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An Online Telepractice Model for the Prevention of Voice Disorders in Vocally Healthy Student Teachers Evaluated by a Smartphone Application

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Abstract

This article describes the Global Voice Prevention Model (GVPM) facilitated with student teachers at West Chester University and the VoiceEvalU8 smartphone application (app) used to assess the effectiveness of the GVPM. Twenty-one participants completed 1 of 3 conditions (i.e., in-person GVPM, telepractice GVPM, and control). The in-person and telepractice conditions ran for 4 weeks during fall 2016, with 1 week dedicated to vocal education and vocal hygiene and 3 weeks spent in vocal training. The control condition ran for 1 week and included only vocal education and vocal hygiene. The VoiceEvalU8 app was used at pre- and post-condition twice a day for 5 days to record acoustic, perceptual, and aerodynamic voice measures. The study is ongoing; therefore, preliminary acoustic results for fundamental frequency (F0) and jitter% are presented from pre- to post-condition. During spring 2017, the participants were student teaching and using the VoiceEvalU8 app to record the voice measures before and after teaching all day. A new group of participants will be enrolled fall 2017 for selection into 1 of the 3 conditions and then continue on to student teaching spring 2018.

Introduction

Telehealth is “the use of remote health care technology for the delivery of clinical services,” (American Telemedicine Association [ATA], 2017). The American Speech-Language-Hearing Association (ASHA) adapted telehealth into *telepractice*, the application of technology for the delivery of speech-language pathology and audiology services at a distance (ASHA, 2005a, b). The telepractice models in the literature have used some type of synchronous videoconferencing (i.e., live in real time) as the main form of delivery. Asynchronous methods (i.e., store and access later) have been used as a supplement and as a way to validate what was observed through videoconferencing (Halpern et al., 2005; Hill et al., 2006; Perlman & Witthawaskui, 2002; Trail et al., 2005). Research has demonstrated that synchronous telepractice methods produce similar clinical outcomes when compared with in-person speech-language pathology services for neurogenic communication disorders, fluency disorders, voice disorders, dysphagia, and childhood speech and language disorders

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(Hill & Theodoros, 2002; Lowe, O'Brian, & Onslow, 2013; Mashima & Brown, 2011; Mashima & Doarn, 2008; Swanepoel & Hall, 2011; Theodoros, 2008). In addition to positive clinical outcomes that mirror those of in-person services, client and clinician satisfaction have been remarkably positive across the majority of studies (Brennan, 2006; Brennan, Georgeadis, & Baron, 2002; Georgeadis, Brennan, Barker, & Baron, 2004; Kully, 2002; Mashima et al., 2003), a finding consistent with other areas of telehealth research (Cardoso & Steinberg, 2010).

Voice disorders seem to be the most common communication disorder across the lifespan and are particularly prevalent in professional voice users who depend on their voice for work, such as teachers (Branski, Verdolini, Sandulache, Rose, & Hebda, 2006; Fritzell, 1996; Titze, Lemke, & Montequin, 1997). Estimates indicate that 11–38% of teachers in the United States (i.e., 407,000 to 1.4 million) are regularly confronted with voice problems (Roy, Merrill, Thibeault, Gray, & Smith, 2004; Smith, Lemke, Taylor, Kirchner, & Hoffman, 1998; Thibeault, Merrill, Roy, Gray, & Smith, 2004). There is literature on the prevention of voice disorders in professional teachers (Bovo, Galceran, Petruccelli, & Hatzopoulos, 2007; Ilomaki, Laukkanen, Leppanen, & Vilkmann, 2008; Pasa, Oates, & Dacakis, 2007; Silverio et al., 2008) and on the prevention of voice disorders in vocally healthy student teachers (Duffy & Hazlett, 2004; Nanjundeswaran et al., 2012; Timmermans et al., 2011; Timmermans, De Bodt, Wuyts, & Van de Heyning, 2004; Timmermans, Coveiliers, Wuyts, & Van Looy, 2012). Arguably, addressing the vocal needs of teaching in the education of future teachers may be our best defense for preventing voice problems. Under the United States' occupational safety and health regulations, employers are obligated to provide resources to prevent occupational risks (United States Department of Labor, n.d.); therefore, resources should be used in the prevention of voice disorders in teachers. Surprisingly, not one institution offering teacher training programs in Pennsylvania provides a course or seminar related to vocal health and adjusting to the vocal demands of teaching. As speech-language pathologists (SLPs), we need to convince teacher training programs to offer a course or self-guided learning module related to vocal education, hygiene, and training. This is a serious shift in the education of future teachers with the goal of reducing the number of teachers affected by voice disorders. The current work seeks to fill this need by developing and testing a telepractice voice disorders prevention model for undergraduate student teachers at West Chester University (WCU).

