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International Journal of Research in Choral Singing
(2022) Focus on Vocal Health 272-294**Undergraduate Singers' Voice Use During an Intensive Week of Choir and Musical Rehearsals: A Case Study****Matthew Schloneger¹****Abstract**

The purpose of this case study was to document undergraduate students' ($N = 2$) voice use before, during, and after an intensive week of choral and musical theatre rehearsals through (a) acquired voice dosimeter data; (b) daily surveys, (c) participant activity logs, (d) 3 administrations of the Singing Voice Handicap Index (SVHI), and (e) administrations of the Keirsey Temperament Sorter. Two female students (pseudonyms Kathy and Melissa) wore dosimeters during waking hours for 9 days, including two baseline days prior to an intensive rehearsal week, a five day week in which they participated in a total of 39+ hours of choral and musical rehearsals, and two baseline days one week after the intensive period. Mean phonation time dose percentages (Dt) for both participants during the intensive week (Kathy 18.53%; Melissa 13.76%) exceeded mean Dts during pre and postbaseline days (6.94%; 10.86%). Likewise, mean daily distance doses (Dd) during the intensive week (Melissa 7,216m; Kathy 10,608m) exceeded mean daily Dds during the baseline periods (2,469m; 5,236m). Phonation doses were disaggregated by choir rehearsals, musical rehearsals, and non-rehearsal time. Daily surveys of vocal health evidenced declines in at least six of nine areas between Monday and Friday of the intensive week for both participants. However, SVHI results showed that Kathy, a self-described introvert, experienced an increase in perceived voice handicap between the pre-baseline period and the intensive week while Melissa, a self-described extrovert, perceived less voice handicap. Results and suggestions for further study are discussed in terms of voice use expectations for these participants and possible relationships among voice use, perceptions of fatigue, and personality traits.

Keywords: voice use, vocal dose, voice dosimeter, vocal demand

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Development of an understanding about how much is too much for young singers is unclear in part because of the complex relationship among vocal demand, vocal demand response, vocal effort, and vocal fatigue (Hunter et al., 2020). Research has suggested that different individuals may tolerate higher vocal demands than others before experiencing fatigue and functional decline. These differences may be attributable to a complex variety of factors, from habilitation to vocal hygiene to personality factors.

Following the lead of exercise science, the voice science community has begun to examine the relationship among voice habilitation, fatigue resistance, and metabolic mechanisms as they relate to vocal fatigue, noting differences between individuals based on factors such as aerobic conditioning (Nanjundeswaran et al., 2017; Smith et al., 2017). Sandage and Hoch's (2019) comparison of vocal dose measurements and perceived effort during a training regimen for a recital performance found that with training considerations, perceived vocal fatigue decreased over the same vocal dose following training. In terms of vocal function, Whitling et al. (2017) found that women with functional dysphonia (a voice problem without an obvious physical cause) took longer to recover from a 30-minute vocal loading task than those without.

A group of studies has examined the relationship between personality traits or psychological factors and vocal health. In a large survey analyzing risk factors for voice problems in teachers ($N = 1878$), Kooijman et al. (2006) found that voice load and environment were less important risk factors for voice problems than were physical and psycho-emotional factors. Roy and Bless (2000) theorized that introverts who tested high for negative emotionality were more at risk for functional dysphonia, and extroverts who tested high for negative emotionality were more at risk for vocal fold nodules. Roy et al. (2000a) found patients with functional dysphonia were "introverted, stress reactive, alienated, and unhappy" (p. 521) compared to control groups, and patients with vocal fold nodules were more "socially dominant, stress reactive, aggressive, and impulsive" (p. 521). Further research also suggested that the above traits may put individuals more at risk for functional vocal problems (Roy et al., 2000b). Verduyck et al. (2019) found that children with vocal fold nodules were significantly more extroverted than controls. Dietrich and Verdolini Abbott (2012) found that introverts and extroverts both exhibited increased perceived vocal effort and decreased acoustic measures during an activity designed to create psychological stress (public speaking) but that increased intrinsic laryngeal muscle activity was significantly correlated with introversion and Voice Handicap Index scores.

