

A Randomized Controlled Trial With Female Teachers: Are there Differences Between and Within the Outcomes in Voice Therapy Groups With and Without Carryover Strategies?

*Pirilä Sirpa, *Saarentaus Paula, †Ansamaa Terhi, ‡Elina Niemitalo-Haapola, *Yliherva Anneli, and *Rantala Leena, *Tampere, and ††Oulu, Finland

Summary: Purpose. We investigated if outcomes differ between voice therapy groups systematically using carryover strategies (attempts to generalize new vocal skills outside the clinic) and voice therapy with no emphasis on any generalizing process (here referred to as traditional voice therapy).

Method. A randomized controlled trial was conducted. Participants (53 female teachers with voice disorders) were randomly allocated into three groups: *Carryover* (a group receiving voice therapy using carryover strategies), *Trad* (a group receiving voice therapy with no emphasis on any generalizing process), *Controls* (a group on an eight-week non-therapy period). Prior to the trial a direct laryngoscopy was performed with a videolaryngoscopy system and/or nasofaryngofiberscope with stroboscopy. Before and after therapy and at follow-up a voice evaluation protocol was implemented consisting of subjective assessments (Questionnaire on Voice Symptoms, and the Voice Activity and Participation Profile; VAPP), and objective measurements (voice sample recordings, acoustic analysis [SPL, sound pressure level; f_0 , fundamental frequency; alpha-ratio, tilt of the sound spectrum slope]).

Results. No differences were found between the groups. Several significant changes occurred within the groups between initial phase vs. post-therapy and initial phase vs. follow-up. In the Carryover group text reading the alpha-ratio became lower ($P = 0.011$) and spontaneous speech f_0 increased ($P = 0.024$) after the therapy and [a:] SPL increased ($P = 0.042$) at follow-up. In the Trad group post-therapy [a:] alpha-ratio became lower ($P = 0.012$) and spontaneous speech f_0 decreased ($P = 0.034$). After therapy VAPP scores showed improvement in voice-related quality of life in both therapy groups (Carryover $P = 0.003$; Trad $P = 0.01$) but only in Carryover at follow-up ($P = 0.000$). Voice symptoms decreased in the Carryover group post-therapy ($P = 0.001$) and at follow-up ($P = 0.000$) and after Controls' eight-week non-therapy period ($P = 0.003$).

Conclusion. The results showed that carryover strategies give no additional advantages in voice therapy. However, the decreasing trend in the Carryover group's voice complaints at follow-up would suggest that carryover strategies may have long-lasting effects. The results also confirm that voice therapy is efficient in improving voice-related quality of life

Key Words: Voice therapy outcome—Carryover—Teacher voice symptoms—Subjective assessment—Voice quality—Follow-up studyI.

INTRODUCTION

Teachers have a high prevalence of voice disorders ranging from 51% to 69% during life-time and from 17% to 57% in clinical examinations.¹ Female teachers have been found to be prone to voice difficulties.² Research has also shown that voice therapy, both direct and indirect, is an effective treatment for voice disorders.^{3–6} However, there is limited information available regarding the process of extending and generalizing new vocal skills in everyday life (carryover) outside clinics.^{7,8} Further, it is not only teachers who benefit from well-functioning voice but also students: a good

quality voice delivers information more effectively and holds students' attention better than a dysphonic voice.^{9–13} Thus, in light of the above, it is important to have economical and efficient means of transferring good voice quality gained in voice therapy to teachers in the classroom.

Carryover strategies include supplementary tasks tailored individually utilizing those direct and indirect methods that a voice therapy client has adopted in the clinic.^{14,15} In some cases, the process of implementing a new vocal behavior takes place spontaneously but quite often clients have difficulties maintaining their new vocal skills and transferring them in daily life.^{7,8,16} To produce best possible voice therapy outcomes, it is necessary for clients to utilize the techniques learnt in therapy to their daily activities. A successful implementation of automaticity requires thoroughly planned and specific training during the voice therapy period in collaboration between the speech therapist and the client.¹⁷ Reminders have an important role in the carryover process calling the client's attention to a new vocal behavior.¹⁸ A reminder can be an object or an event helping the client to remember to use e.g., a good posture or relaxed

Accepted for publication June 22, 2022.

From the *Faculty of Social Sciences, University of Tampere, Tampere, Finland; †Department of Otorhinolaryngology, Oulu University Hospital, Oulu, Finland; and the ‡Faculty of Humanities/Logopedics, Child Language Research, University of Oulu, Oulu, Finland.

Address correspondence and reprint requests to Sirpa, Pirilä, Leppävaarankatu 17 A 1, 02600 Espoo, Finland. E-mail: puheterapeutti@sirpapiirilä.fi
Journal of Voice, Vol. ■■■, No. ■■■, pp. ■■■–■■■
0892-1997

© 2022 The Authors. Published by Elsevier Inc. on behalf of The Voice Foundation. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>)
<https://doi.org/10.1016/j.jvoice.2022.06.029>

phonation when talking.⁷ Concerning teachers' voice therapy, the carryover strategies can also include teachers' and students' vocally oriented teamwork with vocal exercises and attempts to increase students' and teachers' awareness of environmental factors affecting the voice (such as noise during lessons).¹⁹

Traditionally, the content of voice therapy has been described to include voice physiology, breathing, relaxation, posture, vocal function, resonance, voice ergonomics, and vocal hygiene.^{20–22} In addition, explanations for the causes and nature of the voice problems are part of therapy.^{20–22} Techniques for motivational interviewing have recently also been reported to be promising when addressing client's adherence to vocal behavior change.²³ In motivational interviewing skillful listening is used in a directive and constructive discussion about behavior change.²³ However, a carryover process is seldom mentioned as a component of voice therapy.

We found only few publications where carryover processes were considered and highlighted as a part of the voice therapy protocol. In turn, the importance of clients' own practicing and responsibility in a successful carryover is emphasized in several books on voice care and therapy.^{7,14,16,18,24} It has even been stated that all voice use techniques and exercises are almost useless if a client does not carry on using them in daily life.⁷ Furthermore, the process of enhancing carryover should start at the very beginning of the therapy session,⁷ and in a successful generalization process speaking tasks should proceed gradually from easier to more challenging.¹⁷ The challenge of generalization has been in focus in a recently developed non-hierarchical voice therapy approach such as *Conversation Training Therapy*, that uses patient-driven conversation as the only therapeutic stimulus, thereby incorporating carryover into the method from the very beginning.²⁵ The results of the approach have been promising. In some studies, the carryover process has been included in voice therapy,^{5,26,27} but to the best of our knowledge only in one study, conducted by Holmberg et al²⁸ was the contribution of carryover to therapy outcomes separately assessed (Table 1). According to this study, newly acquired vocal behaviors were successfully transferred to daily situations after carryover exercises.²⁸

The purpose of the present study was to investigate if outcomes differed between and within two voice therapy groups: in one group, carryover strategies (attempts to generalize new vocal skills outside the clinic) were guided systematically to voice patients from the very start of a therapy period (*Carryover* group) but in the other group, no exceptional emphasis was placed on any generalizing process than is typically included in traditional voice therapy (*Trad* group). A control group (*Controls*) with an eight-week non-therapy period was also included to assess the effects of the therapies. We aimed to investigate (1) if subjective evaluations and acoustic features in participants' voices changed during the two voice therapies with six-month follow-up, (2) if the changes of the two therapy groups differed from each other, and (3) what the values of the variables were after the control group's non-therapy period.

MATERIAL AND METHODS

Participants

Participants were recruited from 31 elementary schools in Finland. The principals of the schools were asked to inform their female teachers about the study and to pass on the recruitment information. The inclusion criteria for the participants were as follows: female elementary school teacher, voice symptoms and willingness to participate in voice therapy, Finnish as mother tongue, no hearing loss, non-smoking, no neurological diseases, and no voice therapy during the past year. The total number of participants was fifty-three: fifty-one were regular classroom teachers and two were special education teachers. One participant in the *Trad* group had an otosclerosis prosthesis in one ear. Because the teacher felt she could hear normally and because the initial measurements had already been done for her, the authors decided that the teacher could continue in the study. For practical reasons, one of the *Trad* group's teacher's post-therapy assessments was performed a short time after the end of the spring semester and one of the *Carryover* group's teacher's follow-up assessments during the weekend when voice production is not as loaded as on school days. Compared to the mean and median values of the parameters, the results showed no deviation and the authors decided to retain those results in the data.

Participants were randomly divided into three groups: 1. *Carryover* (a group receiving voice therapy using carryover strategies), 2. *Trad* (a group receiving voice therapy with no emphasis on any generalizing process), and 3. Control Group (*Controls*; a group with an eight-week non-therapy period). Based on the sample size calculation and power analysis the number of teachers was determined to be 27 teachers in each group (α 0.05, $1-\beta$ 0.80). Because indoor air quality problems are quite common in school buildings,²⁹⁻³¹ the authors decided to limit the number of teachers from each school to a maximum of five.

