Intensive versus traditional voice therapy for vocal nodules: perceptual, physiological, acoustic and aerodynamic changes

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Abstract

Summary: Objectives. To investigate the perceptual, physiological, acoustic and aerodynamic outcomes of patients with vocal nodules following intensive voice treatment compared to traditional voice treatment.

Study Design. Pragmatic randomised clinical trial

Methods. Fifty-three women diagnosed with bilateral vocal nodules participated in the study. Voice recordings, stroboscopic recordings, acoustic and aerodynamic assessments were made prior to voice treatment, after vocal hygiene education, and immediately postvoice treatment. All participants completed one session of vocal hygiene and eight sessions of direct voice therapy, however the delivery of the treatment between the two groups differed in treatment intensity.

Results. Physiological improvements were observed after vocal hygiene alone, while physiological, perceptual, and acoustic parameters all improved to some degree in both treatment groups immediately posttreatment. There were no differences in the extent of change observed between the two groups at any time point following treatment.

Conclusions. The investigation provided initial evidence that individuals with vocal nodules are able to recover voice function, vocal health and vocal communication through intensive voice treatment. The results suggest comparable positive perceptual,

physiological and acoustic outcomes from intensive voice therapy compared with traditional voice therapy. Further investigation is required to determine the long-term effects of intensive treatment.

Keywords: Vocal nodules-Voice treatment-Perception-Physiology-Acoustic-Aerodynamic

Introduction

Vocal nodules are benign lesions of the vocal folds caused by repetitive mucosal injury leading to histological changes and concomitant voice mutation.[1] Their presence causes changes to the vibratory pattern of the vocal cords due to an increase in vocal fold mass and can impact vocal fold adduction both anteriorly and posteriorly to the nodule.[2] The resultant dysphonia is perceived as breathy with various degrees of turbulent noise, strained vocal quality, roughness, instability and vocal fry/creak, with a tendency towards a low pitch.[2-4]

Individuals with vocal nodules constitute a large part of the client population at voice clinics.[5] The voice disturbances can cause personal problems and societal losses, as individuals with vocal nodules in professions with high voice demands are forced to take long periods of sick leave and sometimes may have to change careers.[5,6] As a consequence, extensive research has been conducted on the efficacy of treatment for vocal nodules, with voice therapy recommended as first-line treatment.[5,7-14]

Behavioural intervention has been shown to have a positive impact on vocal nodules, with number of studies confirming a marked reduction or complete elimination of the nodules posttreatment.[5,7,8,11,15-20] Evidence also confirms that voice quality significantly improves postvoice therapy.[7,8,10,19,21] Positive outcomes have also been reported across a range of acoustic measures, with jitter, shimmer,

signal-to-noise ratio, fundamental frequency (F_0), maximum phonation time (MPT) and mean airflow rate positively correlated with voice improvement following treatment for vocal nodules.[7,8,12,19]

Although the majority of research conducted to date has demonstrated the positive effects voice therapy has on vocal nodules, there is considerable variation in the duration and intensity of the therapy provided. In fact, no report has provided evidence or clear guidelines as to the optimal intensity or duration of voice therapy for clients with this vocal pathology.[5,8,11,14,16,19] Studies have reported voice treatment protocols which include 2 to 16 sessions,[12] once per week for 12 weeks,[18] twice weekly for 2 to 4 months,[16] and 4 to 6 months in duration.[8]

For voice therapy to be effective, both motor learning and cognitive processes for maintenance and transfer of the new vocal behaviour should be considered. According to Schmidt and Lee,[22] motor learning is a set of processes associated with practice or experience leading to relatively permanent changes in movement. Practice conditions include the following: amount and distribution of practice, the variability of practice, the scheduling of practice with several different tasks, and part versus whole practice. These independent variables affect the learning of motor skills. One variable which may have an effect on learning and has not been widely investigated, is the distribution of practice. Practice distribution refers to how a given amount of

practice is distributed over time,[23] and may be described as massed or spaced practice. In massed practice, all the practice periods occur very closely together with little or no rest time in between sessions. In a spaced practice schedule, the time interval between the practice periods is increased significantly.[24]

Few empirical data exist on the effects of practice distribution in speech motor learning. The strongest evidence exists for massed practice. For example, the Lee Silverman Voice Treatment (LSVT®), which incorporates principles of multiple repetition, high intensity, and high frequency of practice (four treatment sessions per week for four weeks), has been shown to result in long-term vocal improvements in the speech and voice of people with Parkinson's disease.[25,26] It is postulated that this treatment facilitates intensive motor relearning, maximises motor output and effort, increases drive and goal directed activity, and enhances sensory awareness to promote internal cueing, self monitoring and upscaling of motor output.[27]

The benefits of massed, intensive practice were also noted in the treatment of functional dysphonia.[28,29] In a concept article, the authors provided a framework and indications for delivery of intensive short-term voice therapy, referred to as "boot camp".[28] This involved concentrated practice, using a variety of voice therapy techniques, delivered in a concentrated time frame (1 to 4 days with 4 to 7 hours of therapy per day). This type of therapy was reported to be tailored to the nature of the

voice disturbance and individual specific needs, thereby maximizing the individual's ability to learn and carryover targets to non-clinical environments. The authors stated that this approach can be successfully used with various types of dysphonia, especially those who have not been successful with traditional voice treatment approach, and with clients living at geographical distances sufficiently far from voice centres.[28] However, clinical trials have not yet been conducted on the "boot camp" treatment approach. Patel et al.[28] speculated that the nature of the high-intensity training may better mimic cognitive, motor, and physiological requirements of activities of daily living than traditional therapy.

Potential advantages of intensive treatment are that: rigorous practice (overload) is possible; simultaneous interventions can be conducted for multiple components involved in voice production; and opportunities for specificity, individuality, and facilitating transfer of learned skills which may influence patient compliance are readily available.[29] Thus in translating this evidence to the management of vocal nodules, it is possible that intensive voice therapy may be more beneficial than traditional treatment protocols, and offer greater speed and efficiency in achieving improvement in vocal function. To date no study has explored the relative efficacy of intensive treatment specifically for individuals with vocal nodules. Therefore, the aim of the present study was to investigate the perceptual, physiological, acoustic, and

aerodynamic outcomes of patients with vocal nodules following intensive voice treatment when compared to traditional voice therapy. It is hypothesised that greater improvement in perceptual, physiological, and acoustic parameters will occur following intensive voice treatment for vocal nodules compared to traditional voice therapy.

Methods

Ethics approval for the study was obtained from the Taipei Veterans General Hospital and The University of Queensland Medical Research Ethics Committee.