Younger singers may be the most at risk of high vocal doses due to their still developing voices, yet they may also be less aware of the risk to their voices. Daugherty et al. (2009) examined self-reports of high school students at a summer choral camp in order to examine voice use. Participants ($N = 141$) were surveyed prior to and following an intensive week of singing (up to eight rehearsal hours per day) to see if students perceived any changes in their vocal production. In questions regarding 12 aspects of vocal health, students reported deterioration in six categories, including hoarseness, tiredness, dryness, throat pain when singing, straining to sing, and more effort needed to sing or talk. Students also reported a significant increase in "vocal difficulty" between the pre and posttests. However, there was

no significant change from the pre to posttest regarding the prompt, “I have taken good care of my voice this past week.”

Daugherty et al. (2011) asked two singer participants to wear voice dosimeters during the three days of an all-state choral music festival. The students had phonation percentages (percentage of recording time the vocal folds were vibrating) of 20.92% and 20.34% in rehearsal and 17.96% and 19.88% out of rehearsal, indicating that a great deal of voicing was happening outside of rehearsal despite the vocal intensity of the weekend. While the choral conductor used a rehearsal style that emphasized vocal pacing and rest, the participants both indicated perceived declines in vocal efficiency over the weekend. In fact, in surveys distributed to the entire all-state choir ($N = 256$), participants indicated a mean decline in several vocal-health factors over the weekend. However, a majority said they felt that they were taking good care of their voices.

Likewise, undergraduate voice students may have not received enough vocal health education necessary for good vocal hygiene. Flynn (2019) surveyed 352 singers within five years of college graduation and found that many schools did not provide adequate vocal health education. Only 45% percent of graduates reported vocal health taught in an organized setting such as a workshop or class lecture, 48% had vocal health taught only as it happened to come up in lessons or class, and 31% had the information presented multiple times. Seventy-three percent responded that they or someone they knew had a vocal injury while in school.

Researchers have implemented a considerable body of studies that have captured real-time data through voice dosimeters to reveal information about typical human voice use (Assad et al., 2017). Terminology regarding collected vocal dose data can be defined as follows:

Phonation time dose (D_t) refers to the cumulative duration of time (hr,min,s) or the percentage of time the vocal folds have actually touched in a given period.

Fundamental frequency (F_0) describes the rate at which the vocal folds vibrate, measured in Hz. It is perceived as pitch.

A vibratory cycle is one complete sequence of opening and closing the vocal folds.

Cycle dose (D_c) refers to the accumulated number of such repetitive cycles in a particular time period.

Distance dose (D_d) is an estimate of “how far” vocal folds travel in a period of time using a mathematical formula that incorporates dose time, frequency, and amplitude. This measure provides a more complete view of vocal demand.

A number of vocal-dose studies have examined the voice use of university singing students. These students may experience higher vocal doses and more voice disorders than other university students and the broader population (Gaskill et al., 2013). Austin and

Hunter (2010) used dosimeters to monitor the voice use of eight vocal performance majors during waking hours over the course of a typical five-day week. Vocal dose time (Dt) ranged from 9% to 26% and the distance dose ranged from .69 m/s to 1.37 m/s. Gaskill et al. (2013) monitored six student singers for four or five class days and reported average daily Dt of 12.91%. Manternach (2014) found that preservice music educators' Dt ranged from 6.87% to 13.52% during a typical week during a school year. Although voice emphasis students experienced raised Dt percentages during voice lessons (38.54%), choral rehearsals (30.33%), and vocal performances (24.82%), participants were afforded rest times during other school-related activities (e.g., nonperformance music classes and non-music classes). Manternach and Schloneger (2019) monitored eight female university students of various majors over seven days and recorded a mean Dt of 8.76%. Distance dose averaged 212.61 meters per hour and ranged from 89.55 for a psychology major to 338.65 for a voice performance major. Toles et al. (2020) monitored vocally healthy females ($N = 64$) currently enrolled in a vocal performance or similar program at a college or university over a seven-day week. Participants had a total Dt of 8.4%, spending 6.2% of the total monitoring time speaking and 2.1% singing.