The participants were randomized to the groups by lottery. When the first teacher from each school enrolled, her therapy group was selected by drawing lots. Later, teachers participating from the same school were placed in the same group. At pre-therapy and post-therapy assessments we had 27 teachers in the *Carryover* group and 26 teachers in the *Trad* group. At the follow-up measurements the number of teachers was 25 in the *Carryover* group and 23 in the *Trad* group. In the Control group there were 24 teachers before and after the control period. Teachers showed great commitment and motivation when participating in the voice therapy sessions and in the measurements. The dropout rates of *Carryover* and *Trad* groups were 0% in post-therapy and 9% (five teachers) in follow-up measurements. The reasons for the dropouts were maternity, sickness, and being on leave, and one teacher was excluded for personal reasons. In the Control group the dropout rate was 0%. Compared to dropout rates reported earlier, from 47% to 65%,³²⁻³⁴ our dropout rates were very low. It is possible that the use of motivational interviewing had a positive effect on the teachers' commitment to the intervention.²³

TABLE 1.
Studies Using Carryover Process

Study	Participants	Phases of Voice Therapy	Carryover Procedure	Outcomes
Holmberg et al ²⁸	11 women with vocal nodules (19–35 years, mean age 23.3 years).	1) Vocal hygiene 2) Respiration 3) Direct facilitation 4) Carryover Three sessions for each phase. One session per week.	Using new vocal skills when (1) mimicking speaking situations in therapy room (e.g., phone talk) (2) talking outside therapy room (3) talking places outside clinic (e.g., in a restaurant).	After phases: - vocal hygiene: no changes. - respiration and direct facilitation: voice quality improved. - carryover: voice quality remained good outside clinic.
Niebudek-Bobusz et al ⁵	186 female teachers with voice disorders (23–60 years, mean age 38.7 years) Voice therapy group: n = 133 Control group: n = 53 Vocal hygiene advice for both groups	1) Breathing and relaxation (3–6 sessions) 2) Vocal function (3–6 sessions) 3) Resonant improvement (1–2 sessions) 4) Carryover (1–2 sessions.) One session per week.	Using new vocal skills when(1) mimicking speaking situations, (e.g., phone talk) (2) talking outside therapy room (3) in conversations outside therapy or clinic.	The contribution of the carryover to the results were not assessed separately. Therapy group: improvement in voice use. Several participants assessed their voice as normal. Control group: no improvements.
Rodríguez-Parra et al ²⁶	42 participants with voice disorders: 39 women, 3 men (16–65 years, mean age 33.1 years). Voice therapy group: n = 21 Voice hygiene group: n = 21; one vocal hygiene session of 60 min.	1) Basic information and counseling 2) Relaxation (5–15 min) 3) Breathing (5–10 min) 4) Emission and placement (15–25 min) 5) Carryover (5–10 min) One or two therapy sessions per week Therapy period 12 weeks.	Exercises tailored to participants' individual needs in their jobs and daily lives (e.g., singing or talking for a long period).	The contribution of the carryover to the results was not separately assessed. Voice therapy group: significant changes in voice status in several voice variables. Voice therapy was superior to voice hygiene program.
Lu et al ²⁷	55 women with dysphonia (20–60 years; mean age 36.4 years). Groups: people with (1) nodules and polyps (2) chronic laryngitis and (3) dissatisfaction with phonosurgical results. Control group: 50 healthy women	1) Vocal hygiene 2) Muscle relaxation 3) Respiration 4) Humming 5) Carryover One therapy session per week (60 min.). Therapy period 8 weeks.	Using new vocal skills in real-life situations (e.g., calling others, giving lectures, or reciting).	The contribution of the carryover to the results was not separately assessed. Vocal status improved significantly in each therapy group.

In the Carryover and Trad groups the teachers received a 45-min therapy session once a week for eight weeks. Actually, our teachers received six therapy sessions, because the first and the last meetings were used for recording and filling out questionnaires and no therapy exercises were performed. We can therefore talk about a short period of voice therapy,³⁵ which has been reported to be widely used.^{35,36}

To obtain realistic data on the voice quality and the generalization process (i.e., testing how well a participant had acquired a new voice use habit) without the immediate effect of the voice therapy practice, the post-therapy assessments were conducted around a week after the last therapy session. In addition, the teachers came to the assessments directly from their teaching work without any guided voice exercises. Control group had an eight-week non-therapy period after which half of the group was assigned to the Carryover group and the other half to the Trad group. The groups were comparable in terms of age and duration of employment (Table 2). Between the Trad and Carryover groups no significant differences were found in the initial scores of the voice symptoms nor in VAPP (Table 4 and Figure 1).

Phoniatric examination

The phoniatric laryngeal examination was carried out on all the participants before enrollment by a phoniatrician (MD) (one of the authors; TA). Those participants found to need treatment other than voice therapy (e.g., medication/surgery) were excluded from the study. Thus, one person with severe laryngitis was not included in the study. The laryngeal examination was performed with a videolaryngostroboscopy (VLS) system and/or nasofaryngofiberscope (ENF type P4, Olympus). The VLS system (Rp-Szene version 6.2, Rehder/Partner GmbH, Germany) consisted of a frequency

analyzer (MEZ-2/T), a strobe light source (KS-4200), a camera (rpCam250P) combined with a 70-degree rigid laryngeal endoscope (model 4450.501, Richard Wolf and/or model 8706CA, Karl Storz). Recordings were made in digital format on a personal computer (with RP Szene software). The participants were seated leaning forward with the chin elevated during the examination with the rigid endoscope or the nasofiberscope. The recordings were performed during an intermittent and sustained vowel [e:], during a glissando and a reading task during the nasoendoscopy. VLS could be carried out on all 53 subjects, either with the rigid scope or the nasoendoscope or both. Two persons could not tolerate these measures, or the larynx could not be visualised with the rigid endoscope, and they were assessed only through the nasal endoscope.

The teachers were classified into two categories according to the laryngeal examination: (1) functional voice disorder: teachers with no laryngeal changes and those with minor changes such as mild vocal fold erythema and/or swelling, excessive mucus, supraglottic lateral or anterioposterior contraction, some closure incompetence, asymmetry of vocal fold vibration, and (2) organic changes such as vocal fold nodules, vocal fold polyp, vocal fold atrophy or vocal fold hemorrhage. Characteristics of the groups' phoniatric findings are presented in Table 2.

Vocal training programs

The vocal training period lasted eight weeks; the total number of sessions was eight with 45-minute sessions once a week. All the therapy sessions with carryover strategies were delivered by the first author (SP). She also delivered most of the traditional voice therapy, but five of the traditional voice therapy sessions were delivered by the other

TABLE 2.
Characteristics of Carryover Group (Carryover), Traditional Therapy Group (Trad), and Control Group (Controls)

	N	Mean age \pm SD years (min-max)	Mean Employment time \pm SD years (min-max)	Findings in Phoniatric Examination
Carryover	Pre: 27 Post: 27 Follow-up: 25	39 \pm 9 (26 – 62)	13 \pm 9 (2 – 32)	- Functional voice disorder 93% (43% no changes, 50% minor changes) - Organic findings 7% (1 vocal fold nodules, 1 vocal fold polyp)
Trad	Pre: 26 Post: 26 Follow-up: 23	45 \pm 9 (32 – 63)	17 \pm 9 (2 – 37)	- Functional voice disorder 88% (48% no changes, 40 % minor changes) - Organic findings 12% (1 vocal fold nodules, 1 vocal fold hemorrhage, 1 vocal fold atrophy)
Controls	Before the control period: 24 After the control period: 24	42 \pm 10 (26 – 62)	16 \pm 9 (2 – 37)	- Functional voice disorder 92% (50% no changes, 42 % minor changes) - Organic findings 8% (1 vocal fold nodules, 1 vocal fold hemorrhage)