Treatment studies in the voice telepractice literature have focused on patients with Parkinson's disease (PD) using the Lee Silverman Voice Treatment (LSVT) through videophone, Skype, and other multimedia videoconferencing. Results demonstrated improvements in voice and speech related outcome measures from pre- to post-treatment (Howell, Tripoliti, & Pring, 2009; Tindall, Huebner, Stemple, & Kleinert, 2008). One randomized controlled trial (RCT) demonstrated no difference in treatment outcomes across in-person and videoconferencing (Constantinescu et al., 2011). Other researchers have developed software to enable people with PD to practice LSVT techniques at home, independently. In a treatment study by Halpern et al. (2005), 16 people with PD received 50% of their sessions at home using the software and the remaining sessions were carried out in person. Positive outcomes similar to previously published data for in-person LSVT were obtained. An evolution of the software used at home has been the development of a

prototype LSVT virtual therapist (LSVTVT), an animated agent that interacts with a client in the delivery of the program (Trail et al., 2005).

Three additional treatment studies for voice disorders are found in the literature that are not tied to patients with PD (Fu, Theodoros, & Ward, 2015; Mashima et al., 2003; Rangarathnam et al., 2015). Fu et al. (2015) delivered intensive voice therapy (i.e., eight sessions over three weeks) via videoconferencing to 10 women with vocal nodules and found significant improvements in acoustic, perceptual, quality-of-life measures, and nodule size at post-treatment, mirroring the outcomes in a separate in-person study. In Mashima et al. (2003), 23 adult participants with voice disorders were treated online using a videoconferencing system integrated with speech analysis software. An additional 28 adult participants with voice disorders were treated in a traditional, in-person method. Pre- and post-treatment data collection were conducted in person. Positive treatment effects were achieved in the videoconferencing group with outcomes being similar to those obtained for the participants treated in-person. Rangarathnam et al. (2015) compared telepractice (i.e., synchronous videoconferencing) and in-person voice therapy for patients with muscle tension dysphonia and found that perceptual and quality-of-life measures were significantly better at post-treatment for both groups. Acoustic and aerodynamic measures showed improvement from pre to post in both groups, but the differences did not reach statistical significance.

From the telepractice voice literature, however, several gaps are identified. First, no studies have investigated a telepractice model for the prevention and treatment of voice disorders in teachers. Second, no studies in voice have investigated a telepractice model with both synchronous and asynchronous learning opportunities delivered totally online. Third, the techniques to assess the effectiveness of a telepractice model in voice have primarily been through in-person data collection sessions. The techniques for collecting the measures should be consistent with the telepractice method and offer data collection at a distance to represent the effects of vocal loading from teaching.

To advance the prevention of voice disorders in teachers, we need to offer a telepractice model that is delivered totally online with synchronous and asynchronous learning opportunities, as a cost effective and functional alternative to traditional in-person methods. The type of technology that will allow for the online telepractice model is available at institutions of higher education through academic internet-based computing software. The author's institution, WCU, supports such a model through software called Desire 2 Learn (D2L). All students enrolled at WCU must have internet to access all course material through D2L. Student teachers, at WCU, are an ideal population for study because of access to the telepractice model through D2L and inappropriate vocal behaviors for teaching have not yet been habituated; therefore, a true prevention paradigm can be tested. If the outcomes of the current work are successful, then there will be evidence to support adding a telepractice voice disorders prevention model to the curriculum of teacher training programs.

A major barrier to testing clinical models in voice is the lack of accessible, user-friendly data collection methods that can be captured throughout a day of talking. Currently, the in-person method involves traveling to the SLP's office to participate in data collection at only pre-

and post-treatment; therefore, valuable information about voice is lost. We encountered such a problem when investigating voice changes of physical education student teachers during a semester of student teaching (Grillo & Fugowski, 2011). Because we only collected data at pre, mid, and post, we lost valuable information about voice loss reported by the participants in the first 2–3 weeks of student teaching. We need an accessible data collection method that can be used anywhere and anytime allowing for more opportunities to record voice throughout a day of talking. These methods also must match the online telepractice model allowing clients to record voice measures at a distance. The measures also must represent a comprehensive voice assessment including objective and subjective client-centered measures (Roy et al., 2013). In addition, the measures recorded from the method must be uploaded to a central location (i.e., cloud-based technologies) for access by the clinician and researcher. The current work seeks to fill this need by creating the VoiceEvalU8 app, server, and web portal that records objective and subjective client-centered measures, analyzes the measures, and links the measures to the web portal (VoiceEvalU8, 2017). This online model of data collection is relevant for telepractice and in this case, *teleresearch*, to offer more opportunities to record the voice and to better represent the effects of vocal loading on the voice. The focus of the current work is to test an online telepractice model for the prevention of voice disorders in vocally healthy student teachers through voice-related measures captured on a smartphone app. The following sections will describe the prevention model used with student teachers at WCU and the VoiceEvalU8 app. The study is ongoing, therefore, preliminary acoustic results will be presented.