Participants

Fifty-three women (mean age 37.5 years, range 20-54) referred from the outpatient clinic at the Department of Otorhinolaryngology Department, Taipei Veterans General Hospital, Taiwan, and diagnosed with bilateral vocal nodules were included in the study. The diagnoses of vocal nodules were made by one of five otolaryngologists from videostroboscopic examination, while the severity of dysphonia was determined by one speech-language pathologist (SLP) experienced in the area of voice and blind to the study purpose. Overall severity was rated using the “Grade” scale from the GRABS (Grade, Roughness, Breathiness,

Asthenia, Strain) scale[30] (where 0 = normal, 1 = mild, 1.5 = mild-to-moderate, 2 = moderate, 2.5 = moderate-to-severe, and 3 = severe) and was based on evaluation of a sample of reading (a standard Mandarin passage). Participants were included in this study if they: 1) were aged between 18 years and 55 years; 2) had normal articulation, resonance, and language ability; 3) had normal hearing as determined by a screening test at 20 dB HL at 3 frequencies 500, 1000, 2000 Hz; 4) had no previous professional singing or speaking training; and 5) had no previous voice therapy or laryngeal surgical treatment. Exclusion criteria included: 1) use of prescription medication which may cause changes in laryngeal function, mucosa or muscle activity (list provided by National Center for Voice and Speech [NCVS][32]); 2) current psychiatric or neurologic conditions; or 3) a history of allergies, lung disease, or other concomitant vocal pathology (eg, vocal polyp and vocal cyst).

Participants were matched in pairs according to their age, occupation, and severity of dysphonia. The duration of dysphonia prior to treatment was not taken into consideration. The participants occupations were categorised into non-professional voice users (eg, factory worker, students, catering, clerical worker, home carers, and unemployed) versus professional voice users (eg, teachers, health professional, and sales personnel). All participants were diagnosed with bilateral broad-based nodules before treatment. Participants in each pair were then assigned to either of two

treatment groups according to their availability: intensive voice therapy (IVT) or traditional voice therapy (TVT) groups. Thirty-one participants were recruited to the intensive voice program. Seven withdrew or failed to complete the full program (for health, work or personal reasons), leaving 24 participants who completed the intensive voice therapy program. A total of 37 participants were recruited to the traditional voice therapy program group. Eight withdrew or failed to complete the entire program, leaving 29 participants who completed the entire traditional voice therapy program. Demographic information of the 53 participants who completed both programs is detailed in Table 1.

Comparisons of baseline characteristics between the two groups were conducted using independent *t*-tests for parametric data (age, acoustic, and aerodynamic measurements) and chi-square tests and Mann-Whitney U tests for non-parametric data (occupation, severity of dysphonia, existence of vocal fold oedema and vocal nodule location). There were no statistical differences between the groups with regards to their age (t= -0.165, p = 0.871), severity of dysphonia (Z = -1.861, p = 0.063), or occupation (χ^2 = 0.053, p = 0.817) at presentation. With respect to pretreatment acoustic and aerodynamic measurements no significant differences were found between groups all on all parameters. There were no significant differences between the groups with respect to vocal nodule location (Z = -0.195, p = 0.845) or

surrounding oedema of the vocal folds ($\chi^2 = 2.511$, $p = 0.113$). In the TVT group, 27 (93%) had nodules located on the front 1/3 of the vocal folds while 2 (7%) were located mid-vocal folds. In the IVT group, 22 (92%) had nodules located on the front 1/3 of the vocal folds with 2 (8%) participants having nodules located mid-vocal fold. All of the participants from TVT group had surrounding oedema prior to treatment as did 92% (n = 22) of the IVT group.

Procedure

Participants completed assessments at three time intervals relative to therapy: 1) before the initial vocal hygiene session, 2) three weeks after the vocal hygiene session and immediately prior to IVT/TVT voice therapy, and 3) immediately following IVT or TVT. All assessments were performed by a SLP and otolaryngologists experienced in voice disorders who were independent to the study and blinded to group allocation.

Auditory perceptual ratings

At each assessment interval, the participants were asked to read a Mandarin passage consisting of five sentences. Samples were recorded with a Shure SM48-LC microphone and stored in the Computerised Speech Laboratory system (CSL; model 4500, Kay Elemetrics Co.) at a 4.41 KHz sampling rate in a sound-treated room. The

desktop microphone was positioned in front of each participant's mouth at a mouth-to-microphone distance of 15 cm.

Perceptual analysis was conducted by one SLP with 15 years experience assessing voice disorders. Voice quality was assessed using the GRBAS scale, [30] which consists of five parameters: grade (G), roughness (R), breathiness (B), asthenicity (A) and strain (S). Ratings of the GRBAS parameters were conducted as paired comparisons, using the Comparison Mean Opinion Score (CMOS) process.[33] This process allows the rater to detect even subtle changes in a patient's voice or speech characteristic by allowing them to listen to, and compare an individual's speech sample in pairs (eg, pre- and posttherapy), and rate the second sample relative to the characteristics of the first sample. A clinician independent of the rating process created pairs of recorded speech samples for each participant relating to the assessment time points (ie, prevocal hygiene and postvocal hygiene; prevocal hygiene and postvoice therapy; postvocal hygiene and postvoice therapy). The order of the two samples in each pair was randomized to reduce any potential expectation bias. After listening to each pair of the entire speech sample, the clinician then rated sample 2 in relation to sample 1 on a scale of -3 to +3, in which 0 indicates the samples are equal. If the value is negative, it indicates that sample 2 is worse than sample 1 (-1 mildly worse; -2 worse and -3 severely worse). However, if the value is positive, it

indicates that sample 2 is better than sample 1 (+1 mildly better; +2 better and +3 much better). The SLP was able to listen and compare the speech samples as often as they wished. Once the paired samples were rated, the principle investigator revealed the order of the two samples and transposed the scores to ensure data accurately reflected perceptual differences relative to the time of speech sample recording such that any positive score indicated an improvement, and negative values, a decline in function.

Inter-rater reliability was explored by having a SLP with eight years experience assessing voice disorders rate a random set of 33 samples (20% of the total voice samples). Reliability was calculated using intraclass correlation coefficient (ICC) as well as direct calculation of the Percent Exact Agreement (PEA) and the Percentage of Close Agreement (PCA - where raters differed by no more than 1 scale point). The calculated results were derived from mean values of all perceptual parameters. Results of the ICC (0.64) revealed substantial agreement[33] while the PEA was 74% and the PCA was 93%. For intra-rater reliability the primary rater re-rated 20% of the sample a second time, at no sooner than four weeks following initial assessment. The ICC of 0.85 indicated almost perfect agreement,[33] with the PEA 71% and PCA was 99%.

Videostroboscopic evaluation – physiological ratings

The videostroboscopic recordings were made during the sustained phonation of the vowel /i/ produced at a comfortable loudness and pitch. The stroboscopic assessments were conducted by any one of five otolaryngologists at any assessment point. The recorded videostroboscopic samples were then subsequently rated by one primary otolaryngologist with seven years experience assessing voice disorders.

