

LITERATURE REVIEW

Systematic review of the treatment of functional dysphonia and prevention of voice disorders

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OBJECTIVE: To evaluate the effectiveness of interventions for treating functional dysphonia or preventing voice disorders in adults.

DATA SOURCES: We searched MEDLINE (1950 to 2006), EMBASE (1974 to 2006), CENTRAL (Issue 2 2006), CINAHL (1983 to 2006), PsychINFO (1967 to 2006), Science Citation Index (1986 to 2006), and the Occupational Health databases OSH-ROM (February 2006).

REVIEW METHODS: Systematic review and meta-analysis of randomized controlled trials. Included studies evaluated the effectiveness of interventions for 1) treating functional/nonorganic dysphonia or 2) preventing voice disorders. We identified six randomized controlled trials about treatment and two about prevention. Two authors independently extracted data and assessed trial quality.

RESULTS: A combination of direct and indirect voice therapy, compared with no intervention, improves self-reported (standardized mean difference -1.07 ; 95% CI -1.94 to -0.19), observer-rated (weighted mean difference [WMD] -13.00 ; 95% CI -17.92 to -8.08), and instrumentally assessed vocal functioning (WMD -1.20 ; 95% CI -2.37 to -0.03) in adults with functional dysphonia. Effects are reported to remain for at least 14 weeks. Effects are similar in patients and in teachers and student teachers screened for voice problems. We found two studies that did not show voice training, compared with no intervention, to have a preventive effective in improving self-reported vocal functioning. Assessment of publication bias showed that the real effect sizes are probably smaller.

CONCLUSION: Comprehensive voice therapy is effective in improving vocal performance in adults with functional dysphonia. There is no evidence of effectiveness of voice training in preventing voice disorders.

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Voice disorders are generally characterized by abnormalities in pitch, loudness, and/or quality of the voice that can limit the effectiveness of oral communication.¹⁻³ Recent definitions of a disordered voice stress the ability of the voice to fulfill the speaker's social and occupational

requirements.⁴⁻⁶ There is no universally accepted classification system for voice problems, apart from two major classes of voice disorder related to etiology: organic and functional.⁷⁻⁹ However, this dichotomy is somewhat problematic, because minor tissue changes such as vocal fold thickening and vocal nodules can be understood as either organic or functional disorders.¹⁰ In this review we define functional dysphonia as an impaired voice sound and/or reduced vocal capacity^{11,12} in the absence of organic lesions.

In the United Kingdom, up to 40,000 patients with dysphonia are referred to voice therapy every year.¹³ In a study of 1262 voice patients, the prevalence of voice disorders that could be considered functional dysphonia was 57.6 percent.¹⁴ In other studies, 20 to 80 percent of teachers reported suffering from various voice symptoms,^{15,16} and in voice clinics they are the largest occupational group seeking medical help for voice problems.^{14,17}

Because voice is a multidimensional phenomenon, like physical strength, it cannot be measured with a single scale or test.^{18,19} A considerable number of techniques and instruments have been developed to measure the aerodynamic, electromyographic, perceptual, phonatory, and vibratory aspects of vocal function and the self-reported impact of voice problems.²⁰⁻²²

When it comes to the treatment of functional dysphonia, most experts agree that surgical or medical interventions are not indicated.²³ Voice therapy is recommended for the treatment of voice disorders caused by vocal misuse.⁶ The numerous different treatment techniques available for patients with dysphonia fall into two main categories: 1) direct²⁰ and 2) indirect²³ treatment techniques. Direct techniques focus on the components of voice production, such as breathing, laryngeal re-posturing, or vocal fold medial compression. Examples of direct techniques are the yawn-sigh method,²⁴ establishment of optimal pitch,²⁵ and laryngeal manipulation.²⁶ Indirect treatment techniques, on the other hand, concentrate on eliminating factors that contribute to or

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maintain the voice problem. The educational approach can help individuals to identify factors that may contribute to a voice problem, to alter and avoid the factors, and to modify vocal behavior before any damage occurs.²⁷ Examples of indirect methods are patient education,⁴ auditory training,^{8,25} and vocal hygiene programs.²⁸

There are no previous systematic reviews or meta-analyses of preventive voice training or of treatments for functional dysphonia. Previous narrative literature reviews or overviews^{1,7,20} have identified altogether a total of 87 articles, published between 1960 and 2001, that evaluated the effectiveness of voice therapy. According to Oates,⁷ 12 of the 87 published studies can be categorized as randomized controlled trials. Only two of the studies included in these previous reviews^{2,23} studied the effectiveness of voice therapy for functional dysphonia. Both studies are included in this review.