Methods

Participants

Recruitment of the student teachers at WCU began during spring 2016. The author and student research assistants attended classes in which the student teachers were enrolled to announce the study and collect contact information (i.e., email, cell phone number) of any interested participants. Recruitment procedures continued in the summer and early fall of 2016. Additional procedures included posting flyers through campus, sending a mass email to all student teachers at WCU, and attending four student teacher meetings in early fall. Following recruitment, 26 participants completed informed consent and screening procedures. To be included in the study, the participants met the following criteria: senior status as of fall 2016 with student teaching occurring spring 2017, owner of a smartphone (iOS or droid), and vocally healthy as determined by no current voice complaints reported by the participant and no abnormal voice patterns perceptually judged by the author. Five participants dropped out of the study in the first week due to schedule conflicts and lack of interest; therefore, 21 vocally healthy student teachers (i.e., 18 women and 3 men) completed all study procedures during fall 2016.

Following informed consent and screening, the student teachers were selected for one of three conditions, in-person Global Voice Prevention Model (GVPM), telepractice GVPM, and control (i.e., additional methods component of the GVPM, vocal education and vocal hygiene only delivered asynchronously). The selection was based on each participant's availability. Eight completed the in-person GVPM, six completed the telepractice GVPM,

and seven completed the control. There was one man in each of the three conditions, totaling three across all conditions. Table 1 indicates the specific area of study for each of the participants.

After selection into one of the three conditions, the participants received training on use of the VoiceEvalU8 app. The training included downloading the app to the participant's smartphone, giving the participant the 4cm plastic stick to measure microphone to mouth distance for all acoustic measures, adding the participant to the VoiceEvalU8 web portal, and running through an app session to review all of the voice measures and procedures for recording. A packet of information also was given to the participant to provide written instructions with app screen shots for each of the voice measures. For the acoustic measures, participants were reminded, in the app, to use the 4cm stick to measure microphone-to-mouth distance and to be in a quiet room. All participants completed pre- and post-condition voice measures with the VoiceEvalU8 app across 5 days, twice a day at a.m. and p.m. sessions. The a.m. sessions ran from 6–11 a.m. and the p.m. sessions ran from 4–11 p.m. The app sent text and email alerts every 30 minutes for the a.m. sessions and every 60 minutes for the p.m. sessions, until the participant completed the session. Each app session took 5–8 minutes to complete.

Global Voice Prevention Model (GVPM)—For the in-person and telepractice conditions, the long-term goal was to achieve a “new” voice for one-on-one conversational speech tasks, a falsetto voice for quiet talking, oral twang for healthy projected loud voice, and belt for healthy yelling. All of the voices trained in the study were achieved through the treatment hierarchy from words to conversation. The control condition facilitated only the additional methods component of the GVPM for 1 week, covering vocal education and vocal hygiene. The GVPM contains the same four components of the Global Voice Therapy Model (Grillo, 2012, see Table 2).

In stimulability testing, the clinician, in consultation with the patient, needs to determine the voice production technique that achieves the most improved vocal output. Contrary to current therapy models in the literature (Gartner-Schmidt et al., 2016; Ramig, Bonitati, Lemke, & Horii, 1994; Smith & Thyme, 1976; Stemple, Glaze, & Klaben, 2000; Verdolini-Abbott, 2008), the GVPM does not support one technique. The GVPM encourages the SLP to determine the technique that facilitates the most improved vocal output, thereby, providing a greater likelihood of a successful treatment outcome. In the current study, Estill's 13 Figures were used for stimulability to facilitate the “new” voice for one-on-one conversation (Klimek, Obert, & Steinhauer, 2005a) across all participants. Estill's Figures were used because they represent anatomical and physiological components of the voice production system that are actually occurring when producing various voice productions (e.g., retracted false vocal folds in Figure 2, tilted thyroid cartilage in Figure 4, narrow aryepiglottic sphincter in Figure 9). Each of the 13 Figures has a specific number of physical manipulations with an accompanying hand or body gesture. For example, Figure 1: true vocal folds onset/offset has three manipulations, glottal, aspirate, or smooth. As the Figures are combined in training, the result is a “new” voice unique to that individual. We trained internal components of the voice through blocked and random practice schedules with varying amounts of feedback and an external focus of attention that involved the

accompanying hand gesture and the target sound of the voice (Freedman, Maas, Caligiuri, Wulf, & Robin, 2007; Lai & Shea, 1998; Lai, Shea, Wulf, & Wright, 2000; Wong, Whitehill, Ma, & Masters, 2013). The goal of the current work was to keep the techniques consistent across all participants, thus Estill's Figures were used. Future work will compare various stimulability techniques in the GVPM (e.g., resonant voice versus stretch-and-flow versus Estill's Figures).

Estill's Qualities of falsetto, oral twang, and belt, which are combinations of the 13 Figures, were used in the study to facilitate various voices that teachers need for the classroom, gym, cafeteria, playground, or other space (Klimek, Obert, & Steinhauer, 2005b). Falsetto was facilitated by aspirate true vocal fold onset, stiff or thin true vocal fold body cover, mid false vocal folds, mid larynx, and vertical thyroid cartilage. Oral twang was facilitated by smooth true vocal fold onset, retracted false vocal folds, thin or thick true vocal fold body cover, titled thyroid cartilage, narrow aryepiglottic sphincter, mid or high larynx, and head/neck anchor, if needed. Belt was facilitated by glottal or smooth true vocal fold onset, retracted false vocal folds, thick true vocal fold body cover, tilted cricoid cartilage, narrow aryepiglottic sphincter, head/neck anchor, and torso anchor. The literature demonstrates evidence that Estill's Figures and Qualities were successful in improving acoustic, aerodynamic, and perceptual measures for patients with voice disorders (Lombard & Steinhauer, 2007; Tellis, 2014).