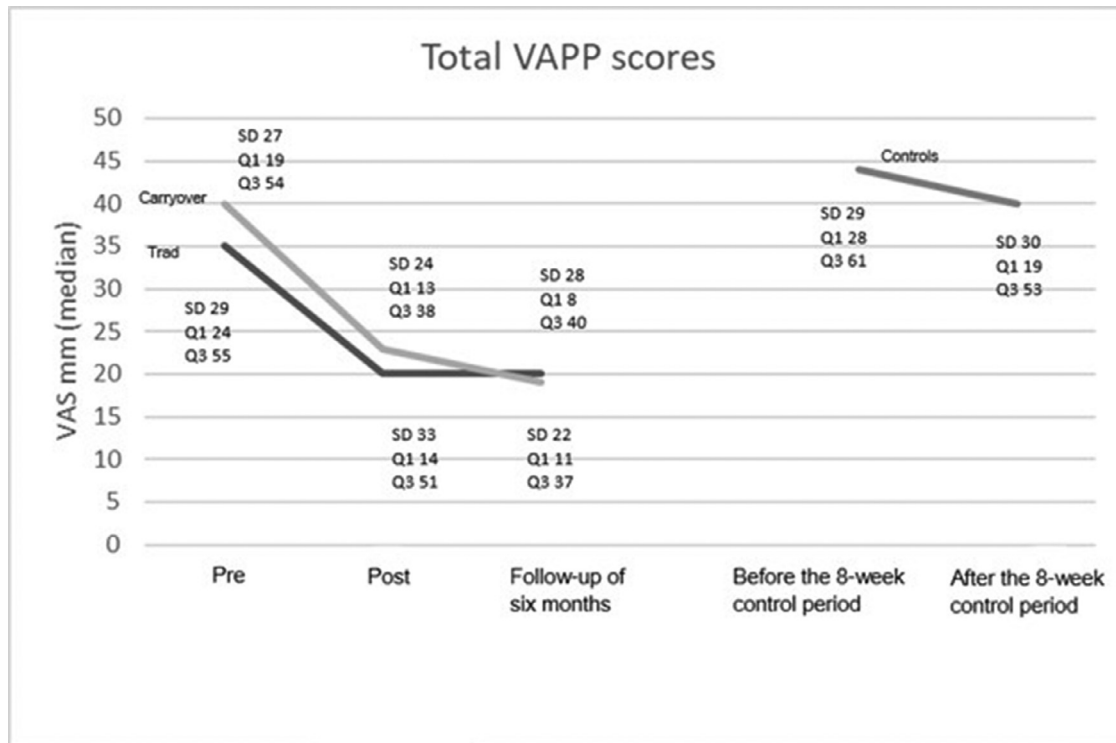


FIGURE 1. Median values of total scores of voice-related quality of life (VAPP). The higher the value the greater the perceived disadvantage (VAS 0–100 mm). Pre=before the interventions, post = after the interventions, follow-up = six months after the end of the therapy. Carryover = a group receiving voice therapy with carryover strategies (n = pre 27, post 27, six months 25); Trad = a group receiving voice therapy with no emphasis on any generalizing process (n = pre 26, post 26, six months 23); Controls = a group without therapy for 8 weeks (n = pre 24, after = 24). IQR (Q3 [upper quartile] - Q1 [lower quartile]).

authors (LR, AY and PS). To standardize the vocal training program the authors had three planning and introductory sessions before the voice therapy started. For practical reasons therapy sessions were delivered before or after working days at a participant's school or at a clinic.

Traditional voice therapy

The traditional vocal training program consisted of five main elements: (1) breathing and relaxation exercises, (2) vocal function exercises, (3) resonance improvement exercises, and (4) voice ergonomic guidance.^{15,20–22,37} In addition, (5) motivational interviewing was used.²³ The participants were asked to do the same exercises once a day at home as were done during the therapy session but no extra attempts to generalize or transfer the new vocal skills outside the therapy sessions were made. If a participant herself noticed the ideas of generalization or transferring, the therapist acknowledged the idea, but did not give any additional advice.

Voice therapy with carryover strategies

The content of the voice therapy with carryover strategies included the same five elements as in the traditional voice therapy sessions and same home practice exercises. In addition, the therapist gave guidance (see below) to help the participant to generalize and transfer new vocal skills

outside the therapy sessions in daily situations in the classroom.^{7,15,17,37} Moreover, teachers were asked to do voice training exercises and vocally oriented teamwork with their students according to advice given by the researcher (SP). The above-mentioned exercises included, for example, vocal warm up, relaxation of the larynx, neck, and shoulders, and attempts to increase students' and teachers' awareness of environmental factors having an impact on the voice (such as noise during lessons).¹⁹

The carryover guidance included individually tailored tasks such as:

1. When looking at the clock, remember to relax your jaw and check that you have space between your teeth.
2. When waiting for your students to take their seats when entering the classroom, remember good posture and deep breaths.
3. When saying aloud your students' names, greetings, and instructions, try to use the kind of voice that was practiced during your therapy session.
4. Include short moments in your lesson when you do not have to talk and relax your mind and body (e.g., when waiting for the children to complete their independent school assignments).
5. Every time you go to work at your desk, drink a small amount of water.

6. When you come across a nice picture or object in your classroom, try to slow down and relax your speech as practiced during your therapy session.
7. If the person is farther away from you, do not use a loud voice, but walk closer and talk in a soft voice.
8. During recessions, try to rest your voice.
9. When listening to your communication partner, let your face and vocal system relax.
10. Be calm even if your day is busy.

A questionnaire on voice symptoms and the voice activity and participation profile VAPP)

To elicit the voice symptoms and dysfunctions caused by voice malfunctioning we gathered data on voice symptoms and voice-related quality of life. Voice symptoms were evaluated with a modified version of the voice screening method by Simberg et al.³⁸ The teachers reported how often their voices felt tired, hoarse or dry, how often their voices were not able to penetrate the noise, how often they had voice breaks or aphonia and a feeling of a lump, irritating mucus, or pain in their throats. The responses were given once at each measuring point: before and after the therapy sessions and six months after the end of the therapies (follow-up). The score on the questionnaire was summarized for the analyses (0 = less than once a year or never, 1 = a couple of times a year or occasionally, 2 = about once a month or quite often, 3 = almost every week or very often). The total score was from 0 to 27. Our self-report questionnaire reveals the number and the nature of voice symptoms and their frequency, but it has no criterion for voice disorder.

Voice-related quality of life was evaluated by the validated Finnish version of the Voice Activity and Participation Profile (VAPP), in which the teachers gave self-assessments of their voice-related limitations on activities and participation (28 items).³⁹ The responses were given before and after the therapy sessions and at six-month follow-up by marking a 100 mm long visual analog scale (VAS). The higher the value, the greater the perceived disadvantage. The minimum score for each question was 0 and

the maximum 100 (0 = perfect match with the question, 100 = no match at all with the question). Total scores ranged from 0 to 2800.

Voice samples and acoustic analysis

Voice samples were recorded before the therapy and around a week after the last voice therapy session and at six-month follow-up. Voice samples were sustained vowel [a:] and spontaneous speech recorded according to the Finnish version of Consensus Auditory-Perceptual Evaluation of Voice (Cape V – protocol) (translation by the author SP).⁴⁰ In addition to this, teachers read aloud a text of 79 words that did not include any [s]-sounds (in Finnish). A text with no [s]-sounds was used to enable conclusions on changes in voice quality based on voice spectrum analysis because fricatives with a strong noise at a wide frequency band could distort the values of the alpha-ratio.⁴¹ Characteristics of the recorded voice samples and acoustic analysis are presented in Table 3.

The recordings were made in a quiet room using a Zoom H2 handy digital recorder (Zoom Corporation, Tokyo, Japan) and a headset microphone (AKG C555L, Vienna, Australia) with a portable amplifier (AKG B29L). The mouth-to-microphone distance was 8 cm (0.08 m) from the middle of the upper lip.⁴² The recordings were calibrated for the measurements of voice SPL using a sound generator (BOSS TU-120, Roland Corporation, Los Angeles, CA) and a sound level meter (Brüel & Kjær, 2206). The mean signal-to-noise ratio was 38 dB (SD 2.6 dB) during the recordings indicating that the conditions were acceptable for acoustic analysis of the data (recommended SNR > 30 dB).⁴³

Acoustic variables analyzed were fundamental frequency (f_0), sound pressure level (SPL), and the tilt of the sound spectrum slope (so-called alpha-ratio, that is, relation of the energy levels of the frequency bands of 50–1000 Hz and 1000–5000 Hz) expressing voice quality on a continuum hyperfunctional – hypofunctional

TABLE 3.

Characteristics of the Voice Sample Recordings and Acoustic Analysis. Consecutive Sustained [a:] Sounds and Spontaneous Speech Samples Were Recorded According to CAPE-V. In Addition, Finnish Reading Samples With no [s]-sounds Were Recorded.