In this review we aim to establish whether interventions aimed at 1) treating adult patients diagnosed with functional dysphonia or 2) preventing voice disorders or reducing the incidence of voice problems in adults are effective compared with no intervention or alternative interventions. We define prevention programs as interventions offered to people at risk of voice disorders.

METHODS

We performed a systematic literature search to locate studies in electronic databases, including MEDLINE (1950 to 2006), EMBASE (1974 to 2006), CENTRAL (Issue 2 2006), CINAHL (1983 to 2006), PsychINFO (1967 to 2006), Science Citation Index (1986 to 2006), and the Occupational Health databases OSH-ROM (February 2006). References from articles were also reviewed. Authors of studies and other experts in the field were contacted for advice on further studies. The search string for randomized controlled trials is based on Robinson and Dickersin²⁹ and the string for non-randomized studies on Verbeek et al.³⁰ The date of the last search was April 5, 2006. Table 1 outlines our MEDLINE search strategy.

We included all randomized controlled studies or cluster-randomized trials that evaluated the effectiveness of treatments targeted at treating functional dysphonia or preventing voice disorders in adults (16 years or older). For environmental or work-related interventions, we also considered prospective cohort studies for inclusion, because it is much more difficult to randomize when the intervention is applied at the group level. In treatment studies, participants had to have been diagnosed with functional/nonorganic dysphonia. For practical reasons, we also included studies in which a minority of participants (less than 50%) had been diagnosed with minor tissue changes of the vocal fold cover (nodules, polyps, edema) that are generally regarded as results of vocal misuse. In preventive studies, participants had to be at risk of developing a voice disorder because of their occupation, studies, hobby, or lifestyle but had *not* yet been identified/diagnosed as having one.

Table 1
MEDLINE search strategy

- #1 dysphoni*[tw] OR hoarseness[mh] OR phonastheni*[tw] OR trachyphoni*[tw] OR functional voice disorder*[tw] OR psychogenic voice disorder*[tw] OR ventricular phonation[tw] OR conversion voice disorder*[tw] OR functional aphonia[tw] OR conversion aphonia[tw] OR conversion dysphonia[tw] OR phonation break[tw] OR functional falsetto[tw] OR mutational falsetto[tw] OR puberphonia[tw] OR juvenile voice[tw] OR laryngeal myasthenia[tw]
- #2 phonation[tw] NEAR (disease*[tw] OR disorder*)
- #3 (voice[tw] OR vocal[tw] OR phonation[tw]) NEAR (problem*[tw] OR symptom*[tw] OR complaints[tw] OR hygiene[tw] OR disturbance*[tw] OR tremor*[tw] OR impair*[tw] OR handicap*[tw] OR tension*[tw] OR strain*[tw] OR abuse*[tw] OR fatigue*[tw] OR misuse*[tw] OR reduct*[tw])
- #4 (randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized controlled trials[mh] OR random allocation[mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial[pt] OR clinical trials[mh] OR "clinical trial"[tw] OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw]))) OR "latin square"[tw] OR placebos[mh] OR placebo*[tw] OR random*[tw] OR research design[mh:noexp] OR comparative study[mh] OR evaluation studies[mh] OR follow-up studies[mh] OR prospective studies[mh] OR cross-over studies[mh] OR control*[tw] OR prospectiv*[tw] OR volunteer*[tw]) NOT (animal[mh] NOT human[mh])
- #5 (effect*[tw] OR control*[tw] OR evaluation*[tw] OR protect*[tw]) NOT (animal[mh] NOT human[mh])
- #6 (#1 OR #2 OR #3) AND (#4 OR #5)

We excluded treatment studies in which any of the participants had been diagnosed as having any of the following: a voice disorder associated with local nervous system involvement (eg, spasmodic dysphonia, vocal fold paralysis); neurological disorders (eg, Parkinson's disease and Alzheimer's disease, amyotrophic lateral sclerosis); organic disease or trauma (eg, keratosis, contact ulcers, papillomas); the pediatric (eg, with congenital anomalies) or the geriatric voice (normal age-related deterioration of the vocal apparatus); carcinoma or other tumors or gastroesophageal reflux disease.