During the treatment hierarchy, the client acquires a new skill in a basic motor pattern first before increasing to a more complex pattern (Schmidt, 1975, 1976, 2003; Schmidt & Lee, 1999). The steps in the hierarchy of short memorized speech acts (i.e., pledge of allegiance) and specific spontaneous speech acts (i.e., tell me how to make a peanut butter and jelly sandwich) are unique to the literature and are crucial to generalize and maintain the "new" voice beyond the sentence level. At each step of the hierarchy, the client participates in blocked practice first to master the new voice with frequency of feedback occurring less often (Lai et al., 2000; Wulf, 1991, 1992; Wulf & Schmidt, 1996). For example, the client will produce the "new" voice in the phrase "thank you" across 10 trials without interruption from the clinician. Feedback about performance is provided after the 10th trial. Every effort is made to have the client self-evaluate the performance before the clinician offers his or her evaluation.

Production of "new" voice (i.e., improved vocal output achieved in training) versus "old" voice (i.e., poor vocal output before training) immediately follows the achievement of 90% accuracy of "new" voice at a certain level of the hierarchy. For example, the client first achieves the "new" voice at 90% accuracy across sentences, and then the clinician moves onto the "new" versus "old" voice component by asking the client to switch between the two voices at the sentence level. In addition, the clinician may ask the client to switch between the voices and the clinician has to guess the correct voice. This pattern will continue at each step of the hierarchy until conversational speech is achieved. The "new" and "old" voice is a unique random practice schedule that facilitates transfer of newly learned behaviors. Recent evidence in speech suggests that learning improves when both practice schedules are used with suggestions to use blocked practice, first to enhance acquisition and random practice, second to promote generalization and maintenance (Wong et al., 2013). In addition,

frequency of feedback occurs more often in random practice, after the second or third production (Lai & Shea, 1998; Lai et al., 2000).

Additional methods that augment and support the target voice are considered secondary to the work spent in vocal training. Such methods may include vocal hygiene, vocal education for the anatomy and physiology of the “new” and “old” voice, vocal loading tasks for teaching (e.g., quietly talking to a student in a room with noise, yelling through the cafeteria to get someone’s attention, yelling in a gym over background noise, using the voice in a classroom to get the attention of all students or just one), respiratory work, posture work, and stress reduction.

Procedures

The in-person and telepractice GVPM ran for 4 weeks (Table 3). All goals, methods, measures of performance, and homework assignments were the same across the two conditions. The delivery of instruction varied from in-person to telepractice. The in-person sessions met as a group once a week on Mondays from 1–2 p.m. with 5 participants and on Mondays from 7:30–8:30 p.m. with 3 participants. Each participant was paired with a graduate student clinician. The author rotated around the room and provided supervisory support. There were five graduate student clinicians. All of the students were in their second year of graduate study and had participated in a 5-day conference held at WCU in May 2016 covering Level 1: Estill’s Figures and Level 2: Estill’s Qualities led by Drs. Kimberly Steinhauer and Cari Tellis, both certified course instructors for Estill Voice International. The author also attended the same conference. During the summer of 2016 and into the fall of 2016, the student clinicians also had the experience of working with patients with voice disorders in WCU’s Speech and Hearing Clinic and using Estill’s Figures and Qualities in the Global Voice Therapy Model.

For the telepractice condition, each participant was paired with a graduate student clinician and vocal training occurred synchronously online through D2L. The online rooms in D2L were used, which are supported through Blackboard Collaborate. The clinician was able to share the computer screen with the participant and provide the phrases and sentences of the treatment hierarchy (TH) on the screen. The author was able to enter the room to supervise and provide support when needed. The software recognized who was talking and turned on the camera for that person. Everyone in the room could hear and see the speaker. In addition, there was a chat function that was always present. The author and the clinicians utilized the chat to post comments without interrupting the flow of dialogue. The telepractice groups ran once a week on Tuesday and Wednesday nights from 7:30–8:30 p.m. There were 2 participants on Tuesdays and 4 participants on Wednesdays.

In Week 1, additional methods (AM) of vocal education (VE) and vocal hygiene (VH) were targeted in four goals. Goals 1 and 2 were linked to VE by studying the anatomy and physiology of the voice production system and understanding Estill’s Figures and Qualities. Goals 3 and 4 were related to VH by understanding VH strategies and applying them to the daily teaching environment. For the in-person condition, the author led the discussion on VE and VH by presenting three different power point lectures. Three 10-question quizzes were given to the participants after each lecture. In addition, the participants created a paper

larynx and a discussion was facilitated about how to apply VH strategies in the classroom. The entire time spent on VE and VH was 90 minutes for Week 1 during a one-time meeting. For the telepractice and control conditions, the participants completed the work asynchronously online through D2L. They watched video lectures, completed online quizzes, submitted a picture of their paper larynx, and completed an online discussion board for application of VH strategies in the classroom. They were given 1 week to complete all assignments. All could have been completed in one setting requiring 90 minutes of work. With the completion of VE and VH, the commitment for the participants in the control condition ended. Vocal training was not facilitated for the participants in the control condition.