The videostroboscopic ratings were performed in two stages. The first stage rated: the symmetry of vocal fold abduction and vibration; the regularity and amplitude of the vocal fold movement, vocal fold edge smoothness, mucosal wave characteristics and glottal closure using a 4 point scale (0 = normal; 1 = mild; 2 = moderate; 3 = severe); Additional parameters, nodule location (very front, front, mid, back of the vocal fold membranous portion), nodule shape (narrow-based, broad-based); and surrounding oedema (yes/no) were also rated. The 159 samples (53 participants by three samples per participant) were randomized prior to presentation to the otolaryngologists for rating in order to reduce any potential bias. The otolaryngologists were able to review each videostroboscopic sample for as long as they wished. The ratings were completed from visual impression only and the videos were presented without sound.

The second stage of the videostroboscopic rating process, was to use the paired sample comparison process (as described previously) to rate paired samples (prevocal

hygiene and postvocal hygiene; prevocal hygiene and postvoice therapy; postvocal hygiene and postvoice therapy) using a questionnaire adapted from Holmberg, Hillman, Hammarberg, Sodersten, and Doyle.[8] Ratings of sample two compared to sample one were rated for changes in: (1) nodule size (difference between the two recordings, -1 larger; 1 smaller; 0 no difference), and; (2) surrounding oedema (difference between the two recordings: -1 larger; 1 smaller; 0 no difference). Once the samples were rated, the principle investigator revealed the order of the samples and transposed the scores to ensure data accurately reflected differences relative to the time of videostroboscopic sample recording (prevocal hygiene, postvocal hygiene and postvoice therapy).

Inter rater reliability of the primary rater was determined using a second otolaryngologist with nine years experience assessing voice disorders who rated a random set of 33 samples (20% of the total videostroscopic samples). The calculated results were mean values of all physiological parameters. The ICC revealed almost perfect agreement for inter-rater reliability (0.88), while the PEA was 74% and PCA was 99.6% respectively. Intra-rater reliability (based on 20% of the sample rated no sooner than four weeks following initial assessment) was also almost perfect (0.91), with PEA falling at 91.5% and PCA 97.4%.

Aerodynamic assessment

Aerodynamic assessment included measures of maximum phonation time (MPT), mean airflow rate (MFR) and subglottic pressure. MPT was measured with a stopwatch while participants were asked to produce the sustained vowel /a/ for as long as possible at a comfortable loudness and pitch level on a single breath, three times. The MFR and subglottic pressure were obtained and analysed using the Aerophone II (Model 6800, Kay Elemetrics Co., Lincoln Park, NJ). Each participant was asked to produce a sustained vowel /a/ for as long as possible at a comfortable intensity and pitch level with a face mask, sealed over the nose and mouth connected to a pneumotachograph- based flow system, three times. The subglottal pressure was measured indirectly using an intraoral pressure probe positioned behind the lips and resting on the tongue. The participants were asked to repeat /ipipip/ with the face mask and probe in place at a rate of 1.5 syllables/second, three times. Results for each parameter were averaged to produce one single value which was used in the statistical analyses.

Acoustic assessment

All acoustic recordings were conducted in a sound-proof room. The participants were asked to produce a sustained vowel /a/ on one breath at a comfortable pitch and

loudness level, three times. Vowel productions were recorded via the desktop microphone of the Computerized Speech Lab (CSL) (Model 5105, Kay Elemetrics Co.). The microphone was positioned in front of the participant with a mouth-to-microphone distance of 15 cm. Each participant's production of sustained /a/ was analysed using the Multi-Dimensional Voice Program (MDVP) software (Kay Elemetrics, Lincoln Park, NJ) in the CSL. The middle 3-second segment from each of the sustained vowels was selected for acoustic analysis. Detailed voice stability measures included: vocal fundamental frequency (Fo) (Hz), mean percentage vocal jitter and shimmer, and noise-to-harmonics ratio (NHR) (dB). Results across the three vowel phonations were averaged to produce a single value for each measure. In addition, participants' vocal intensity (VI) (dB) for the three prolonged vowels /a/ and additional conversational speech samples were simultaneously measured using Sound Level Meter (320 series, Center Technology Corp., Taiwan) which was also positioned in front of the participant with a mouth-to-microphone distance of 15 cm. Vocal intensity recorded for the prolonged vowel phonations and conversational speech samples were averaged to produce a single value for each measure.

Therapy program

The therapy program for each treatment group consisted of both indirect and direct

therapy treatment strategies. Both groups began voice therapy with indirect treatment strategies in which all participants were asked to follow general voice hygiene measures (adapted from Weinrich,[34] Verdolini Abbott,[35] and NCVS[36]). Participants in each group were then scheduled to return for eight-sessions of direct voice therapy three weeks later. The therapy program which was followed over the eight sessions in both groups was identical. Only the intensity of its delivery varied between the groups. The TVT (control) group received one session of direct therapy per week for eight weeks (8 sessions of therapy). The IVT group received eight sessions delivered within a three week period (ie, three times per week in the first two weeks and two times in the third week). All sessions, regardless of group, were 45 minutes in duration.

The voice therapy was provided by the principle investigator who was not involved in assessment of the participants. The principle investigator was trained and certified to provide the therapy program which was adapted from the Lessac-Madsen Resonant Voice Therapy (LMRVT) developed by Verdolini Abbott.[35] Components of the Vocal Function Exercises (VFE) program developed by Stemple were also incorporated in the speech tasks.[37] LMRVT focuses on the production of resonant voice which has been defined as a vocal quality that projects well, is easy to produce; involves a sensation of vibration in the mask of the face; and is characterised by ample harmonic content.[38] It is generally produced with relatively complete

anteroposterior vocal fold closure during phonation.[14] The focus of this therapy is: (1) the production of concentrated vibratory sensations on the anterior palate during phonation, using an "inverted megaphone" facial posture, and (2) upper body relaxation, using manual manipulations to reverse any obvious head, neck, or shoulder tensions and to obtain good head and neck alignment.[14] VFE represents a holistic approach to voice treatment designed to rebalance the three subsystems of voice, respiration, phonation, and resonance.[39] These exercises are designed to build strength and endurance in the laryngeal muscles and in doing so improve range and control for voice production.[2,38] The exercises also facilitate better control over airway valving and in so doing reduce hyperfunctional laryngeal behaviours.[2]

Therapy began with shoulder, neck, and facial muscle relaxation followed by basic training gestures as described by Verdolini Abbott[35] and Roy et al.[40] Direct facilitation of voice through stretch (ascending pitch glide) and contraction exercises (descending pitch glide) on the word "knoll", "whoop", or "boom" with an extreme forward focus was completed. Therapy tasks extended to sounds in isolation, conversation, and real-life applications outside of the therapy room, based on the clinician's impression that earlier levels in the therapy hierarchy had been successfully mastered. All participants were asked to practice voice techniques worked on in the therapy session at home, in two 15-minutes sessions per day on

non-therapy days, and once per day on therapy days. The techniques were provided in worksheets in the form of a daily checklist for participants to take home.