We categorized interventions as 1) direct voice therapy or training, meaning that the intervention is applied directly to the voice production apparatus; 2) indirect voice therapy or training, meaning intervention that is applied to other mental or bodily structures or functions that influence voice production; 3) a combination of the two therapies; and 4) other interventions.

In this review we chose self-reported measures of voice handicap, voice symptoms, and voice-related quality of life

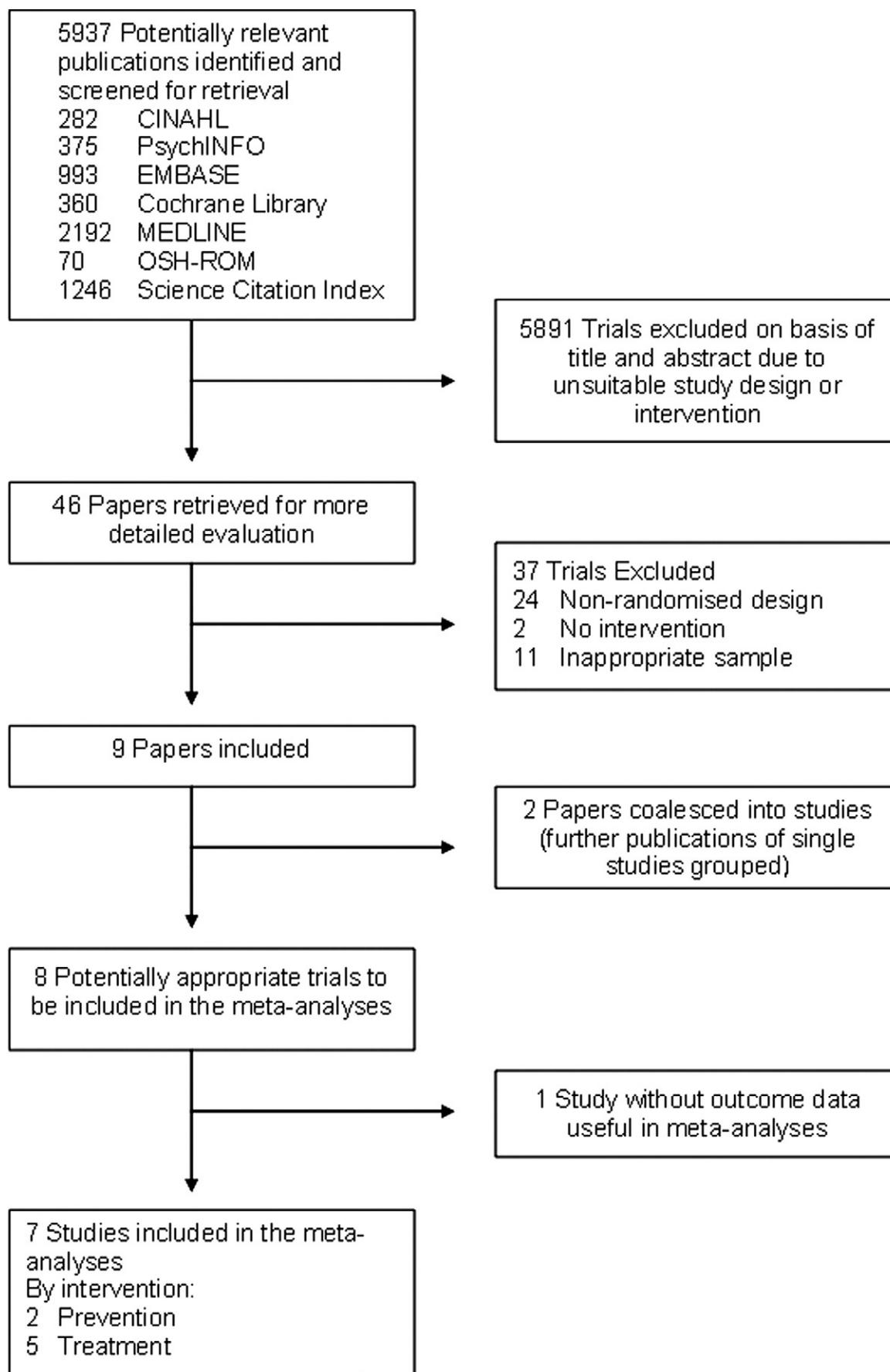


Figure 1 Quality of reporting of meta-analyses (QUOROM) statement trial flow.

Table 2
Characteristics of included studies

Study ID	Design	Participants	Interventions (group n's)	Outcomes*
Treatment				
Beranova et al 2003 ³⁴	RCT	16 consecutive patients with dysphonia persisting for more than 2 wk	A) Indirect treatment (9) B) Pharmacotherapy (7)	1) Voice-Related Quality of Life 2) Videostroboscopy; phonetogram
Carding et al 1999 ²³	RCT	45 patients diagnosed with nonorganic dysphonia	A) Indirect treatment (15) B) Direct and indirect treatment (15) C) No intervention (15)	1) Vocal Performance Questionnaire 2) Auditory voice quality ratings; laryngoscopy; laryngography; fundamental frequency analysis; acoustic analysis
Gillivan-Murphy et al 2005 ³³	RCT	20 teachers with self-reported voice/throat symptoms	A) Direct and indirect treatment (10) B) No intervention (10)	1) Voice-Related Quality of Life; Voice symptom scale 2) Voice care knowledge VAS
MacKenzie et al 2001 ²	RCT	133 outpatients with persistent hoarseness for at least two months	A) Direct and indirect treatment (70) B) No intervention (63)	1) Vocal Performance Questionnaire 2) Laryngeal rating; Buffalo Voice Profile; amplitude and pitch perturbation