In Week 2, vocal training began with stimulability (STM). The clinician, directly working with the participant, perceptually determined how the participant was producing his or her “old” voice for speaking across all 13 Estill Figures in Goal 5. Based on the findings with input from the participant, a “new” voice was shaped for one-on-one conversational speaking tasks. The author, acting as the supervisor for all clinicians, perceptually confirmed the “old” and “new” voices for each participant. Across all participants, the common Estill Figures used were Figure 1: true vocal fold onset/offset, Figure 2: false vocal folds, Figure 3: true vocal fold body-cover, Figure 4: thyroid tilt, and Figure 12: head and neck anchor. The “new” voice was shaped through the treatment hierarchy (TH) and “new” versus “old” voice (NO) in Goals 6 and 7 (see Video 1 for training constricted versus mid versus retracted false vocal folds in Estill’s Figure 2). Conversational speech was achieved by the end of the session, which lasted 60 minutes.

There were two homework assignments that were due to the D2L dropbox by the end of Week 2. Assignment 1 involved creating a video or audio of using the “new” voice in five sentences, one memorized speech act (pledge of allegiance), and one specific spontaneous speech act (describe the inside of your apartment or house). Assignment 2 involved creating a video or audio of using the “new” and “old” voice in five sentences, one memorized speech act (pledge of allegiance), and one specific spontaneous speech act (describe the inside of your apartment or house; see Video 2 switching between “new” and “old” voice). The student clinicians listened to the assignments and provided feedback to the participants via email.

In Week 3, student clinicians assessed maintenance of the “new” voice in conversational speech tasks at the beginning of the session in Goal 8. Work may have been necessary to fine-tune the “new” voice. TH and NO were used to ensure mastery of conversational speech at 90% accuracy. In Week 3, student clinicians also facilitated the Estill Qualities of falsetto, oral twang (see Video 3 of telepractice), and belt. The audio quality of Video 3 is distorted due to recording the telepractice training session from D2L through Camtasia software, thereby recording the session two times. The real time audio quality was not distorted. Each Estill Quality was facilitated in the TH and with NO in Goals 9 and 10. The “old” voice in this case was an unhealthy quiet whisper for falsetto, and an unhealthy loud projected voice for oral twang and belt. The unhealthy voices included false vocal fold constriction for all, slack or thick body-cover for falsetto, wide aryepiglottic sphincter for twang and belt, and relaxed head/neck and torso anchor for belt. Belt was facilitated with the entire group led by

the author because it was difficult to facilitate belt in one room with five different groups belting at the same time (see Video 4). The vocal training for Week 3 lasted 60 minutes and the same pairing between the student clinicians and participants continued.

There were two assignments for Week 3 that were due at the end of the week with student clinicians providing feedback via email. Assignment 1 involved creating a video or audio using (1) the “new” voice in normal everyday speaking tasks for 30 seconds describing what the participants did over the summer, (2) falsetto describing the steps for getting ready in the morning (see Audio 1), (3) oral twang describing the outside of the participant’s house or apartment, and (4) belt describing the roads the participant takes to drive from WCU’s campus to their parents’ house. Assignment 2 involved creating a video or audio using “new” and “old” voice in normal everyday speaking tasks for 30 seconds describing what the participant did over the summer (start out in new voice- switch to old voice- switch back to new; see Audio 2).

In Week 4, maintenance of the “new” voices for one-on-one conversation, quiet talking (falsetto), loud talking (oral twang), and healthy yelling (belt) was assessed first in Goal 11. The student clinicians asked the participants to produce the various voices across conversational topics. If the participants did not maintain the “new” voices at 90% accuracy, then the TH and NO was used to fine-tune the voices. In Goals 12 and 13, vocal loading tasks linked to teaching were then facilitated. In Goal 12, the participants produced the “new” voice for one-on-one conversation, falsetto, oral twang, and belt across a prepared lesson plan. The student clinicians prompted the participants to switch between the voices. In Goal 13, the participants used the same lesson plan and switched between “new” and “old” voice for one-on-one conversation, falsetto and unhealthy whisper, oral twang and unhealthy loud talking, and belt and unhealthy yelling. Throughout the lesson plan, the student clinicians and participants role-played simulated student responses that are typically heard in the classroom. The plan was to simulate the classroom environment as much as possible.

There were two assignments for Week 4 that the participants uploaded to D2L by Friday of that week. The student clinicians provided feedback to the participants via email. In Assignment 1, participants created a video or audio using oral twang in the prepared lesson plan for 1 minute. In Assignment 2, participants created a video or audio using oral twang and an unhealthy loud voice in the prepared lesson plan for 1 minute (see Video 5). Participants needed to start out in oral twang, switch to an unhealthy voice, and then switch back to oral twang. The audio quality in Video 5 is slightly distorted due to the loud voice productions.