Statistical Analysis

The *Statistical Package for the Social Sciences (SPSS) version 20* (SPSS, Inc., Chicago, IL) was used for all statistical analysis and level of significance was set at $P < 0.05$. Analysis involved both within group and between group analyses. For within group analysis, the paired comparison ratings (between baseline and postvocal hygiene, baseline and posttreatment, and postvocal hygiene to posttreatment) conducted for the perceptual parameters of grade; roughness; breathiness; asthenia; strain and also for the physiological parameters of nodule size and oedema were analysed using a series of one sample *t* tests (2-tailed) where 0 was taken to indicate no difference between the sample pairs.

For the physiological parameters of the symmetry of vocal fold abduction and vibration; the regularity and amplitude of the vocal fold movement; vocal fold edge smoothness; mucosal wave; and glottal closure were analysed using Friedman's tests to explore extent of within group change in each treatment group (IVT and TVT) across the three time points (baseline, postvocal hygiene, and postvoice treatment). Any significant result was examined further using *posthoc* Wilcoxon signed rank

tests.

Prior to conducting the between group analysis, data from the physiological ratings (symmetry of vocal fold abduction and vibration, the regularity and amplitude of the vocal fold movement, vocal fold edge smoothness, mucosal wave and glottal closure) were converted to change scores, calculated as the difference between the baseline and postvocal hygiene ratings, between baseline and posttreatment ratings, and between postvocal hygiene and posttreatment for each participant in each group. Mann-Whitney *U* tests were then used to determine any differences in the extent of change across the physiological parameters at baseline to postvocal hygiene, baseline to posttreatment and postvocal hygiene to posttreatment between the IVT and TVT groups.

To explore between group differences for the perceptual and physiological data from the paired comparisons ratings, the proportions of participants identified as either better, worse or no different at postvocal hygiene and posttreatment were calculated then compared between the groups, using chi-square tests.

With regards to acoustic and aerodynamic measures, to identify differences between the two treatment groups (IVT and TVT) across time (pre-, postvocal hygiene, and after voice treatment) as well as any interaction occurring between treatment group and time, two-factor repeated measures analyses of variances

(ANOVAs) were used. Where a significant ($P < 0.05$) effect for time was found, *posthoc* procedures were performed to determine where the significant difference occurred (ie, between pre- and postvocal hygiene, postvocal hygiene and posttreatment, or pre- and posttreatment) within each group.

Results

Perceptual ratings – paired comparisons

Within group analysis. *T* tests revealed that between baseline and postvocal hygiene, there were no significant changes across any of the perceptual parameters except for strain, which improved significantly ($P < 0.05$) in the TVT group only (Table 2). The comparison between baseline and posttreatment showed that both the TVT and IVT groups were found to have significantly improved ratings of overall voice quality, roughness, breathiness, weakness of voice, and strain. Comparison between postvocal hygiene and posttreatment also demonstrated significantly improved ratings of overall voice quality, roughness, and strain of voice in both groups, with IVT group showing additional significant improvement in breathiness and weakness of voice (Table 2).

Between group analysis. Descriptive analysis and chi-Square tests showed that there were no differences in the proportions of patients making positive change between the groups at either baseline to postvocal hygiene, baseline to postvoice treatment or post-

vocal hygiene to postvoice treatment for all perceptual parameters (Table 3).

Videostroboscopic ratings – physiological parameters

Within group. Results of the physiological ratings over time for TVT and IVT groups are shown in Table 4. Friedman tests revealed a significant ($P < 0.05$) difference across the three time points for the ratings of mucosal wave, vocal fold edge smoothness, regularity of vocal fold movement, and glottal closure in both the IVT and TVT groups. There were no significant differences observed for symmetry of vocal fold abduction or amplitude of vocal fold movement over time in either group (Table 4).

Posthoc Wilcoxon signed rank tests revealed statistically significant improvements from baseline to postvocal hygiene for both the TVT and IVT groups for ratings of mucosal wave (TVT: Z = -2.738, $P = 0.006$; IVT: Z = -3.441, $P = 0.001$), vocal fold edge smoothness (TVT: Z = -3.317, $P = 0.001$; IVT: Z = -2.887, $P = 0.004$) and glottal closure (TVT: Z = -2.500, $P = 0.012$; IVT: Z = -1.968, $P = 0.049$). No significant differences were found between baseline and postvocal hygiene for regularity of vocal folds (TVT: Z = -0.707, $P = 0.480$; IVT: Z = -1.667, $P = 0.096$) for either groups.

Comparisons between postvocal hygiene to posttreatment revealed further

significant ($P < 0.05$) improvements in mucosal wave (Z = -3.625, $P < 0.001$), vocal fold edge smoothness (Z = -3.464, $P = 0.001$), regularity of vocal movement (Z = -2.530, $P = 0.011$) and glottal closure (Z = -3.500, $p < 0.001$) for participants in TVT group. In the IVT group only, a significant improvement in mucosal wave (Z = -3.477, $P = 0.001$) was found between postvocal hygiene and posttreatment.

Between baseline and immediately postvoice therapy significant ($P < 0.05$) improvements were observed in mucosal wave (TVT: Z = -4.567, $P < 0.001$; IVT: Z = -4.110, $P < 0.001$), vocal fold edge smoothness (TVT: Z = -4.347, $P < 0.001$; IVT: Z = -3.300, $P = 0.001$), regularity of vocal fold movement (TVT: Z = -2.517, $P = 0.012$; IVT: Z = -2.496, $P = 0.013$) and glottal closure (TVT: Z = -4.181, $P < 0.001$; IVT: Z = -2.982, $P = 0.003$) in both the TVT and IVT groups.

Between group analysis. Mann-Whitney *U* tests revealed no significant differences in the extent of change between the groups at either baseline to postvocal hygiene, postvocal hygiene to pos treatment, or baseline to posttreatment for all parameters (Table 5).

Videostroboscopic ratings – comparison of pairs

Within group analysis. One sample *t* tests revealed that both groups demonstrated significantly improved ratings of vocal nodule size (TVT: $t = 2.3$, df = 26, $P = 0.026$,

mean diff = 0.333; IVT: $t = 3.7$, df = 23, $p = 0.001$, mean diff = 0.500) and vocal fold oedema (TVT: $t = 2.6$, df = 26, $P = 0.015$, mean diff = 0.370; IVT: $t = 4.1$, df = 23, $P < 0.001$, mean diff = 0.500) following vocal hygiene. Comparison between postvocal hygiene and posttreatment revealed significantly improved ratings of vocal nodule size (TVT: $t = 3.808$, df = 27, $P = 0.001$, mean diff = 0.536; IVT: $t = 2.865$, df = 22, $P < 0.001$, mean diff = 0.435) and vocal fold oedema (TVT: $t = 4.688$, df = 27, $P < 0.001$, mean diff = 0.607; IVT: $t = 4.447$, df = 22, $P < 0.001$, mean diff = 0.609). From baseline to postvocal therapy both groups demonstrated significantly improved ratings for vocal nodule size (TVT: $t = 4.03$, df = 28, $P = 0.001$, mean diff = 0.552; IVT: $t = 15.199$, df = 22, $P < 0.001$, mean diff = 0.913) and vocal fold oedema (TVT: $t = 4.04$, df = 28, $P < 0.001$, mean diff = 0.586; IVT: $t = 10.199$, df = 22, $P < 0.001$, mean diff = 0.826).