Rattenbury et al 2004 ³¹	RCT	50 consecutive patients with MTD	A) Direct and indirect treatment (26) B) TFL-assisted voice therapy (24)	1) Vocal Performance Questionnaire 2) GRBAS; amplitude and pitch perturbation
Simberg et al 2006 ³	RCT	40 student teachers reporting voice symptoms and/or observed deviant voice quality	A) Direct and indirect group treatment (20) B) No intervention (20)	2) GRBAS; vocal fry and pitch
Prevention				
Bovo et al 2006 ³²	RCT	41 female kindergarten and primary school teachers	A) Direct and indirect voice training (21) B) No intervention (20)	1) Voice Handicap Index 2) Videolaryngostroboscopy
Duffy et al 2004 ²⁷	RCT	55 student teachers	A) Indirect voice training (20) B) Direct voice training (12) C) No intervention (23)	1) Voice Handicap Index 2) Dysphonia Severity Index

*1) and 2) refer to primary and secondary interventions, respectively.

RCT, Randomized controlled trial; VAS, visual analogue scale; MTD, muscle tension dysphonia; TFL, transnasal flexible laryngoscopy; GRBAS, Grade, Roughness, Breathiness, Asthenia, Strain.

as primary indicators of intervention effectiveness. We use this approach because of the variation between individuals as to how a particular voice disturbance can be perceived to affect their communication or ability to fulfill social and occupational requirements. As secondary outcomes we included all 1) instrumental (eg, aerodynamic, stroboscopic ratings) measurements, 2) observer ratings (perceptual analysis of voice quality [eg, GRBAS]), and 3) combined multidimensional measures (eg, Dysphonia Severity Index).