For the in-person and telepractice conditions, the GVPM ended by the second week of November 2016. The control group ended the last week of October 2016. A follow-up meeting for the in-person and telepractice conditions was scheduled for the first week of December to assess maintenance of the voices. Following a conversational speech task in which the participants were required to switch between the voices, the clinician and supervisor perceptually determined that all of the participants had maintained the voices. In addition, the participants reported positive maintenance of the voices and strategies that were

being used to practice. At the conclusion of the fall 2016 semester, all of the participants were compensated for their time by an Amazon gift card. The participants in the in-person and telepractice conditions received \$50 for completion of the app at pre and post and an additional \$130 for work in the GVPM. The participants in the control condition received \$50 for completion of the app at pre and post and an additional \$45 for completion of VE and VH. Participants were made aware that if they missed an assignment, a vocal training session, or an app session via VoiceEvalU8, then \$5 was deducted for each missed opportunity. None of the participants across all conditions missed an assignment or a vocal training session. We had a 100% compliance rate. Six participants missed one or two app sessions at either pre or post and three participants missed three or four app sessions at either pre or post. None of the participants missed more than four app sessions. Twelve participants completed all app sessions. During spring 2017, the participants were student teaching 5 days a week in an elementary, middle, or high school. The participants used VoiceEvalU8 to record voice measures before and after teaching all day. At the conclusion of the spring semester, they were compensated with an Amazon gift card for completion of the app measures.

VoiceEvalU8

Central to the success of the current work were preliminary findings that demonstrated no within-subject variability of acoustic voice measures recorded simultaneously from different devices (i.e., smartphones and head mounted microphone; Grillo, Brosious, Sorrell, & Anand, 2016). Based on those results, it is possible to capture reliable acoustic voice information using smartphones.

The VoiceEvalU8 smartphone and tablet app captures acoustic, perceptual, and aerodynamic measures, representing a comprehensive voice assessment (Roy et al., 2013). For the study, the primary outcome measures are perceptual to determine the presence and frequency of a voice problem during student teaching (Behlau, Zambon, Guerrieri, & Roy, 2012; Roy et al., 2004; Thibeault et al., 2004). The secondary outcome measures are acoustic (see Table 4), perceptual (e.g., voice handicap index 10 and 30, vocal fatigue index, novel perceptual scales developed by the author that require the participants to assign daily auditory-kinesthetic-perceptual ratings of their voice), and aerodynamic (i.e., maximum phonation time and s/z ratio). Recording of the acoustic data, captured twice daily (i.e., in the morning from 6–11 a.m. and in the evening from 4–11 p.m.), was modeled after the tasks in the Consensus Auditory Perceptual Evaluation of Voice (CAPE-V, Kempster, Gerratt, Verdolini Abbott, Barkmeier-Kraemer, & Hillman, 2009). Participants completed three repetitions of sustained /a/ for 5 seconds each, the sentence “we were away a year ago,” and a 15-second connected speech sample. In all utterances, the participants were instructed to use his or her normal, everyday speaking voice. The files for each utterance were recorded at a sampling rate of 44,100 Hz and saved as .wav files. The acoustic analysis was completed by the VoiceEvalU8 server using algorithms available to the public on Praat’s website, a freeware software program on the internet (Boersma & Weenink, 2016).

Preliminary Findings

The study is ongoing; therefore, preliminary acoustic results from pre- to post-GVPM during the fall 2016 semester are presented. Descriptive statistics were used to provide a preliminary analysis of F_0 and jitter% for the 18 women (see Table 5). These measures were chosen for a preliminary snapshot because of their direct relationship to vocal fold vibration.

To highlight F_0 , the sentence, “we were away a year ago,” was chosen for analysis because it contains all voiced phonemes enabling periodic vocal fold vibration, while simultaneously facilitating a connected speech task (see Figure 1). At pre-GVPM, all conditions demonstrated lower F_0 s at a.m. and higher F_0 s at p.m. At post-GVPM, the in-person and telepractice conditions demonstrated higher F_0 s at a.m. as compared to the a.m. F_0 s at pre-GVPM. The higher F_0 s post-a.m. in both the in-person and telepractice conditions were maintained post-p.m. The pattern of F_0 s in the control condition remained constant from pre- to post-GVPM across a.m. and p.m. The increase in F_0 for the in-person and telepractice conditions from pre to post may be explained by the “new” voice that was achieved during vocal training. Most of the participants had an attractor state of glottal fry or slack in Estill’s Figure 3: true vocal fold body cover during connected speech. Slack vocal fold vibration produces a low F_0 . As the “new” voice was trained, slack was eliminated by changing to thin or thick true vocal fold body cover, retracting the false vocal folds, tilting the thyroid, and anchoring head and neck, if needed, producing a vocal fold vibration with a higher F_0 . That change may have been captured in the sentence because all the phonemes are voiced to detect a periodic vocal fold vibration in a connected speech task. The sustained /a/ is not a functional task, which typically facilitates a higher F_0 as compared to connected speech. In the preliminary data (see Table 5), the F_0 s are higher in sustained /a/ than in the sentence. The all-voiced sentence may provide a better representation of vocal fold vibration during typical speech than the nonfunctional task of sustained /a/.