Between group analysis. Descriptive analysis and chi-Square tests showed there were no significant differences between the groups at either baseline to postvocal hygiene, baseline to postvoice treatment or postvocal hygiene to postvoice treatment for all physiological paired comparisons with respect to the proportion of participants who had improved, declined, or had no change in vocal nodule size or oedema (Table 6).

Aerodynamic measures

A series of two-factor ANOVAs (group x time) conducted for each aerodynamic parameter revealed no significant interactions between group and time for any parameters (Table 7). There was also no main effect for time for any aerodynamic parameter. Furthermore, the between group effect was not significant for any aerodynamic parameters, suggesting no difference in the effectiveness of the two approaches regarding aerodynamic measures (Table 7).

Acoustic measures

Two-factor ANOVAs conducted for each acoustic parameter showed no significant interaction between group and time (Table 8). There was however a significant main effect for time for F_0, jitter, shimmer, NHR and VI for prolonged /a/, with both groups showing an increase in values across the three time periods for F_0 and VI of prolonged /a/ and a reduction in values for jitter, NHR and shimmer. There was no main effect observed for VI in conversation. In addition, the between group effect was not significant across all acoustic parameters, suggesting no difference in the effects of the two interventions on acoustic measures (see Table 8).

Posthoc tests performed on the acoustic parameters demonstrated a significant main effect for time. Analysis revealed no significant differences between pre- and postvocal hygiene across all acoustic parameters for both treatment groups, except for

VI for prolonged /a/ ($P = 0.019$) in IVT group. However, significant increases in mean F_0 were found for participants in both the IVT and TVT groups between baseline and immediately postvoice therapy. Both groups also experienced significant reductions in jitter ($P < 0.001$ and $P = 0.012$), and shimmer ($P = 0.001$ and $P = 0.03$) following treatment. Although there was a significant main effect for time for NHR, no significant differences were found in the *posthoc* analysis between time points in both groups, though a trend ($P = 0.099$ and $P = 0.381$, respectively) was observed for a reduction in NHR between baseline and posttreatment for TVT and IVT groups. Results of VI for prolonged vowel /a/revealed a significant increase immediately posttreatment in TVT group ($P = 0.005$) but not in IVT group ($P = 0.069$).

Discussion

Extensive studies have been conducted to investigate the benefits of voice therapy in the management of vocal nodules, however there is large variation in the duration and intensity of the therapy reported. This study examined perceptual, physiological, acoustic, and aerodynamic outcomes following two treatment intensity protocols for individuals with vocal nodules. The results of the current investigation provide support for comparable positive perceptual, physiological and acoustic effects from intensive voice therapy delivered over a shorter period of time (three weeks),

compared with the traditional model of service delivery provided over eight weeks. Although both treatments modalities contributed to significant improvements posttreatment across most variables, the efficiency of intensive practice may be better suited to some patients. These findings support the benefits of massed practise as reported by other investigations.[25,26,28]

In the current study, no significant differences were noted postvocal hygiene perceptually, acoustically or aerodynamically in either group, except for a perception of reduced strain in the TVT group. In contrast, physiological assessment showed significant positive changes to mucosal wave, vocal fold edge smoothness, and glottal closure nodule size and surrounding oedema following the vocal hygiene program in both groups. This discrepancy in findings was also observed by Verdolini-Marston, Sandage and Titze[41] who found significant improvement in laryngeal appearance following vocal hygiene (ie, hydration), however auditory-perceptual ratings fell short of statistical significance. A possible explanation for the lack of change in perceptual, acoustic and aerodynamic parameters postvocal hygiene could be that the subtle changes identified under videostroboscopic examination were not yet sufficient to result in other changes.

Although the intensive treatment protocol used in the current study may be considered to increase or exacerbate vocal loading for participants with vocal nodules,

the significant improvements in perceptual and physiological parameters identified in participants postintensive treatment were comparable to the results yielded posttraditional treatment. Therefore, the results suggest that an intensive treatment schedule did not result in an increase in vocal loading with subsequent exacerbation of vocal pathology in this cohort.

Previous case study reports have documented positive changes in vocal fold morphology and function following vocal hygiene counselling alone.[18] A specific vocal hygiene target, hydration, has been shown to have significant benefit on the laryngeal appearance on a group of participants with vocal nodules and polyps.[41] The current findings also suggest that vocal hygiene education remains an important part of voice therapy as the issues discussed in vocal hygiene session (eg, hydration, reduction in voice use, reduction in consumption of foods which may cause gastric reflux) may have been responsible for the development of vocal nodules in the first place. However several reviews of vocal hygiene training have concluded that although it is beneficial to include vocal hygiene program, it should be considered only as a component of a comprehensive vocal rehabilitation program.[42,43] Indeed recent studies have revealed that vocal hygiene education alone is ineffective for treating individuals with existing voice problems and that direct voice therapy is required to optimise treatment benefits.[40,44-46] The current data would also support this

opinion.

Previous investigators have reported that voice therapy is effective in restoring normal voice and improving voice quality in individuals with vocal nodules.[7,8,10,19-21] Specifically, it has been reported that breathiness and pressed quality of voice is significantly reduced posttherapy.[8] Our study also yielded a similar result, in that participants from both TVT and IVT groups had significantly less rough, breathy, weak, and strained voices, and overall had a better voice quality immediately posttherapy when compared with baseline. As implied by Holmberg et al[8] the decreased breathiness may reflect a reduction in nodule size, thus making more complete glottal closure possible. This is consistent with our physiological findings in that our participants had significantly reduced nodule size and glottal closure posttherapy.

The reduction in strained voice identified posttherapy in both groups, may have indicated decreased muscle tension, and improved speech respiratory behaviour with better management of air supply and a more efficient relationship between subglottal pressure and glottal function.[8] The decrease in strained voice may also be reflected through the improved regularity of vocal fold movement and mucosal wave. A combination of the improvement of all voice qualities can be seen as an indicator of the efficacy of the voice therapy delivered in both groups.

Several researchers have found regularity of vocal fold vibration, quality of mucosal wave and vocal fold closure to have improved with voice training; and elimination or marked reductions in nodules and surrounding oedema to have dissipated postvoice therapy.[5,7,8,15-18,20] These findings were also demonstrated in the current study. When comparing baseline to immediately postvoice therapy, both the IVT and TVT groups demonstrated significant improvements in mucosal wave, vocal fold smoothness, regularity of vocal fold movement and glottal closure. In addition, there was significant reduction in nodules and surrounding oedema posttreatment for both groups. The improvement in mucosal wave, vocal fold smoothness, regularity of vocal fold movement and glottal closure may reflect an increase in effective mass of the vocal fold and a reduction in the size of the vocal nodules.