Recordings	Instructions for Participants	Edits for Analysis	Parameters Analyzed
Three consecutive sustained [a:] sounds	Use comfortable, normal voice.	Middle [a:] sound	f_0 , SPL, alpha-ratio
Spontaneous speech	Response to: "Tell me about your voice problem/how is your voice functioning?"	3 sec. segment from the sample's middle section with as much continuous speech as possible	f_0 , SPL
Reading sample (no [s]-sounds)	Use comfortable, normal voice.	Whole sample was analyzed. Any unrelated noise (i.e., coughing, laughing, comments) was deleted.	f_0 , SPL, alpha-ratio

axis. In the present study our interest was to study voice characteristics without vocal fry. We have previously found that the amount of creaky voice in female teachers has been up to 54%,⁴⁴ and in the future we will also focus our research on creaky voice. To be able to set the proper f_0 values for the analysis in the present study, we explored 20% of the voice samples before the therapy sessions. We found that f_0 was on average 13 Hz lower with the settings of 40 to 320 Hz (mean 166 Hz, \pm SD 23) compared to settings of 130 to 450 Hz (mean 179 Hz, \pm SD 17). Based on this the f_0 settings for the analysis were set at 130 to 450 Hz in the present study. The samples were analyzed using Praat software for Windows (Version 6.1.04).⁴⁵

Statistical analysis

Differences in the changes between and within the Carryover and Trad groups were compared as follows: (1) Before the therapy session – after the therapy session, and (2) Before the therapy session – at six-month follow-up. Differences in the changes within the Controls were compared as follows: At the beginning of the eight-week control period – at the end of the control period. The statistical analyses were conducted with SPSS software (IBM SPSS Statistics v. 27, Armonk, NY) The distributions of the variables were checked and calculated with Kolmogorov-Smirnov test. Means and standard deviations were calculated for normally distributed variables (the data from the Questionnaire of Voice Symptoms, and the voice parameters f_0 , SPL, alpha-ratio) and medians and interquartile range for non-normally distributed variables (data on VAPP). The differences between the groups were analyzed with ANOVA. Student's t test for paired samples and Wilcoxon signed rank test were used for the comparisons of the variables' values within the groups. Effect sizes for the group differences were calculated with Cohen's d (normally distributed variables) and with r (with non-normally variables).⁴⁶ Interpretation of the values was as follows: 0.2 = small, 0.5 = medium, and 0.8 = large effect. The significance level was set at $P \leq 0.05$.

RESULTS

Voice symptoms and VAPP within the groups

The Carryover group's total voice symptom scores decreased significantly, by 22%, during the therapy sessions ($t = 3.607$, $df = 26$, $P = 0.001$, $d = 0.67$, 95 % CI [0.14, 0.51]) and the scores were 42% lower at follow-up compared to the scores before the intervention ($t = 5.249$, $df = 22$, $P = 0.000$, $d = 1.095$, 95 % CI [0.36, 0.83]) (Table 4). The Trad group's voice symptom scores also decreased but only by 6% in the course of the therapy ($t = .929$, $df = 24$, $P = 0.362$, $d = 0.186$, 95 % CI [-0.092, 0.243]) and 17% between the assessment points pre-therapy and follow-up ($t = 0.967$, $df = 21$, $P = 0.362$, $d = 0.206$, 95 % CI [-0.128, 0.350]). The Control group's voice symptom scores decreased significantly by 15% after the eight-week non-therapy period ($t = 3.271$, $df = 22$, $P = 0.003$, $d = 0.682$, 95 % CI [0.087, 0.387]) (Table 5).

Total VAPP score decreased significantly within both groups between pre-therapy and post-therapy assessments: the decrease was 27% in the Carryover group ($Z = -3.006$, $P = 0.003$, $r = -0.409$) and 21% in the Trad group ($Z = -2.570$, $P = 0.01$, $r = -0.356$) (see Figure 1). At six-month follow-up the total VAPP score within the Carryover group continued to decrease and was 37% lower than the value measured before the intervention ($Z = -3.721$, $P = 0.000$, $r = -0.516$). No change was found in the Trad group's scores between the assessment points pre-therapy and the follow-up. Within the Control group total VAPP decreased 13% after the eight-week non-therapy period, but the decrease was not significant (see Figure 1).

Acoustic voice parameters within the groups

The Carryover and Trad groups' acoustic voice parameters are presented in Tables 6, 7, and 8. Within the groups several changes occurred in the course of the therapy and the follow-up period. Within the Carryover group the alpha-ratio of text reading decreased 1.3 dB ($t = 2.722$, $df = 26$, $P = 0.011$, $d = 0.52$, 95 % CI [0.31, 2.24]) and the f_0 of spontaneous speech increased 8 Hz ($t = -2.400$, $df = 26$, $P = 0.024$, $d = -4.6$, 95 % CI [-1.24, -2.4]) compared to the values measured in the initial and post-therapy assessments. At six-month follow-up the Carryover group's mean SPL

TABLE 4.

Mean and SD of Voice Symptoms Scores in the Group Receiving Voice Therapy With Carryover Strategies (Carryover) and the Group Receiving Voice Therapy With No Emphasis on Any Generalizing Process (Trad). Measurement Points: Beginning (pre) and After Therapy (post) and at Six-month Follow-up. Range of Scores 0 – 27

Voice Symptoms	Carryover			Trad		
	Pre n=27	Post n=26	Follow-up n=25	Pre n=26	Post n=26	Follow-up n=23
Mean	13.7	10.7	8.6	11.2	10.6	10.5
\pm SD	14.0	14.7	11.8	12.8	13.4	10.0
<i>P</i>		<i>pre-post</i> 0.001*	<i>pre-follow-up</i> 0.000*		<i>pre-post</i> <i>ns</i>	<i>pre-follow-up</i> <i>ns</i>

* significant.

ns, not significant.

TABLE 5.
Mean and SD of Control Group's (Controls) Voice Symptom Scores. Measuring Points: Beginning of 8-Week Non-Therapy Period and After it. Range of Scores 0 – 27.

Voice Symptoms	Beginning of Control Period n=24	End of 8-week Control Period n=24	<i>P</i>
Mean	14.0	11.9	0.003*
±SD	3.8	5.0	

* significant.
 ns, not significant.

(at 0.08 m) of vowel [a:] was 2 dB higher than before the therapy session ($t = -2.144$, $df = 26$, $P = 0.042$, $d = 0.41$, 95 % CI [-2.75, -0.58]). Within the Trad group, in the post-therapy assessments, the alpha-ratio of vowel [a:] was 2.3 dB ($t = 2.716$, $df = 24$, $P = 0.012$, $d = .54$, 95 % CI [0.49, 3.64]), and the f_0 of spontaneous speech was 7 Hz ($t = 2.245$, $df = 24$, $P = 0.034$, $d = 0.45$, 95 % CI [0.56, 13.36]) lower than at the beginning of the therapy. There were no significant changes within the Trad group's follow-up assessments compared to the initial situation. In the Trad group the voice parameters did not change between the assessment points pre-therapy and at follow-up. Within the Control group, voice parameters did not change significantly after the eight-week non-therapy period (Table 9).

Changes between the groups

Although some variables changed in different ways between the groups (such as bigger drop in voice symptom scores in

Carryover group and non-parallel change in f_0), the statistical analyses did not reveal any differences between the groups.

DISCUSSION

In the present study we investigated if carryover strategies can give an additional benefit to a traditional voice therapy. Thus, two voice therapy groups were compared: *Carryover group* with a systematic guidance how to generalize new vocal skills outside the clinic and *Trad group* without a specific emphasis on it. To assess the effects of the therapies, changes in the voice status of the control group were measured. According to the results the carryover strategies did not enhance the results of the voice therapy, but the participants' voice-related quality of life (VAPP) improved during both interventions. However, only within the Carryover group this improvement continued further during the six-month follow-up. Also, the amount of voice symptoms decreased within the Carryover group after the therapy and at the follow-up, whereas within the Trad group this was not seen. SPL, f_0 and alpha-ratio changed in different ways in the groups. After the control group's eight-week non-therapy period voice symptoms decreased significantly but VAPP and voice parameters did not change significantly.

Carryover strategies: Are they worth of trying or not?

Although the results of the present study did not reveal any differences between the Carryover and Trad groups, the fact that the voice complaints only continued to decrease after the end of the therapies in the Carryover group would suggest that carryover strategies may enhance motor learning with long-lasting effects in the classroom context. Indeed,

TABLE 6.
 f_0 Values in the Voice Therapy Group With Carryover Strategies (Carryover) and in the Group Receiving Voice Therapy With No Emphasis on Any Generalizing Process (Trad). Values From Three Tasks Measured Before (Pre) and After Therapy (Post) and at Six-month Follow-up

	f_0 values (Hz) of Carryover and Trad Groups								
	Sustained [a:]			Text Reading			Spontaneous Speech		
	Pre	Post	Follow-up	Pre	Post	Follow-up	Pre	Post	Follow-up
CARRYOVER									
n	27	27	25	27	27	25	27	27	25
mean	192	197	198	178	179	180	174	182	179
±SD	20	20	24	17	17	16	16	18	20
min	163	162	153	151	147	152	147	152	137
max	236	244	268	222	221	223	203	211	222
<i>P</i>	<i>pre-post ns pre-follow-up ns</i>			<i>pre-post ns pre-follow-up ns</i>			<i>pre-post 0.024* pre-follow-up ns</i>		
TRAD									
n	26	26	23	26	26	23	26	26	23
mean	189	186	185	176	177	175	176	169	176
±SD	22	20	20	17	17	17	19	18	22
min	150	158	150	151	149	155	150	143	144
max	251	240	234	216	214	214	234	229	221
<i>P</i>	<i>pre-post ns pre-follow-up ns</i>			<i>pre-post ns pre-follow-up ns</i>			<i>pre-post 0.034* pre-follow-up ns</i>		

* significant.
 ns, not significant.

TABLE 7.