Jitter% is the cycle-to-cycle variation in the F_0 (i.e., the average absolute difference between consecutive periods). Jitter% is measured on a percent scale, with a good score being lower, meaning that the F_0 changes very little between cycles.

At pre-GVPM, all conditions demonstrated a similar pattern with increased jitter% at a.m. as compared to p.m. The same pattern was maintained at post-GVPM with the control condition demonstrating the largest difference between a.m. and p.m. jitter% (Figure 2). At post-GVPM, both the in-person and telepractice conditions showed a jitter% that was almost the same at a.m. and p.m. The similar jitter% scores at post for both in-person and telepractice conditions was not seen in the control condition; therefore, the vocal training may have facilitated less of a change in F_0 between cycles as demonstrated by an almost constant jitter% score at post.

Another interesting finding is that jitter% was increased for a.m. sessions as compared to p.m. sessions for all conditions. A similar result was seen for F_0 in the sentence. F_0 s were lower in the a.m. and higher in the p.m. for the in-person, telepractice, and control conditions across pre and post. Perhaps the data show evidence for the “morning” voice phenomenon. The “morning” voice can be described as the rough, hoarse, lower in pitch,

and not quite warmed-up voice that people experience when first phonating after waking from sleep. That voice may tend to have more variability between consecutive periods. As the vocal folds warm-up throughout the day by talking and/or singing, the variability between cycles may decrease by the afternoon/evening (i.e., p.m. session). This pattern was seen in all conditions; however, at post-GVPM, the in-person and telepractice conditions had lower percent scores and less change in F_0 than the control condition perhaps due to vocal training facilitating a more consistent vocal fold vibration.

Summary

Considering advances in technology and the need to provide services at a distance, online telepractice models that involve both synchronous and asynchronous learning opportunities need to be developed and tested. Methods to assess the effectiveness of such models must adapt to meet the needs of the client at a distance. The focus of the current work addresses these needs by testing the effectiveness of the GVPM delivered by two methods, (1) in-person and (2) online telepractice, and comparing the two methods to a control condition (i.e., VE and VH of the GVPM only delivered asynchronously). Effectiveness is being assessed by standard voice-related measures captured on the VoiceEvalU8 smartphone app during student teaching.

The VoiceEvalU8 app, server, and web portal allow for measurement and analysis of acoustic, perceptual, and aerodynamic measures. The primary outcome measures are perceptual and based on presence and frequency of a voice problem during student teaching. The secondary outcome measures are acoustic, perceptual, and aerodynamic. Currently in the literature and in clinical practice, the relevant secondary outcome measures that document voice change on a daily basis are not known. Typically, only pre- and post-intervention measures have been investigated. Principal components analysis or other dimension reduction methods will be used to determine which secondary outcome measures are most relevant. Those most relevant measures will be used to support the primary outcome measures and to generate hypotheses that may inform future clinical studies. The measures of F_0 during the sentence, “we were away a year ago,” and jitter% during sustained /a/ may be promising measures considering that the participants are all vocally healthy with periodic vocal fold vibration; therefore, F_0 and jitter% may be successful in detecting a change in voice. As the VoiceEvalU8 app, server, and web portal are used with patients with voice disorders, alternative acoustic measures that are not time-based, for example, CPP and CPPS, may hold more promise to document a change in voice. Future work using the VoiceEvalU8 app with patients with voice disorders will explore that question.

In the preliminary analysis, F_0 and jitter% did demonstrate changes in voice from pre- to post-GVPM in the in-person and telepractice conditions. The significance of those changes will be determined when all participants complete the study. The study will run for 2 years. Currently, Year 1 is underway. Participants have finished work in the in-person, telepractice, and control conditions and completed student teaching spring 2017. A new group of participants will be enrolled during fall 2017 for selection into one of the GVPM conditions.

Those same participants will be followed during student teaching in spring 2018 using the VoiceEvalU8 app.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Mean Fundamental Frequency (Hz) in the Sentence “We Were Away Ago” Across Time (Pre-GVPM and Post-GVPM) and Session (a.m. and p.m.) for the Three Conditions (In-Person, Telepractice, and Control).

Figure 2. Mean Jitter% in Sustained /a/ Across Time (Pre-GVPM and Post-GVPM) and Session (a.m. and p.m.) for the Three Conditions (In-Person, Telepractice, and Control).

Table 1

Area of Study (EG=Early Grades, Prekindergarten–4th; MG=middle grades, 5th–7th; SG=Secondary Grades, 9th–12th; ME=Music Education, Kindergarten–12th; and SE=Special Education, Kindergarten–12th) by Condition (In-Person, Telepractice, and Control).

