using knowledge of voice ergonomics in daily practice, 45% of conductors gave a positive answer; while 37% answered that they do it only occasionally. Though on the whole, conductors had

knowledge about voice ergonomics and implemented this knowledge in daily practice, there was a significant number of conductors (41%) who had two or more vocal symptoms appearing weekly or more often. The study carried out in Finland used the same Vocal Symptom Scale, and only 21% of choir singers had vocal problems (Ravall & Simberg, 2020). So, significantly lower number of voice disorders was found amongst choir singers compared to conductors with almost the same level of knowledge of voice ergonomics. These results can be explained by the fact that singers do not have such extensive and prolonged voice use as conductors do. Although generally, the study showed a statistically significant correlation between a better voice quality (no vocal symptoms) and better knowledge of voice ergonomics, nevertheless in both groups of conductors (with and without voice disorders), many respondents assessed their knowledge about voice ergonomics as being poor. Moreover, frequent vocal symptoms were observed in the group of conductors who scored their knowledge of voice ergonomics as very good and almost good. This observation leads us to conclude that probably the knowledge about voice ergonomics is superficial, and a dearth of understanding does not enhance the use of this knowledge in everyday practice.

Conclusions

Knowledge about voice ergonomics is essential for professions where voice is the principal tool of work. For the choir, a conductor is something more than merely the leader of the collective. He/she is simultaneously a teacher, advisor, guide in the world of music and an inspirer. He/she is the one who demonstrates the model of correct voice production and singing and sees to it that every singer should acquire and follow it. Our research characterised the conductor's working environment and revealed those factors of voice ergonomics that impact the conductor's voice. The research outcomes indicate the fact that knowledge about voice ergonomics needs improving among conductors. Therefore, teaching voice ergonomics should be brought into choir conductors' educational programs, the standard of professions and post-diploma education.

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