SPL Values in the Voice Therapy Group With Carryover Strategies (Carryover) and in the Group Receiving Voice Therapy With No Emphasis on Any Generalizing Process (Trad). Values From Three Tasks Measured Before (Pre) and After Therapy (Post) and at Six-month Follow-up

	SPL values (dB, at 0.08 m) of Carryover and Trad groups								
	sustained [a:]			text reading			spontaneous speech		
	Pre	Post	Follow-up	Pre	Post	Follow-up	Pre	Post	Follow-up
CARRYOVER									
n	27	27	25	27	27	25	27	27	25
mean	82	82	84	72	71	72	76	75	76
± SD	3	5	3	3	3	3	5	4	4
min	74	68	76	67	66	65	69	68	67
max	90	91	91	78	78	78	85	83	84
P	<i>pre-post ns pre-follow-up 0.042*</i>			<i>pre-post ns pre-follow-up ns</i>			<i>pre-post ns pre-follow-up ns</i>		
TRAD									
n	26	26	23	26	26	23	26	26	23
mean	83	82	82	73	72	72	75	76	76
± SD	4	4	4	3	3	3	4	4	3
min	78	72	75	68	66	67	66	68	71
max	93	89	90	78	75	79	84	82	83
P	<i>pre-post ns pre-follow-up ns</i>			<i>pre-post ns pre-follow-up ns</i>			<i>pre-post ns pre-follow-up ns</i>		

* significant.

ns, not significant.

speaking (and voice use) is a goal-directed motor skill, in which learning new skills can be thought of as motor learning.⁴⁷ For adults, skilled motor learning requires time and is acquired in several stages: an initial “fast” learning phase (fast improvement phase within-session), which is followed by a “slow” learning phase (post-training slowly evolving, incremental performance emerging after continued practice).⁴⁸ These phases can also be found in the process of

learning new voice use habits and ergonomic ways to protect voice organs. We can consider some vocal behaviors as habits and their successful change in a client’s every day speech needs automatization and good collaboration between speech therapist and client.¹⁷ According to our results, it seems that for the teachers in the Carryover group it was easier to transfer the healthy vocal habits to teaching situations after they had separately practiced the words and phrases

TABLE 8.

Alpha-ratio Values in the Voice Therapy Group with Carryover Strategies (Carryover) and in the Group Receiving Voice Therapy With No Emphasis on Any Generalizing Process (Trad). Values From two Tasks Measured Before (pre) and After Therapy (post) and at Six-month Follow-up

	Alpha-ratio Values (dB) of Carryover and Trad Groups					
	Sustained [a:]			Text Reading		
	Pre	Post	Follow-up	Pre	Post	Follow-up
CARRYOVER						
n	27	27	25	27	27	25
mean	-16	-17	-16	-16	-17	-16
± SD	4	5	5	3	3	3
min	-23	-29	-24	-22	-23	-23
max	-7	-7	-6	-12	-11	-10
P	<i>pre-post ns pre-follow-up ns</i>			<i>pre-post 0.011* pre-follow-up ns</i>		
TRAD						
n	26	26	23	26	26	23
mean	-14	-16	-16	-16	-17	-17
± SD	5	5	5	3	3	3
min	-23	-25	-26	-23	-21	-22
max	-1	-6	-7	-9	-12	-11
P	<i>pre-post 0.012*</i>			<i>pre-post ns pre-follow-up ns</i>		

* significant.

ns, not significant.

TABLE 9.
Control Groups' Alpha-ratio Values (two tasks) and f_0 and SPL Values (three tasks). Values Were Measured Before the 8-Week Non-Therapy Period and After It

	Voice parameters of Control Group					
	Before the 8-week control period			After the 8-week control period		
	Sustained [a:]	Text reading	Spontaneous speech	Sustained [a:]	Text reading	Spontaneous speech
n	24	24	24	24	24	24
Alpha-ratio (dB)						
mean	-16	-16	-	-15	-17	-
± SD	5	3	-	5	3	-
min	-26	-22	-	-23	-22	-
max	-6	-12	-	-1	-12	-
<i>P</i>				<i>before-after ns</i>	<i>before-after ns</i>	<i>before-after ns</i>
f_0 (Hz)						
mean	195	182	179	197	179	178
± SD	24	19	20	22	16	19
min	162	157	148	173	157	150
max	253	223	217	251	213	234
<i>P</i>				<i>before-after ns</i>	<i>before-after ns</i>	<i>before-after ns</i>
SPL (dB, at 0.08 m)						
mean	85	74	77	84	73	77
± SD	3	3	4	4	3	5
min	80	68	63	77	67	68
max	93	78	84	93	78	85
<i>P</i>				<i>before-after ns</i>	<i>before-after ns</i>	<i>before-after ns</i>

ns, not significant.

used in the classroom (e.g., student names, instructions, greetings, discussions). In addition, teachers reported spontaneously that using carryover strategies was motivating, the strategies were easy to implement in lessons, and all this increased the feeling of being able to influence the well-being of one's own voice in the classroom. It has also been reported that direct voice therapy and early inclusion of the carryover strategies are important in order to achieve greater treatment satisfaction and success.⁴⁹ In the light of our results we think the carryover strategies are indeed worth trying.

Voice symptoms within the Carryover and Trad groups

Voice symptoms decreased significantly after the therapy session with medium effect size and at six-month follow-up with large effect size within the Carryover group. There was also a slight improvement in the Trad group's voice symptoms post-therapy and at follow-up, but the changes were not significant and the effect sizes were small. The results indicate that the carryover strategies may enhance transferring and generalization the new vocal behavior with long-lasting effect in a classroom context. In order to transfer new vocal skills into everyday life, it is important to allow time and individually tailored homework.⁸ However, this individual guidance entails listening intently to the client. Voice symptoms are clients' complaints about voice-related problems that may be

described in various ways. Some symptoms can be verified (e.g., hoarseness), others not (e.g. pain, dry throat), but they are all real to the client and must be carefully considered in voice therapy.²² Further, the individual meaning is also important as voice symptoms can cause a high level of emotional strain and anxiety,²¹ and on the other hand, physical changes caused by a stress reaction may lead to vocal symptoms.⁵⁰ Because of the highly individual and multifaceted nature of voice disorders, our results permit the conclusion that one way to achieve a more permanent change in the vocal behavior of a teacher with a voice disorder and for her to benefit from voice therapy is a carryover approach implemented in sessions right at the start of a therapy.

VAPP within the Carryover and Trad groups

The results showed a significant reduction of total VAPP in the Carryover group after therapy with a small effect size and in the follow-up with a medium effect size. Furthermore, the teachers in the Trad group found that their voice-related quality of life improved significantly after therapy with a small effect size. However, at follow-up this outcome persisted, but did not improve further. Our results are in line with those of earlier studies also reporting a positive impact of carryover exercises in transferring the new acquired vocal behaviors into daily situations.^{28,51} It seems that in the present study, the teachers in the Carryover

group benefited from individual memory hints created and confirmed during therapy sessions.

The carryover strategies also included teachers' and students' vocally oriented teamwork with vocal exercises and attempts to increase students' and teachers' awareness of environmental factors affecting the voice (such as noise during lessons).¹⁹ It would appear that these above-mentioned procedures have increased teachers' voice well-being holistically and are in line with the International Classification of Functioning, Disability and Health (ICF) by taking into account environmental factors regarding vocal usage.^{52,53} These results are also noteworthy in light of students' speech perception, because it has been reported that teachers' dysphonic voices alter speech perception among students in classrooms.^{9,10,13} In the future, it would be useful to study students' experiences of vocally oriented workshops and develop them further. It would be interesting to study if students could possibly be trained to reduce the noise levels of classroom activity, thereby helping teachers to preserve their voices.

Acoustic voice parameters within the Carryover and Trad groups

Within both groups alpha-ratio values decreased after the therapy periods. Lowered alpha-ratio values (more negative values) indicate more relaxed or less hyperfunctional voice production after the therapy sessions as has been reported earlier.^{54,55} In our study the alpha-ratio changed significantly with medium effect sizes in the Carryover group's text reading and in the Trad group's [a:] vocalization. Hence, we can conclude that both therapy methods may help teachers to achieve relaxed voice usage during the therapy process.