Although significant improvements were noted by the end of treatment, for the majority of the participants, their vocal nodules had not completely resolved, as has been observed by other researchers.[5,8] It is postulated that although the trauma to the vocal folds may have decreased after therapy, the impact on the vocal fold physiology might not have been significant enough to allow complete amelioration of the nodular lesions.[5,8] It is also suspected that those with larger nodules may require a longer care period.[12] Direct treatment periods of three weeks and eight weeks may be insufficient

for vocal nodules to completely resolve. Therefore, further long-term observations should be conducted to determine whether or not the resolution of vocal nodules persists.

The results of the acoustic analyses revealed there were significant increases in F_0, and decreases in jitter, and shimmer, immediately after voice treatment for both groups which is consistent with previous research findings.[20,47,48] The increase in F_0 may be due to a reduction in size of the vocal nodules and a decrease in surrounding oedema resulting in a decrease in the mass loading effects on the vibratory characteristics of the vocal folds.[2,8,49] It was also noted there was a significant increase in vocal intensity for TVT group but not the IVT group. This increased vocal intensity may be attributed to the extended time provided for the TVT group to familiarise themselves with the use of vocal projection, which is a treatment component of LMRVT. As a result, participants developed a louder voice. The overall acoustic improvements found in both groups reflected increases in effective mass of the vocal fold, reduction in the vocal noise, and possibly diminishing vocal nodule size.[8,50] This was confirmed by our physiological findings which showed significant improvement in mucosal wave, vocal fold edge smoothness, regularity of vocal fold movement, glottal closure, and significant reduction in vocal nodule size and vocal fold oedema immediately posttreatment. In addition, the acoustic improvement also positively

correlated with participants' perceptual ratings in which overall voice quality, roughness, breathiness, weakness, and strain of voice were significantly improved. These changes indicated that the intensive and traditional treatment dosages used in this study were effective in the management of vocal nodules. As no statistical differences were found between the treatment groups, it is further suggested that intensive intervention over a three week period is of sufficient duration to improve voice outcome for individuals with vocal nodules.

Similar to the aerodynamic findings yielded by Holmberg et al[5] and Treole and Trudeau,[51] the current study found no significant changes in aerodynamic parameters posttreatment. It may be that as the participants' aerodynamic measures were already in the normal range before voice treatment, significant changes were unable to be detected immediately following therapy.[52] It may also be the case that as the smoothness of the vocal fold edges in the majority of the participants was only mildly or moderately affected at baseline, this did not impact on aerodynamic function through the therapy period.

It is known that majority of the individuals with vocal nodules work in professions which are high in voice demand, therefore, it is essential that they return to workforce as soon as possible with an adequate voice. Therefore, intensive voice therapy may be a preferable service delivery model as these individuals would be able

to return to work with an improved voice within a shorter period of time. The benefits of such an intensive voice treatment include: voice improvement in a short period of time, increased patient compliance and understanding of home practice, more time efficient for both clinician and client, decreased time between sessions, and increased ability to carryover learned strategies into everyday life. Individuals are able to accelerate learning regulated by increasing therapy rate, therapy phase duration, and variability of practice, and decreasing the rest phase duration.[28] Intensive contact with the clinician allows individuals with vocal nodules to resolve any queries and be provided with clinician's feedback regarding their use of voice in a shorter time frame. This process can assist patients to consolidate their awareness and facilitates generalisation of treatment effects to daily living.[29] In contrast, prolonged voice therapy as noted by Spielman et al.[26] extends the time commitment for both client and clinician, with no additional gains to be made.

The overall outcome of this current investigation showed that both treatment approaches were able to provide improvements to vocal fold condition and vocal function. As such the data demonstrated that participants were able to improve voice and vocal fold health in the short period of time needed for the intensive therapy approach and were able to carryover vocal strategies into everyday life. Thus, the intensive model may be more time efficient and beneficial for people who have busy

work schedules as they have the need to go back to work as soon as possible with a satisfactory voice.

While the present study revealed the potential value of providing treatment to individuals with vocal nodules in an intensive approach, there are limitations to the study. The first issue is the use of a pragmatic randomized controlled trial (RCT) design, over the more conventional RCT method. The pragmatic allocation of participants to treatment groups was necessary to facilitate recruitment in the research setting of Taiwan where there is high work demands and minimal support for sick leave. The typical workforce in cultures such as Taiwan face considerable issues when seeking therapy, as people rarely take sick leave and are encouraged not to, for fear of job loss and reduced pay. Although a conventional RCT would have provided stronger internal validity, a pragmatic RCT reflects the 'real world' scenario which provides good external validity.[53] Hence a pragmatic RCT approach was adopted to allow more participants to be included in the study with less attrition. Future studies would also benefit from the use of standardised self-rating questionnaires to further monitor participants' perception of the possible changes in quality of life and satisfaction with voice therapy. Furthermore, long-term follow-up of both treatments should occur to determine whether or not there is continuous improvement or maintenance of vocal quality, vocal fold health and vocal communication.

Conclusions

In conclusion, the positive improvements in perceptual, physiological, and acoustic parameters of voice identified in this study provide evidence that intensive voice treatment is equally as beneficial in treating vocal nodules as a traditional voice therapy model. Intensive voice therapy should be considered as an option when providing clinical management to individuals with vocal nodules. Consequently this population would be able to regain better vocal communication and return to the workforce in a condensed period of time. This research warrants further investigation of the effects of intensive voice treatment on the long-term follow-up and participant perception of the benefits of this treatment protocol. Such research will ultimately lead to better quality of life and service delivery for the many individuals with vocal nodules.

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Table 1. Demographic Information of Participants

Demographic variables	TVT Group	IVT Group	*P*
Total number of participants	29	24	
Mean age	37.52	37.54	0.871
Severity of dysphonia			0.063
Mild	2	-	
Mild-moderate	19	12	
Moderate	7	12	
Moderate-severe	1	-	
Occupations			0.817
Professional voice user	16	14	
Non-professional voice user	13	10	

Abbreviations: TVT, traditional voice therapy; IVT, intensive voice therapy.