Two authors (J.R. and J.S.) independently determined inclusion, assessed trial quality, and extracted data. Study quality was assessed in terms of randomization, allocation concealment, and blinding procedures as well as with regard to attrition suffered. Disagreements were resolved by consensus. If interventions, participants, and outcomes were comparable, we pooled the results of individual studies. If sufficient numerical data were available, we performed meta-analysis of outcomes by combining trials. Outcomes

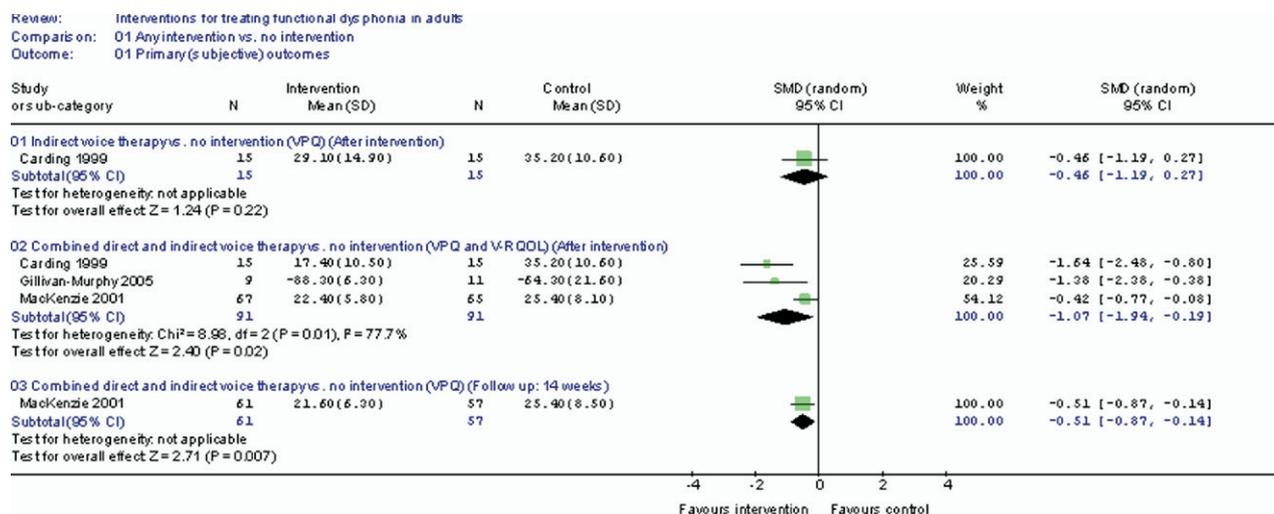


Figure 2 Indirect and combined voice therapy versus no intervention as measured with self-reported measures.

were summarized as mean differences or standardized mean differences. When there was significant heterogeneity, we applied a random effects model instead of a fixed effect model. To assess publication bias, we plotted the effect sizes and standard errors of similar comparisons in a funnel plot and assessed the effect statistically with the use of the Egger test.

Role of the Funding Source

The Finnish Ministry for Social Affairs and Health and the Dutch Pension Fund Loyalis enabled the finalization of this review. Neither had any role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; or preparation, review, or approval of the manuscript.

RESULTS

Study Characteristics

Figure 1 shows the details of exclusion and inclusion of studies. Table 2 shows the characteristics of the eight included randomized controlled trials consisting of 216 participants in intervention groups and 184 in control groups. Two of the included studies^{2,31} reported using an acceptable method of randomization of the intervention to the participants (ie, computer-generated random numbers). All studies reported some descriptive data comparing the study groups after allocation, thus portraying the acceptability of the randomization procedure. Blinding was not an issue for participants, because they could not help but notice if they received treatment or not. With secondary (ie, observer-rated) outcomes, the voice samples were assessed in each trial by an independent panel of blinded judges. The loss of participants was low because only three studies^{2,3,32} suffered a loss exceeding 20 percent of the initial sample. The MacKenzie et al study² was the

only one to have conducted a priori power calculations to ensure adequate statistical power.

TREATMENT

Combination of Direct and Indirect Voice Therapy Versus No Intervention

Short-term follow-up. According to three studies^{2,23,33} a combination of direct and indirect voice therapy is effective in improving vocal functioning (standardized mean difference [SMD] -1.07 ; 95% confidence interval [CI] -1.94 to -0.19) compared with no intervention, when measured with self-reported measures of vocal functioning (Vocal Performance Questionnaire [VPQ] and Voice-Related Quality of Life scale, Fig 2). Transformation of the effect size back to a score on the VPQ yielded a mean difference of -11.3 scale points. This value covers 25 percent of the range of the VPQ scale. There was considerable heterogeneity in this meta-analysis ($I^2 = 77.7\%$), which may be due to publication bias, differences in responsiveness to change of the scales used, and methodological quality of studies. Even though Carding et al²³ and Gillivan-Murphy et al³³ used participants drawn from different populations (consecutive patients and volunteer teachers, respectively), their results were quite similar.