Within the groups, significant and interesting divergent f_0 post-therapy results were observed: f_0 of spontaneous speech increased (with a large effect size) in the Carryover group and decreased (with a medium effect size) in the Trad group. In several studies divergent or unchanged post-therapy f_0 values have also been reported.⁵⁶⁻⁵⁹ In our study 57% of the teachers in the Carryover group and 52% of those in the Trad group had minor laryngeal changes or organic findings in the larynx. It is possible that these pathological conditions limited the frequency to a particular range by compromising phonatory function.²² In voice rehabilitation it is meaningful to find an appropriate pitch level for a person by normalizing the phonatory physiology rather than imposing an arbitrary pitch level.²²

As mentioned above, our result showed that f_0 changed differently within the groups: there was an ascending trend in the Carryover group and a descending trend in the Trad group. Initially the mean f_0 values did not differ significantly between the groups. In light of the lowered post-therapy alpha-ratio and SPL values in the Carryover group, we assume that the slight increase in f_0 occurred with relaxed and economically produced voice usage. Moreover, most of the teachers in the Carryover group reported that they were confident in the functioning of their voice and felt that they had adopted ways to improve their voice well-being in the

classroom. We can perceive this as a sign of a successful carryover effect leading to vocal freedom and thus helping to gain students' attention in a teaching situation.⁶⁰ It is also possible that the increase in f_0 was due to increased use of so-called "clear speech" (i.e., speakers' attempts to modify their speech production in a way that benefits the listener).⁶¹ Instead, as our results showed, teachers in the Trad group with their low post-therapy f_0 results may have been careful not to raise the pitch. Because we did not use any specific voice pitch exercises during the therapy sessions but tried to improve the phonatory process, it is possible that the teachers in the Trad group used lower pitch unconsciously, possibly as their own idea of saving their voices.²¹

Clients habitually using lowered pitch and volume may have a misconception of reducing risks for a voice disorder by speaking in this manner.²¹ However, habitual use of an inappropriate low pitch could lead to organic changes in the vocal folds.²¹ Teachers with voice symptoms have been found to use lower f_0 than their vocally healthy peers.^{62,63} On the other hand, an increase in f_0 after teachers' vocally loading working days has been reported.^{44,64,65} It should also be noted that prevalence of creaky voice use (resulting in low f_0) has increased in young Finnish university students from the 1990's to the 2010's, particularly in females,⁶⁶ and has been reported to be up to 54% in some female teachers' speech.⁴⁴ However, in the present study we wanted to rule out creaky voice by setting the lower limit of fundamental frequency at 130 Hz in acoustic analysis. In future, our interest is to focus our research on creaky voice as well.

The Carryover group's SPL values of the vowel [a:] increased significantly from 82 dB to 84 dB (0.08 m) with a medium effect size from pre-therapy to follow-up assessment. These SPL values correspond to $\sim 62 \sim 64$ dB (@ 1 m), meaning that teachers used loudness levels typical of conversational speech.⁶⁷ The lowered alpha-ratio values also indicated that this SPL increase occurred with relaxed voice use showing that the teachers in the Carryover group succeeded in utilizing their new vocal skills practised during the therapy sessions. Otherwise, there were no additional significant changes in SPL values in the Carryover group's other vocal tasks nor in any task in the Trad group. All in all, it is difficult to assess the meaning of the SPL change in our study while in earlier studies SPL has also changed unsystematically: values have increased, decreased, or remained unchanged after therapies.^{56,59,67,68}

Outcome in the control group

The Control group's voice symptom scores decreased significantly (with a medium effect size) after the eight-week non-therapy period. Post hoc analysis showed that a few symptoms (*feeling of dryness* and *tiredness of the voice* and of a *lump and irritating mucus in the throat*) decreased, whereas other symptoms (*hoarseness*, *pain in the throat*, *not able to penetrate the noise*, *voice breaks*, *aphonia*) remained unchanged. It has been reported that teachers seek treatment specifically for their voice symptoms,⁵⁹ and further

speculated that involvement in a voice study may activate people to change their behavior only by participating in a study (the so-called *Hawthorne effect*).⁶⁹ This phenomenon may also have occurred among the teachers in the Control group. They may have made small changes in vocal hygiene and ergonomics such as decreasing voice loudness, using better working postures and so on which decreased vocal loading. On the other hand, the improvement in self-rated voice symptoms in the present study could be due to a possible regression towards a mean, as Ohlsson et al.⁸ concluded from their findings on improvement in self-rated hoarseness in their control group. Regarding voice parameters, no changes were found after our Control group's eight-week non-therapy period, which corroborates the findings of Gillivan-Murphy et al.⁷⁰ This shows that voice clients need straight guidance and feedback from a speech therapist to change their voice behavior in order to change the interaction process of airflow, air pressure, and muscular activity of the vocal cords.²² Our VAPP results did not change either after the non-therapy period, as also reported by Ferreira et al.⁷¹ In contrast to our study, Ribeiro et al.⁵⁷ reported improvement in their control participants' voice-related quality of life, possibly as a consequence of the so-called Hawthorne effect mentioned above.⁶⁹

Teachers with organic laryngeal findings

In our initial phoniatric examination organic findings were observed in five teachers: in the Carryover group one polyp in the vocal fold and nodules in one vocal fold; in the Trad group there was one vocal fold hemorrhage, one vocal fold atrophy, and one case of vocal fold nodules. Post hoc analysis with voice symptoms results revealed that all the teachers with hemorrhage, atrophy, and polyp findings benefited from the therapy sessions as also reported in earlier studies,^{72,73} but during follow-up their vocal symptoms increased again: Carryover vocal polyp (posttherapy decrease four points, follow-up increase two points), Trad hemorrhage (posttherapy decrease one point, follow-up increase four points), Trad atrophy (posttherapy decrease nine points, follow-up increase five points). Instead, the two teachers with vocal nodules experienced more improvement after the six-month follow-up period than immediately after the therapy sessions: Carryover nodules (posttherapy increase two points, follow-up decrease three points), Trad nodules (posttherapy increase two points, follow-up decrease three points). It has been reported that a therapy period of two to four months once a week is effective for minor structural vocal fold pathologies and early-stage vocal nodules and polyps.^{5,27} Our findings are in accordance with those results and suggest that further research is needed to determine the appropriate amount and intensity of voice therapy sessions for organic voice disorders.

Methodological considerations

Although there were changes within the therapy groups' voices after the therapy and at follow-up, our results did not reveal significant differences between the groups. Several

things may explain this. It is possible that in our research design the variables were not sufficiently effective and sensitive to detect the differences although they are commonly used in assessing voice therapy outcomes³⁻⁶ and some of them were also used in a study conducted by Holmberg et al.²⁸ including the contribution of carryover to therapy outcomes. Even though a carryover process is seldom mentioned as a component of voice therapy and not all therapy techniques are geared towards it, many voice-specialized speech therapists focus on it in their clinical work. To better assess and develop the generalization process in the future, it could be useful to develop assessment methods that consider aspects related to changes in voice behavior, such as motor learning and skills acquisition.^{17,47,48}

It is also possible that some participants in the Trad group had spontaneously developed means to generalize healthy voice use habits at work, that is, they used carryover strategies. In addition, the number of participants may have been too small although the sample size calculation was done in advance and the final number of participants in each group differed only slightly from the recommendations. Further, the participants came from different schools and the ergonomic conditions of these were not controlled for. Moreover, the content of voice therapies may have been somewhat different for some participants because they were guided by different speech therapists. Finally, the results may have been affected by the fact that the participants taught different lessons: music (higher vocal load,⁷⁴ four in the Carryover group, five in the Trad group), special education or a class with a small numbers of students (average of seven students, range 1–10, seven in the Carryover group, three in the Trad group).

CONCLUSIONS

- The results revealed no differences in the outcomes between the group receiving therapy systematically using carryover strategies and the group receiving therapy without carryover.
- Voice therapy has positive effects on voice-related quality of life (VAPP) and on some acoustic voice parameters.
- Voice-related quality of life continues to improve after the end of voice therapy if the carryover strategies are systematically used from the very beginning of therapy.

ETHICAL CONSIDERATION

The study was approved by the Regional Ethics Committee of the Northern Ostrobothnia Hospital District and by the Education and Culture Authority of the City of Oulu. The study is registered in ClinicalTrials.gov.

AUTHORS CONTRIBUTIONS

S.P.: conceived the original idea, designed, and directed the study, performed the interventions and the analyses, and took the lead in writing the manuscript; P.S., T.A., A.Y.,

and L.R.: contributed to the design and implementation of the study and performed the interventions, the analyses, and participated in the writing of the manuscript; E.N.-H.: assisted with the analyses and in the writing of the manuscript; All authors provided critical feedback and helped shape the research, analysis, and manuscript.

DISCLOSURE STATEMENT

The authors have no conflicts of interest to declare.

Acknowledgments

We warmly thank the teachers and students for their kind co-operation and teamwork and Virginia Mattila for correcting the language of the manuscript. The study was not supported by any grants.