Table 2. Results of the One Sample *t* Tests for the Perceptual Parameters Over Time for the TVT and IVT Groups

		TVT			IVT		
Time	Parameter	Mean difference	t	p	Mean difference	t	p
Baseline to post-VH	Grade	0.310	1.877	0.071	0.042	0.196	0.846
	Roughness	0.241	1.425	0.241	0.125	0.681	0.503
	Breathiness	0.138	1.162	0.255	0.042	0.296	0.770
	Asthenia	0.103	1.140	0.264	0.208	1.735	0.096
	Strain	0.276	2.512	0.018*	0.250	1.543	0.137
Post-VH to post-tx	Grade	0.552	3.266	0.003*	0.625	3.498	0.002*
	Roughness	0.517	2.824	0.009*	0.625	3.498	0.002*
	Breathiness	0.241	1.885	0.070	0.292	2.290	0.032*
	Asthenia	0.241	1.885	0.070	0.292	2.598	0.016*
	Strain	0.241	2.045	0.050*	0.292	2.598	0.016*
Baseline to post-tx	Grade	0.897	5.363	<0.001*	0.875	4.764	<0.001*
	Roughness	0.828	5.255	<0.001*	0.750	3.892	0.001*
	Breathiness	0.345	2.415	0.023*	0.458	2.696	0.013*
	Asthenia	0.483	3.524	0.001*	0.458	3.114	0.005*
	Strain	0.586	4.308	<0.001*	0.542	2.716	0.012*

Abbreviations: IVT, intensive voice therapy; TVT, traditional voice therapy; VH, vocal hygiene; tx, treatment.

* Statistically significant difference.

Table 3. Analysis of the Proportion of Change in Perceptual Ratings at Each Time Point Observed Between the Two Groups

Parameter/Time		TVT, n (%)	IVT, n (%)	χ^2	*P*
Grade					
Baseline to post-VH	Post-VH better	11 (38)	6 (25)	3.086	0.544
	Post-VH worse	5 (17)	7 (29)		
	No change	13 (45)	11 (46)		
Post-VH to post-tx	Post-tx better	18 (62)	13 (54)	2.240	0.326
	Post-tx worse	5 (17)	2 (8)		
	No change	6 (21)	9 (38)		
Baseline to post-tx	Post-tx better	24 (83)	17 (71)	4.592	0.204
	Post-tx worse	4 (14)	2 (8)		
	No change	1 (3)	5 (21)		
Roughness					
Baseline to post-VH	Post-VH better	10 (34)	5 (21)	2.613	0.241
	Post-VH worse	6 (21)	8 (33)		
	No change	13 (45)	11 (46)		
Post-VH to post-tx	Post-tx better	18 (62)	13 (54)	2.240	0.326
	Post-tx worse	5 (17)	2 (8)		
	No change	6 (21)	9 (38)		
Baseline to post-tx	Post-tx better	22 (76)	17 (71)	2.304	0.680
	Post-tx worse	3 (10)	2 (8)		
	No change	4 (14)	5 (21)		

Breathiness					
Baseline to post-VH	Post-VH better	6 (21)	5 (20)	2.192	0.700
	Post-VH worse	3 (10)	3 (13)		
	No change	20 (69)	16 (67)		
Post-VH to post-tx	Post-tx better	9 (31)	7 (29)	0.816	0.665
	Post-tx worse	3 (10)	1 (4)		
	No change	17 (59)	16 (67)		
Baseline to post-tx	Post-tx better	11 (38)	10 (42)	0.516	0.915
	Post-tx worse	3 (10)	2 (8)		
	No change	15 (52)	12 (50)		
Asthenia					
Baseline to post-VH	Post-VH better	5 (17)	3 (12)	2.274	0.518
	Post-VH worse	2 (7)	0 (0)		
	No change	22 (76)	21 (88)		
Post-VH to post-tx	Post-tx better	9 (31)	6 (25)	3.185	0.203
	Post-tx worse	3 (10)	0 (0)		
	No change	17 (59)	18 (75)		
Baseline to post-tx	Post-tx better	14 (48)	8 (33)	4.965	0.174
	Post-tx worse	2 (7)	0 (0)		
	No change	13 (45)	16 (67)		

Strain					
Baseline to post-VH	Post-VH better	8 (28)	7 (29)	2.274	0.518
	Post-VH worse	1 (3)	3 (13)		
	No change	20 (69)	14 (58)		
Post-VH to post-tx	Post-tx better	10 (35)	6 (25)	3.679	0.159
	Post-tx worse	3 (10)	0 (0)		
	No change	16 (55)	18 (75)		
Baseline to post-tx	Post-tx better	17 (59)	11 (46)	4.915	0.178
	Post-tx worse	2 (7)	2 (12)		
	No change	10 (34)	10 (42)		

Abbreviations: IVT, intensive voice therapy; TVT, traditional voice therapy; VH, vocal hygiene; tx, treatment.

Table 4. Within Group Analysis of Physiological Parameters for Both TVT and IVT Groups

Parameter/Group	Pre-VH mean (SD)	Post-VH mean (SD)	Post-tx mean (SD)	χ^2	*P*
Symmetry					
TVT	1.22 (0.506)	1.26 (0.447)	1.26 (0.447)	0.182	0.913
IVT	1.28 (0.689)	1.17 (0.650)	1.04 (0.475)	1.200	0.549
Amplitude					
TVT	1.07 (0.550)	0.89 (0.698)	1.00 (0.679)	2.150	0.341
IVT	1.09 (0.733)	1.17 (0.576)	1.13 (0.694)	0.545	0.761
Mucosal wave					
TVT	2.00 (0.480)	1.48 (0.802)	0.63 (0.688)	32.689	<0.001*
IVT	1.83 (0.717)	1.22 (0.671)	0.39 (0.583)	32.747	<0.001*
VF edge smoothness					
TVT	1.81 (0.483)	1.41 (0.501)	0.96 (0.437)	31.524	<0.001*
IVT	1.74 (0.541)	1.30 (0.470)	1.13 (0.548)	16.423	<0.001*
Regularity					
TVT	1.37 (0.492)	1.30 (0.454)	1.00 (0.555)	8.909	0.012*
IVT	1.35 (0.573)	1.13 (0.548)	0.96 (0.475)	8.400	0.015*
Glottal closure					
TVT	1.52 (0.509)	1.15 (0.602)	0.63 (0.565)	27.800	<0.001*
IVT	1.65 (0.573)	1.26 (0.619)	1.09 (0.596)	10.793	0.005*

Abbreviations: IVT, intensive voice therapy; TVT, traditional voice therapy; VH, vocal hygiene; tx, treatment; VF, vocal fold; SD, standard deviation. * Statistically significant difference.