Long-term follow-up. The results of MacKenzie et al² show that the intervention group's vocal performance remained better than that of the control group at 14-week follow-up (mean difference -0.51 ; 95% CI -0.87 to -0.14). In addition to the three studies included in the meta-analysis, the study by Simberg et al³ shows that the intervention group's number of voice-related symptoms remained lower than that of the control group at 3 months and a year after the start of the study.

The findings obtained by using secondary outcomes

partly support those of the primary outcomes. According to MacKenzie et al² voice therapy has no initial effect on voice quality. Neither observer-rated (Buffalo Voice Profile; mean difference -0.20 ; 95% CI -0.51 to 0.11) nor acoustic voice quality (jitter: mean difference 0.00 ; 95% CI -0.53 to 0.53 ; shimmer: mean difference -1.20 ; 95% CI -2.37 to -0.03) compared with no intervention was improved immediately after the intervention. The results of Simberg et al³ do, however, show that voice therapy improved observer-rated voice quality (mean difference -13.00 ; 95% CI -17.92 to -8.08 , overall grade of the Grade, Roughness, Breathiness, Aesthenia, Strain [GRBAS] scale). After 14 weeks of follow-up, MacKenzie et al² also found that the voice quality of patients in the intervention group had improved perceptual ratings (mean difference -0.80 ; 95% CI -1.14 to -0.46) but not instrumental ratings (shimmer: mean difference -0.40 ; 95% CI -1.61 to 0.81 ; jitter: mean difference 0.50 ; 95% CI -0.04 to 1.04).

Direct and indirect therapies are not mutually exclusive, because some indirect treatment is, of necessity, also included in direct therapy. This requirement is perhaps why no studies were found that evaluated the effectiveness of direct voice therapy separately. One study²³ compared indirect voice therapy and no intervention. The study found no difference in effectiveness (mean difference -0.38 ; 95% CI -0.94 to 0.18) when measured with a self-reported measure of vocal functioning (VPQ, Fig 2).

Direct and Indirect Therapies Combined Versus Voice Therapy With Additional Biofeedback

According to the results of Rattenbury et al,³¹ transnasal flexible laryngoscopy (TFL)-assisted treatment did not improve scores on the VPQ more than just a combination of direct and indirect treatment approaches did (mean difference -2.40 ; 95% CI -0.76 to 5.56). However, the patient contact treatment time for TFL treatment was on average two thirds (2 hours) less than the time needed for the traditional approach.

Vocal Hygiene Instructions Versus Pharmacological Treatment

Beranova and Betka³⁴ reported no significant differences between vocal hygiene instructions given by a phoniatrix and pharmacological treatment; however, they did not report standard deviations, so this finding could not be verified statistically.

Subgroup analyses. Because interventions might work differently with groups with heavy vocal load, we looked separately at studies that included only workers. Two studies screened teachers or student teachers for vocal problems.^{3,33} The severity of voice problems in these studies was about 25 percent of the maximum attainable unfavorable score. This finding was slightly lower than the patient studies^{2,23} with values of 58 and 33 percent, respectively.

The outcomes were comparable between patient and teacher studies. Both teacher studies had a positive outcome.

Assessment of publication bias. We included four studies^{2,3,23,33} that compared a combination of direct and indirect voice therapy versus no intervention in a funnel plot. It was clear that the three small studies^{3,23,33} yielded much bigger effect sizes than the larger study.² The Egger test was almost significant with $P = 0.06$ indicating the possibility of publication bias.