REFERENCES

- Cantor Cutiva LC, Vogel I, Burdorf A. Voice disorders in teachers and their associations with work-related factors: a systematic review. *J Commun Disord.* 2013;46:143–155. <https://doi.org/10.1016/j.jcomdis.2013.01.001>.
- Smith E, Kirchner HL, Taylor M, et al. Voice problems among teachers: differences by gender and teaching characteristics. *J Voice.* 1998;12:328–334. [https://doi.org/10.1016/S0892-1997\(98\)80022-2](https://doi.org/10.1016/S0892-1997(98)80022-2).
- MacKenzie K, Millar A, Wilson JA, et al. Is voice therapy an effective treatment for dysphonia? A randomised controlled trial. *BMJ.* 2001;323:658. <https://doi.org/10.1136/bmj.323.7314.658>.
- Ruotsalainen JH, Sellman J, Lehto L, et al. Interventions for treating functional dysphonia in adults. *Cochrane Database Syst Rev.* 2007 CD006373. <https://doi.org/10.1002/14651858.CD006373.pub2>.
- Niebudek-Bogusz E, Szurowska-Przygocka B, Fiszler M, et al. The effectiveness of voice therapy for teachers with dysphonia. *Folia Phoniatri Logop.* 2008;60:134–141. <https://doi.org/10.1159/000120290>.
- Desjardins M, Halstead L, Cooke M, et al. A systematic review of voice therapy: what “effectiveness” really implies. *J Voice.* 2017;31:392.e13–392.e32. <https://doi.org/10.1016/j.jvoice.2016.10.002>.
- Rulnick RK, Heuer RJ, Perez KS, et al. Voice therapy. In: Sataloff RT, ed. *Professional Voice. The Science and Art of Clinical Care.* San Diego: Singular Publishing Group, Inc; 1997:699–720.
- Ohlsson AC, Dotevall H, Gustavsson I, et al. Voice therapy outcome—a randomized clinical trial comparing individual voice therapy, therapy in group, and controls without therapy. *J Voice.* 2020;34:303.e17–303.e26. <https://doi.org/10.1016/j.jvoice.2018.08.023>.
- Rogerson J, Dodd B. Is there an effect of dysphonic teachers’ voices on children’s processing of spoken language? *J Voice.* 2005;19:47–60. <https://doi.org/10.1016/j.jvoice.2004.02.007>.
- Lyberg-Åhlander V, Haake M, Brännström J, et al. Does the speaker’s voice quality influence children’s performance on a language comprehension test? *Int J Speech Lang Pathol.* 2015;17:63–73. <https://doi.org/10.3109/17549507.2014.898098>.
- Brännström KJ, Holm L, Lyberg-Åhlander V, et al. Children’s subjective ratings and opinions of typical and dysphonic voice after performing a language comprehension task in background noise. *J Voice.* 2015;29:624–630. <https://doi.org/10.1016/j.jvoice.2014.11.003>.
- Sahlén B, Haake M, von Lochow H, et al. Is children’s listening effort in background noise influenced by the speaker’s voice quality? *Logoped Phoniatri Vocol.* 2018;43:47–55. <https://doi.org/10.1080/14015439.2017.1324914>.
- Chui JCH, Ma EPM. The impact of dysphonic voices on children’s comprehension of spoken language. *J Voice.* 2019;33:801.e7–801.e16. <https://doi.org/10.1016/j.jvoice.2018.03.004>.
- Moncur JP, Brackett IP. *Modifying Vocal Behavior.* New York: Harper Row, Publishers; 1974.
- Behrman A, Haskell J. The practice of voice therapy. In: Behrman A, Haskell J, eds. *Exercises for Voice Therapy.* Plural Publishing, Inc; 2008:1–8.
- Cooper M. *Modern Techniques of Vocal Rehabilitation.* Charles C Thomas; 1973.
- Iwarsson J. Facilitating behavioral learning and habit change in voice therapy—theoretic premises and practical strategies. *Logoped Phoniatri Vocol.* 2015;40:179–186. <https://doi.org/10.3109/14015439.2014.936498>.
- Leith W, Johnston R. *Handbook of Voice Therapy for the School Clinician.* London. 20 Boston: Taylor & Francis; 1986.
- Pirilä S, Jokitulppo J, Niemitalo-Haapola E, et al. Teachers’ and children’s experiences after an acoustic intervention and a noise-controlling workshop in two elementary classrooms. *Folia Phoniatri Logop.* 2020;72:454–463. <https://doi.org/10.1159/000503231>.
- Boone DR, McFarlane SC, Von Berg SL, et al. *The Voice and Voice Therapy.* 8th ed. Pearson; 2010.
- Stemple JC, Glaze LE, Klaben BG. *Clinical voice pathology. Theory and Management.* 4th ed. San Diego. 22 Baltimore: Plural Publishing; 2012.
- Colton RH, Casper JK, Leonard RJ. *Understanding Voice Problems: A Physiological Perspective for Diagnosis and Treatment.* 3rd ed. Lippincott Williams & Wilkins; 2006.
- Behrman A. Facilitating behavioral change in voice therapy: the relevance of motivational interviewing. *Am J Speech Lang Pathol.* 2006;15:215–225. [https://doi.org/10.1044/1058-0360\(2006\)020](https://doi.org/10.1044/1058-0360(2006)020).
- Fawcus M. Hyperfunctional voice: the misuse and abuse syndrome. In: Fawcus M, ed. *Voice Disorders and Their Management.* Dover: Croom Helm; 1986:189.
- Gillespiel AI, Yabes J, Rosen CA, et al. Efficacy of conversation training therapy for patients with benign vocal fold lesions and muscle tension dysphonia compared to historical matched control patients. *J Speech Lang Hear Res.* 2019;62:4062–4079. https://doi.org/10.1044/2019_JSLHR-S-19-0136.
- Rodríguez-Parra MJ, Adrián JA, Casado JC. Comparing voice-therapy and vocal-hygiene treatments in dysphonia using a limited multidimensional evaluation protocol. *J Commun Disord.* 2011;44:615–630. <https://doi.org/10.1016/j.jcomdis.2011.07.003>.
- Lu D, Chen F, Yang H, et al. Changes after voice therapy in acoustic voice analysis of Chinese patients with voice disorders. *J Voice.* 2018;32:386.e1–386.e9. <https://doi.org/10.1016/j.jvoice.2017.05.005>.
- Holmberg EB, Hillman RE, Hammarberg B, et al. Efficacy of a behaviorally based voice therapy protocol for vocal nodules. *J Voice.* 2001;15:395–412. [https://doi.org/10.1016/S0892-1997\(01\)00041-8](https://doi.org/10.1016/S0892-1997(01)00041-8).
- Haverinen-Shaughnessy U, Borrás-Santos A, Turunen M, et al. Occurrence of moisture problems in schools in three countries from different climatic regions of Europe based on questionnaires and building inspections - the HITEA study. *Indoor Air.* 2012;22:457–466. <https://doi.org/10.1111/j.1600-0668.2012.00780.x>.
- Ferreira AM da C, Cardoso M. Indoor air quality and health in schools. *J Bras Pneumol.* 2014;40:259–268. <https://doi.org/10.1590/S1806-37132014000300009>.
- Putus T, Länsikallio R, Ilves V. *Sisäilmätkimius (Indoor air research).* The Trade Union of Education in Finland, OAJ; 2017.. https://www.oaj.fi/globalassets/julkaisut/2017/sisailmatukimus_3010_final_sivut.pdf. Accessed February 25, 2022.
- Portone C, Johns MM, Hapner ER. A review of patient adherence to the recommendation for voice therapy. *J Voice.* 2008;22:192–196. <https://doi.org/10.1016/j.jvoice.2006.09.009>.
- Hapner E, Portone-Maira C, Johns MM. A study of voice therapy dropout. *J Voice.* 2009;23:337–340. <https://doi.org/10.1016/j.jvoice.2007.10.009>.
- Slavych BK, Zraick RI, Bursac Z, et al. An investigation of the relationship between adherence to voice therapy for muscle tension dysphonia and employment, social support, and life satisfaction. *J Voice.* 2021;35:386–393. <https://doi.org/10.1016/j.jvoice.2019.10.015>.
- Kleemola L, Helminen M, Rorarius E, et al. Twelve-month clinical follow-up study of voice patients’ recovery using the voice activity and participation profile (VAPP). *J Voice.* 2011;25:e245–e254. <https://doi.org/10.1016/j.jvoice.2010.05.003>.