Table 5. Between Group Analysis of Extent of Change in Physiological Parameters in Both the TVT and IVT Groups

Time /Parameter	TVT Mean difference (SD)	IVT Mean difference (SD)	Z	*P*
Pre-VH versus post-VH				
Symmetry	-0.04 (0.518)	0.08 (0.584)	-0.789	0.430
Amplitude	0.19 (0.622)	-0.08 (0.584)	-1.486	0.137
Mucosal wave	0.52 (0.849)	0.63 (0.647)	-0.536	0.592
VF edge smoothness	0.41 (0.501)	0.42 (0.584)	-0.185	0.853
Regularity	0.07 (0.550)	0.21 (0.558)	-0.863	0.388
Glottal closure	0.37 (0.688)	0.38 (0.875)	-0.061	0.951
Pre-tx versus post-tx				
Symmetry	-0.07 (0.456)	0.22 (0.795)	-1.375	0.169
Amplitude	0.07 (0.651)	-0.04 (0.562)	-0.667	0.505
Mucosal wave	1.38 (0.775)	1.43 (0.788)	-0.300	0.976
VF edge smoothness	0.83 (0.602)	0.61 (0.656)	-1.121	0.262
Regularity	0.38 (0.728)	0.39 (0.656)	-0.114	0.909
Glottal closure	0.86 (0.693)	0.57 (0.728)	-1.458	0.145
Post-VH versus post-tx				
Symmetry	0.00 (0.602)	0.13 (0.757)	-0.371	0.711
Amplitude	-0.11 (0.506)	0.04 (0.562)	-1.013	0.311

Mucosal wave	0.85 (0.864)	0.83 (0.778)	0.020	0.841
VF edge smoothness	0.44 (0.506)	0.17 (0.576)	-1.632	0.103
Regularity	0.30 (0.542)	0.17 (0.576)	-1.080	0.280
Glottal closure	0.52 (0.580)	0.17 (0.778)	-1.757	0.079

Abbreviations: VH, vocal hygiene; tx, treatment; VF, vocal fold; IVT, intensive voice therapy; TVT, traditional voice therapy; SD, standard deviation.

Table 6. Physiological Paired Comparison Ratings

Parameter/Time		TVT, n (%)	IVT, n (%)	χ^2	*P*
Vocal nodule size					
Baseline to post-VH	Post-VH smaller	13 (48)	14 (58)	0.752	0.687
	Post-VH larger	4 (15)	2 (8)		
	No change	10 (37)	8 (33)		
Post-VH to post-tx	Post-tx smaller	19 (68)	13 (57)	1.122	0.571
	Post-tx larger	4 (14)	3 (13)		
	No change	5 (18)	7 (30)		
Baseline to post-tx	Post-tx smaller	20 (69)	21 (91)	4.680	0.096
	Post-tx larger	4 (14)	0 (0)		
	No change	5 (17)	2 (9)		
Surrounding oedema					
Baseline to post-VH	Post-VH smaller	14 (52)	13 (54)	1.719	0.423
	Post-VH larger	4 (15)	1 (4)		
	No change	9 (33)	10 (42)		
Post-VH to post-tx	Post-tx smaller	20 (71)	16 (69)	0.156	0.925
	Post-tx larger	3 (11)	2 (9)		
	No change	5 (18)	5 (22)		
Baseline to post-tx	Post-tx smaller	22 (76)	19 (83)	5.264	0.072
	Post-tx larger	5 (17)	0 (0)		
	No change	2 (7)	4 (17)		

Abbreviations: VH, vocal hygiene; tx, treatment; IVT, intensive voice therapy; TVT, traditional voice therapy.

Table 7. Results – MPT, MFR, and Subglottic Pressure for TVT and IVT Groups

Task/Group	Pre-VH Mean (SD)	Post-VH Mean (SD)	Post-tx Mean (SD)	Interaction Effect			Main Effect			Between Group Effect		
				F	*p*	Effect Size (Partial eta Squared)	*F*	*p*	Effect Size (Partial eta Squared)	*F*	*p*	Effect Size (Partial eta Squared)
MPT (s)												
TVT	8.53 (3.59)	8.81 (3.14)	9.57 (3.64)	0.972	0.385	0.037	0.227	0.798	0.009	0.001	0.974	<0.005
IVT	9.04 (4.35)	9.07 (3.24)	8.72 (2.79)									
MFR (mL/s)												
TVT	139.60 (60.65)	143.65 (71.00)	140.34 (65.02)	0.634	0.530	0.005	0.165	0.848	0.007	0.959	0.332	0.018
IVT	163.35 (65.07)	150.68 (75.52)	159.09 (81.21)									
Subglottic pressure (cmH_2O)												
TVT	10.10 (3.08)	9.64 (2.92)	10.68 (3.04)	1.886	0.162	0.070	0.762	0.472	0.030	2.478	0.122	0.046
IVT	11.32 (2.80)	11.41 (3.09)	11.18 (3.37)									

Abbreviations: VH, vocal hygiene; tx, treatment; MPT, maximum phonation time; MFR, mean airflow rate; IVT, intensive voice therapy; TVT, traditional voice therapy; SD, standard deviation.

Table 8. Results – F_0, jitter, shimmer, NHR, VI of Prolonged Vowel /a/ and VI of Conversational Speech Sample for TVT and IVT Groups

Task/Group	Pre-VH Mean (SD)	Post-VH Mean (SD)	Post-tx Mean (SD)	Interaction Effect			Main Effect for Time			Between Group Effect		
				F	*p*	Effect Size (Partial eta Squared)	*F*	*p*	Effect Size (Partial eta Squared)	*F*	*p*	Effect Size (Partial eta Squared)
F_0 (Hz)												
TVT	205.75 (29.28)	205.03 (27.27)	233.92 (29.56)	0.637	0.533	0.025	60.303	<0.001*	0.707	0.342	0.561	0.007
IVT	197.88 (33.56)	203.79 (23.89)	230.67 (25.65)									
Jitter (%)												
TVT	2.03 (1.18)	1.65 (0.96)	1.20 (0.92)	0.515	0.600	0.020	18.537	<0.001*	0.426	0.275	0.602	0.005
IVT	2.08 (1.06)	1.92 (0.89)	1.21 (0.84)									
Shimmer (%)												
TVT	5.17 (1.90)	4.59 (1.82)	3.87 (2.10)	0.495	0.613	0.019	10.231	<0.001*	0.290	1.158	0.287	0.022
IVT	5.83 (2.43)	5.24 (2.21)	3.96 (1.83)									

NHR												
TVT	0.16 (0.04)	0.15 (0.03)	0.14 (0.05)	0.089	0.915	0.004	3.508	0.038*	0.123	0.046	0.831	0.001
IVT	0.16 (0.04)	0.15 (0.03)	0.14 (0.04)									
VI of prolonged /a/ (dB)												
TVT	75.73 (5.53)	76.43 (5.34)	79.92 (6.51)	0.196	0.823	0.008	9.931	<0.001*	0.293	0.541	0.465	0.011
IVT	75.28 (5.79)	75.15 (4.33)	78.70 (6.97)									
VI of conversation (dB)												
TVT	71.50 (3.81)	71.85 (2.75)	72.27 (3.79)	1.184	0.315	0.047	1.122	0.334	0.045	0.097	0.757	0.002
IVT	72.19 (3.52)	70.84 (3.11)	71.91 (3.99)									

Abbreviations: F_0, fundamental frequency; NHR, noise-to-harmonic ratio; VI, vocal intensity; IVT, intensive voice therapy; TVT, traditional voice therapy; SD, standard deviation.

* Statistically significant difference.