PREVENTION

Two randomized studies^{27,32} that examined the effectiveness of preventive voice training were found. Duffy and Hazlett²⁷ found no evidence that either direct (mean difference 4.99 ; 95% CI -0.79 to 10.77) or indirect (mean difference 5.47 ; 95% CI -1.42 to 12.36) voice training is effective in improving self-reported (Voice Handicap Index) vocal functioning compared with no intervention. Bovo et al,³² who compared a combination of direct and indirect voice training with no intervention, found training had no effect when measured with the Voice Handicap Index (mean difference -7.35 ; 95% CI -15.07 to 0.37) but did find an improvement when training was measured with maximum phonation time (mean difference -3.18 seconds; 95% CI -4.43 to -1.93) compared with no intervention. No studies on work-directed interventions were found.

DISCUSSION

According to three randomized studies^{2,23,33} a combination of direct and indirect voice therapy is effective in improving vocal functioning (SMD -1.07 ; 95% CI -1.94 to -0.19) when compared with no intervention and measured with self-reported measures of vocal functioning. There is also evidence from two studies^{2,3} that the remedial effect of voice therapy remains significant at medium- and long-term follow-up. According to one study,³¹ TFL-assisted treatment was considerably faster than the traditional approach. Two randomized studies^{27,32} found no evidence that voice training was effective in preventing voice disorders.

The methodological quality of included studies was mostly poor. Most trials were small and, in all but two of the included trials,^{2,31} the method of randomization was not reported or not valid. It was difficult to get an impression of the concealment of allocation from researchers. Only one² of the eight studies was classified as high quality in terms of randomization, allocation concealment, blinding, and dealing with attrition. The results of this high-quality study are consistent with the overall conclusions of this systematic review.

It has been argued that evidence of a lesser quality than that from randomized controlled trials should also be con-

Table 3
Characteristics of controlled (nonrandomized) studies

Study ID	Participants	Interventions (group N's)	Results
Treatment			
Andrews et al 1986 ⁴¹	10 female subjects matched according to age and dysphonia severity	EMG biofeedback training (5) Progressive relaxation training (5)	Both interventions effective; no significant difference between treatments
Garcia et al 2002 ⁴²	75 professional voice users with a min 4 h of daily voice use with past symptoms or signs of vocal damage due to voice use for a min of 6 months	Hydration treatment (27) Hydration and direct treatment (25) No intervention (23)	Both interventions effective vs. no intervention; no significant difference between treatments
Mendoza-Lara 1990 ⁴³	14 dysphonic teachers and 14 teachers without voice problems	Traditional treatment (7) EMG biofeedback training (7) No intervention (14)	Both interventions effective; vs. no intervention; no significant difference between treatments
Popovici 1993 ⁴⁴	39 patients suffering from psychosomatic or conversive voice problems	Classical therapy and relaxation (24) Classical therapy (15)	Combination of classical therapy with relaxation is effective
Sliwinska-Kowalska et al 2002 ⁴⁵	83 female teachers with chronic dysphonia	Logopedic treatment (47) No intervention (36)	Logopedic voice therapy is effective
Prevention			
Chan 1994 ⁴⁶	25 female kindergarten teachers	Direct and indirect voice training (12) No intervention (13)	Significant improvement in RAP when compared with no intervention
Timmermans et al 2004 ⁴⁷	46 students of a school for audiovisual communication	Direct and indirect voice training (23) No intervention (23)	No significant differences between intervention and control groups

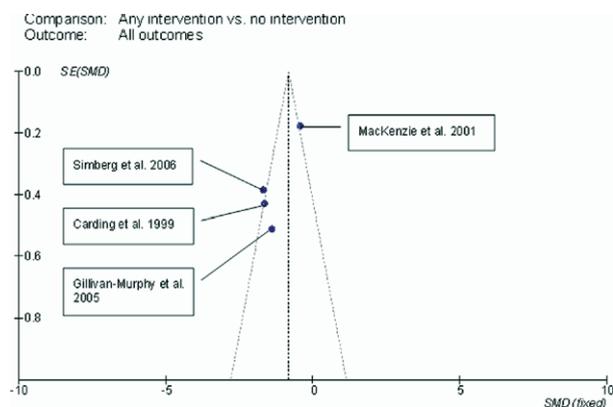
EMG, electromyographic; RAP, relative average perturbation.

sidered in evaluations of treatment options; therefore, we also present an overview of published controlled nonrandomized trials³⁵⁻⁴¹ (Table 3). None of the trials had results that clearly refuted the effectiveness of voice therapy or preventive voice training, or that showed harmful effects.