36. Barsties v. Latoszek B, Watts CR, Neumann K. The effectiveness of voice therapy on voice-related handicap: a network meta-analysis. *Clin Otolaryngol.* 2020;45:796–804. <https://doi.org/10.1111/coa.13596>.
37. Rantala L, Sala E. Working postures. In: Sala E, Rantala L, eds. *Voice Ergonomics. Occupational and Professional Voice Care.* Newcastle upon Tyne: Cambridge Scholars Publishing; 2019:187–193.
38. Simberg S, Sala E, Laine A, et al. A fast and easy screening method for voice disorders among teacher students. *Logoped Phoniatr Vocol.* 2001;26:10–16. <https://doi.org/10.1080/14015430119481>.
39. Sukanen O, Sihvo M, Rorarius E, et al. Voice activity and participation profile (VAPP) in assessing the effects of voice disorders on patients' quality of life: validity and reliability of the Finnish version of VAPP. *Logoped Phoniatr Vocol.* 2009;32:3–8. <https://doi.org/10.1080/14015430600784386>.
40. Kempster GB, Gerratt BR, Verdolini Abbott K, et al. Consensus auditory-perceptual evaluation of voice: development of a standardized clinical protocol. *Am J Speech Lang Pathol.* 2009;18:124–132. [https://doi.org/10.1044/1058-0360\(2008\)08-0017](https://doi.org/10.1044/1058-0360(2008)08-0017).
41. Artkoski M, Tommila J, Laukkanen AM. Changes in voice during a day in normal voices without vocal loading. *Logoped Phoniatr Vocol.* 2002;27:118–123. <https://doi.org/10.1080/140154302760834840>.
42. Titze IR, Winholtz WS. Effect of microphone type and placement on voice perturbation measurements. *J Speech Lang Hear Res.* 1993;36:1177–1190. <https://doi.org/10.1044/jshr.3606.1177>.
43. Deliyski DD, Shaw HS, Evans MK. Adverse effects of environmental noise on acoustic voice quality measurements. *J Voice.* 2005;19:15–28. <https://doi.org/10.1016/j.jvoice.2004.07.003>.
44. Pirilä S, Pirilä P, Ansamaa T, et al. Relationship between activity noise, voice parameters, and voice symptoms among female teachers. *Folia Phoniatr Logop.* 2017;69:94–102. <https://doi.org/10.1159/000484204>.
45. Boersma P, Weenink D. Praat: Doing phonetics by computer (Version 6.1.04). 2021. Accessed 27 February 2021. <https://www.fon.hum.uva.nl/praat/>.
46. Cohen A, Sackrowitz HB. Improved tests for comparing treatments against a control and other one-sided problems. *J Am Stat Assoc.* 1992;87:1137–1144. <https://doi.org/10.1080/01621459.1992.10476270>.
47. Karni A, Meyer G, Rey-Hipolito C, et al. The acquisition of skilled motor performance: fast and slow experience-driven changes in primary motor cortex. *Proc Natl Acad Sci.* 1998;95:861–868. <https://doi.org/10.1073/pnas.95.3.861>.
48. Voelcker-Rehage C. Motor-skill learning in older adults—a review of studies on age-related differences. *Eur Rev Aging Phys Act.* 2008;5:5–16. <https://doi.org/10.1007/s11556-008-0030-9>.
49. Ziegler A, Dastolfo C, Hersan R, et al. Perceptions of voice therapy from patients diagnosed with primary muscle tension dysphonia and benign mid-membranous vocal fold lesions. *J Voice.* 2014;28:742–752. <https://doi.org/10.1016/j.jvoice.2014.02.007>.
50. Holmqvist S, Santtila P, Lindström E, et al. The association between possible stress markers and vocal symptoms. *J Voice.* 2013;27:787.e1–787.e10. <https://doi.org/10.1016/j.jvoice.2013.06.012>.
51. Iwarsson J, Morris DJ, Balling LW. Cognitive load in voice therapy carry-over exercises. *J Speech Lang Hear Res.* 2017;60:1–12. https://doi.org/10.1044/2016_JSLHR-S-15-0235.
52. Howe TJ. The ICF contextual factors related to speech-language pathology. *Int J Speech Lang Pathol.* 2008;10:27–37. <https://doi.org/10.1080/14417040701774824>.
53. World Health Organization (WHO). International Classification of Functioning, Disability, and Health: ICF.2001. Accessed February 28, 2021. <https://who.int/standards/classifications>.
54. da Silva Antonetti AE, Vitor JD, Guzman M, et al. Efficacy of a semi-occluded vocal tract exercises—therapeutic program in behavioral dysphonia: a randomized and blinded clinical trial. *J Voice.* January 4, 2021. <https://doi.org/10.1016/j.jvoice.2020.12.008>. Published online.
55. Ilomäki I, Laukkanen AM, Leppänen K, et al. Effects of voice training and voice hygiene education on acoustic and perceptual speech parameters and self-reported vocal well-being in female teachers. *Logoped Phoniatr Vocol.* 2008;33:83–92. <https://doi.org/10.1080/14015430701864822>.
56. Reetz S, Bohlender JE, Brockmann-Bausser M. Do standard instrumental acoustic, perceptual, and subjective voice outcomes indicate therapy success in patients with functional dysphonia? *J Voice.* 2019;33:317–324. <https://doi.org/10.1016/j.jvoice.2017.11.014>.
57. Ribeiro VV, de Oliveira AG, da Silva Vitor J, et al. The effect of a voice therapy program based on the taxonomy of vocal therapy in women with behavioral dysphonia. *J Voice.* 2019;33:256.e1–256.e16. <https://doi.org/10.1016/j.jvoice.2017.10.019>.
58. Menezes MHM, Ubrig-Zancanella MT, Cunha MGB, et al. The relationship between tongue trill performance duration and vocal changes in dysphonic women. *J Voice.* 2011;25:e167–e175. <https://doi.org/10.1016/j.jvoice.2010.03.009>.
59. Guzman M, Bertucci T, Pacheco C, et al. Effectiveness of a physiologic voice therapy program based on different semi occluded vocal tract exercises in subjects with behavioral dysphonia: a randomized controlled trial. *J Commun Disord.* 2020;87: 106023. <https://doi.org/10.1016/J.JCOMDIS.2020.106023>.
60. Simberg S, Sala E. Practical guidelines how to take care of your voice. In: Sala E, Rantala L, eds. *Voice Ergonomics. Occupational and Professional Voice Care.* Cambridge Scholars Publishing; 2019:210–221.
61. Smiljanic R, Bradlow AR. Production and perception of clear speech in Croatian and English. *J Acoust Soc Am.* 2015;118:1677. <https://doi.org/10.1121/1.2000788>.
62. Lyberg-Åhlander V, Pelegrín García D, Whitling S, et al. Teachers' voice use in teaching environments: a field study using ambulatory phonation monitor. *J Voice.* 2014;28:841.e5–841.e15. <https://doi.org/10.1016/j.jvoice.2014.03.006>.
63. Rantala LM, Hakala S, Holmqvist S, et al. Classroom noise and teachers' voice production. *J Speech Lang Hear Res.* 2015;58:1397–1406. https://doi.org/10.1044/2015_JSLHR-S-14-0248.
64. Rantala L, Vilkman E, Bloigu R. Voice changes during work. *J Voice.* 2002;16:344–355. [https://doi.org/10.1016/S0892-1997\(02\)00106-6](https://doi.org/10.1016/S0892-1997(02)00106-6).
65. Laukkanen AM, Ilomäki I, Leppänen K, et al. Acoustic measures and self-reports of vocal fatigue by female teachers. *J Voice.* 2008;22:283–289. <https://doi.org/10.1016/j.jvoice.2006.10.001>.
66. Uusitalo T, Nyberg L, Laukkanen AM, et al. Has the prevalence of creaky voice increased among Finnish university students from the 1990's to the 2010's? *J Voice.* 2022. <https://doi.org/10.1016/j.jvoice.2021.12.006>. Published online.
67. Chen SH, Hsiao TY, Hsiao LC, et al. Outcome of resonant voice therapy for female teachers with voice disorders: perceptual, physiological, acoustic, aerodynamic, and functional measurements. *J Voice.* 2007;21:415–425. <https://doi.org/10.1016/j.jvoice.2006.02.001>.
68. Christmann MK, Scapini F, Lima JP, et al. Aerodynamic vocal measurements in female teachers: finger kazoo intensive short-term vocal therapy. *J Voice.* 2021;35:259–270. <https://doi.org/10.1016/j.jvoice.2019.08.018>.
69. Fernald DH, Coombs L, DeAlleaume L, et al. An assessment of the Hawthorne effect in practice-based research. *J Am Board Fam Med.* 2012;25:83–86. <https://doi.org/10.3122/jabfm.2012.01.110019>.
70. Gillivan-Murphy P, Drinnan MJ, O'Dwyer TP, et al. The effectiveness of a voice treatment approach for teachers with self-reported voice problems. *J Voice.* 2006;20:423–431. <https://doi.org/10.1016/j.jvoice.2005.08.002>.
71. Ferreira JM, Campos NF, Bassi IB, et al. Analysis of aspects of quality of life in teachers' voice after discharged: longitudinal study. *CoDAS.* 2013;25:486–491. <https://doi.org/10.1590/S2317-17822013000500014>.
72. de Vasconcelos D, Oliveira Camargo Gomes A, de Araújo CMT. Treatment for vocal polyps: lips and tongue trill. *J Voice.* 2017;31:252.e27–252.e36. <https://doi.org/10.1016/j.jvoice.2016.07.003>.
73. Carding P, Bos-Clark M, Fu S, et al. Evaluating the efficacy of voice therapy for functional, organic and neurological voice disorders. *Clin Otolaryngol.* 2017;42(2):201–217. <https://doi.org/10.1111/coa.12765>.
74. Schmidt P, Morrow SL. Hoarse with no name: chronic voice problems, policy and music teacher marginalisation. *Music Educ Res.* 2016;18:109–126. <https://doi.org/10.1080/14613808.2015.1014329>.