In-Person Condition	Telepractice Condition	Control Condition
<ul style="list-style-type: none"> ■ 1 EG ■ 3 double major in EG and SE ■ 2 MG math or science ■ 1 ME ■ 1 SE math 	<ul style="list-style-type: none"> ■ 2 EG ■ 2 double major in EG and SE ■ 2 ME 	<ul style="list-style-type: none"> ■ 2 EG ■ 2 double major in EG and SE ■ 2 ME ■ 1 double major in ME and SE
Total of 8	Total of 6	Total of 7

Table 2

Four Components of the Global Voice Prevention Model (GVPM).

Stimulability Testing	Bottom-up Treatment Hierarchy	“New” and “Old” Voice	Additional Methods
To determine the voice production technique that facilitates the most improved vocal output. → e.g., resonant voice, yawn-sigh, loud voice, Estill’s Figures and Qualities, etc.	Incrementally increasing utterance length and cognitive complexity until conversational speech is achieved. → words, 2–3 word functional phrases, sentences, memorized speech acts, specific spontaneous speech acts, monologue, and conversation.	Production of “new” voice (i.e., improved vocal output) and “old” voice (i. e., poor vocal output) at all levels of the treatment hierarchy.	Additional methods that support the improved vocal output. → vocal hygiene and education, laryngeal massage, abdominal breathing exercises, healthy yelling strategies, body posture, etc.

Table 3

Overall Plan for the In-Person and Telepractice Global Voice Prevention Model (GVPM).

Weeks →	One	Two	Three	Four
Components of GVPM	Additional methods that augment and support the target vocal output (AM): Vocal Education (VE) + Vocal Hygiene (VH)	Stimulability (STM) + Treatment hierarchy (TH) + New versus old voice (NO)	TH + NO	AM: Vocal loading practice in experiences linked to teaching

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Table 4

Acoustic Measures, Definition, and Task Are Presented.

	Definition	Task
F_0	Lowest frequency of periodic vocal fold vibration.	Three sustained /a/s for 5 seconds each. “we were away a year ago” 15-sec connected speech sample
SD of F_0	Variability of the F_0 .	Three sustained /a/s for 5 seconds each. “we were away a year ago” 15-sec connected speech sample
Jitter%	Average absolute difference between consecutive periods divided by the average period.	Three sustained /a/s for 5 seconds each.
Shimmer%	Average absolute difference between the amplitudes of consecutive periods divided by the average amplitude.	Three sustained /a/s for 5 seconds each.
NHR	The amplitude of noise relative to tonal components.	Three sustained /a/s for 5 seconds each.
CPP	A measure of the amplitude of the cepstral peak corresponding to the fundamental period, normalized for overall signal amplitude.	Three sustained /a/s for 5 seconds each. “we were away a year ago” 15-sec connected speech sample
CPPS	Distance between the first harmonic peak and the point with equal frequency on the regression line through the smoothed cepstrum.	Three sustained /a/s for 5 seconds each. “we were away a year ago” 15-sec connected speech sample
AVQI	Weighted combination of six time-, frequency-, and que frequency-domain metrics.	Second trial of sustained /a/ for 5 seconds combined with “we were away a year ago.”

Table 5

Means and Standard Deviations, in Parentheses, of F₀ and Jitter% for Women Across Utterance (i.e., Average /a/ Across Three Trials, “We Were Away a Year Ago,” and 15-sec Connected Speech Sample), Session (a.m. and p.m.), Time (Pre-GVPM and Post-GVPM), and Condition (In-Person, Telepractice, and Control).

Condition	Acoustic Measure	Pre A.M.	Pre P.M.	Post A.M.	Post P.M.
In-Person	F ₀ (Hz) /a/	212 (44.19)	237 (26.22)	223 (31.59)	245 (28.44)
	F ₀ (Hz) sentence	193 (23.97)	212 (20.36)	208 (20.43)	220 (17.53)
	F ₀ (Hz) speech	187 (23.89)	208 (21.11)	202 (19.32)	212 (31.05)
	Jitter: local(%) /a/	0.571 (0.31)	0.380 (0.11)	0.629 (0.71)	0.612 (1.24)
Telepractice	F ₀ (Hz) /a/	193 (44.2)	214 (34.85)	221 (30.55)	222 (28.59)
	F ₀ (Hz) sentence	186 (23.35)	202 (21.6)	208 (21.75)	210 (24.49)
	F ₀ (Hz) speech	173 (23.6)	190 (20.43)	207 (20.61)	201 (24.84)
	Jitter: local(%) /a/	0.908 (1.25)	0.484 (0.20)	0.476 (0.20)	0.425 (0.20)
Control	F ₀ (Hz) /a/	179 (51.91)	197 (50.99)	200 (49.12)	209 (43.47)
	F ₀ (Hz) sentence	170 (43.11)	192 (30.52)	172 (38.24)	192 (29.88)
	F ₀ (Hz) speech	177 (36.78)	200 (31.23)	184 (41.54)	192 (33.4)
	Jitter: local(%) /a/	0.811 (1.04)	0.417 (0.18)	0.652 (0.36)	0.428 (0.17)