The funnel plot, in which we pooled all treatment interventions (Fig 3), and the Egger test indicated the possibility of publication bias. Because we could not explain the heterogeneity in any other way, we assumed that a small studies effect led to an overestimation of the pooled effect size. Language bias was corrected for by not having language restrictions in the systematic search strategy and by translating articles written in other languages than English.

Even though the result of the most robust treatment meta-analysis (Fig 2) was significant and it covered 25 percent of the range of the VPQ after transformation, we cannot be sure how this finding is related to the clinical relevance of the changes achieved in the studies. Further research is needed to determine the relation between a change score on the VPQ questionnaire and an important amount of change in outcome as rated by patients.⁴²

Possible reasons for not finding a significant positive effect for preventive interventions could be inadequacies in the duration of the study of preventive voice training (the length in time and amount of the sessions) or in the formulation of contents of the training. Moreover, all prevention studies were small and probably underpowered to detect

**Figure 3** Assessment of publication bias.

relevant outcome differences. The increase in maximum phonation time found in the preventive studies is not very relevant in a clinical sense, because this measure has no clear relationship with voice disorders. A clinically more relevant outcome would be the number of teachers who go on to develop a voice problem.⁴⁵

In prevention studies it is questionable whether maximum phonation time is a relevant outcome measure at all as there is an exceptionally high variability between and within healthy individuals.⁴³ Large variability then prevents valid individual to group mean comparisons of MPT.⁴⁴

CONCLUSION

A combination of a direct and an indirect voice therapy should be considered the best available intervention for treating functional dysphonia. Screening and subsequently treating teachers and student teachers are feasible and yield positive results. The diagnosis “functional dysphonia” does not, however, in itself reveal what aspects of vocal or speech production (pitch, loudness, intonation, phonation, tempo, breathing, resonance, or overall tension) need to be modified. The speech and language therapist must always assess the patient, and then choose the aims and the specific techniques of voice therapy accordingly. We have not found high-quality evidence to support the current practice of giving training to at-risk populations to prevent development of voice disorders. Future treatment studies should have sufficient statistical power to detect a mean change of 10 points on the VPQ.²⁰ Having access to only small numbers of participants can be overcome by organizing a multicenter study. With interventions that aim to improve vocal performance, outcome should be measured with a validated questionnaire such as the Voice Handicap Index.⁴⁶ Studies should also be blinded so that researchers are unaware of the participants’ allocation into intervention or control. In light of the considerable occupational health impact of voice problems, it would be advisable to study the effectiveness of prevention and treatment in occupational voice users. For both study aims, two groups of participants with high vocal load should be compared, with one group who is not given the preventive training or the voice therapy. The ethical dilemma produced by having a no-treatment control can be overcome by using a delayed treatment control or offering a minimal intervention to the control group. A randomized design is feasible and should be used to prevent bias. The interventions should involve both direct and indirect techniques that are implemented according to a well-designed protocol. The follow-up time should be at least one year, but preferably longer, to establish a long-term effect. For prevention trials, it should also be measured if participants become dysphonia patients.

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Preliminary results from this review were presented at the 28th International Congress on Occupational Health, Milan, Italy June 11-16, 2006. Final results were presented at the 27th World Congress of the International Association of Logopedics and Phoniatrics, Copenhagen, Denmark, August 5-9, 2007.

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AUTHOR CONTRIBUTIONS

Jani Ruotsalainen, conceptualization of review, lead writer, study selection, quality assessment, data extraction; **Jaana Sellman**, study selection, quality assessment, data extraction, extensive comments on all versions of review; **Laura Lehto**, extensive comments on all versions of review; **Jos Verbeek**, conceptualization of review, writing of methods section of two reviews, extensive comments on all versions of review.

FINANCIAL DISCLOSURE

The Finnish Ministry for Social Affairs and Health and the Dutch Pension Fund Loyalis enabled the finalization of this review.

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