Schloneger and Hunter (2017) followed 19 university students who each wore a dosimeter for all waking hours during three consecutive days. These singers had an average voicing percentage of 11.92%, with 38% voicing in choral rehearsals and 35% voicing in solo singing activities. Over the three days, they totaled an average of 4.15 million vibratory cycles and a distance dose of 15.8km. While their phonation percentages were highest in singing, 88% of their mean recording time was during non-singing periods, which meant that the overall cycle dose and distance dose was more than double for non-singing periods than singing over the study period. Student vocal-dose data were compared with voice-quality data acquired from the accelerometer over the three days. The study found that higher vocal doses, as a whole, corresponded with significantly greater voice amplitude, more vocal clarity (pitch strength and Harmonic to Noise Ratio), and less perturbation (shimmer and jitter). This corresponded with laboratory studies that found these factors could have occurred due to increased muscular compensation after fatigue-inducing vocal loading (Boucher, 2008). It was unclear for which students the voice quality changes were due to a warming-up effect and for whom the changes were due to fatigue-induced compensation.

In a companion study to the present case study, Schloneger (2011) examined graduate voice students' ($N = 2$) voice use before, during, and after an intense week of opera rehearsals through (a) acquired voice dosimeter (APM 3200) data, (b) daily surveys, (c) participant activity logs, (d) three administrations of the perceptual Singing Voice Handicap Index (SVHI), and (e) pre- and post-stroboscopic laryngeal examinations. Two female graduate students, both of who were cast in a university opera production and served as graduate teaching assistants in voice, wore ambulatory phonation monitors (APMs) during waking hours for nine days. Replicating the present study, they were monitored for two pretest baseline days, a five-day intensive rehearsal week just prior to the opera production week, and two baseline days after opera performances were completed. Mean Dt and daily Dd averages were similar among the pretest days (15.7%, 4481m/day and 15.3%, 4247m/day),

posttest days (13.0%, 2010m/day, and 17.6%, 4306m/day) and the intensive week (11.8%, 4448m/day and 14.1%, 3841m/day). Disaggregation of acquired data by four types of activities (opera rehearsals, personal practice time, voice teaching time, and non-rehearsal or teaching time) indicated that the highest mean Dts and Dds were acquired during personal practice time and voice teaching time. Perceptual data (daily surveys and SVHI), as well as the pre- and post-stroboscopies, indicated no notable changes occurring in vocal health. Results suggested that these graduate student singers were conscious about their voice use during periods of extensive performance demands.

There remains a limited amount of empirical data regarding vocal doses acquired by college and university students during intensive rehearsal and performance periods of the semester and the relationship between vocal demands and students perceived vocal health and function. Few researchers have observed singing student voice use at smaller liberal arts colleges, where numerous performance opportunities exist for ambitious voice students or compared collected voice use data with personality inventories. Research has yet to indicate optimum levels of vocal dose, both in terms of duration or sound pressure levels for the development of young college-age singers.

The purpose of this case study was to document undergraduate voice students' ($N = 2$) voice use before, during, and after an intense week of choral and musical theatre rehearsals at a small liberal arts college through (a) acquired voice dosimeter (APM 3200) data, (b) participant activity logs, (c) daily surveys, (d) three administrations of the Singing Voice Handicap Index, and (e) the Keirsey Temperament Sorter.

The following research questions guided this investigation: (a) What do ambulatory phonation monitor data indicate about phonation time and distance doses acquired by participants during different periods of activity? (b) What do daily surveys and SVHI scores indicate about participant's perceptions of vocal use? and (c) What do personality inventories tell us about voice use?

Method

Participants

Participants ($N = 2$) in this study were two female singers active in the vocal program at a small Midwestern liberal arts college. The participants were members of the college's select 24-voice choir and were also cast in principal roles in the production of the musical *Quilters*. Both groups were preparing major performances for the college's centennial homecoming celebration early in the semester, so both the choir and the musical cast began an intensive week of rehearsals one week before the fall semester commenced. The select choir met daily throughout the semester, and the director traditionally brought students one week prior to the fall semester for performances at the college's opening weekend celebrations. The early musical production was unique to this centennial year, so the theatre directors' decision to also bring the musical cast one week prior to the semester created a uniquely intense rehearsal week for those singers involved in both activities.

Melissa (pseudonym), 19, was an undergraduate sophomore with an undecided major and was considering a major in music. A mezzo-soprano, she had been involved in singing and theatre throughout her high school and collegiate careers, participating in select choirs in high school (including all-state chorus her senior year) and as a college freshman. She had completed four years of private voice lessons and had studied both classical and contemporary commercial singing techniques. Melissa was also the lead singer in a popular campus bluegrass band. *Quilters* marked her third principal role in a collegiate theatre production.

Kathy (pseudonym), 18, also a mezzo-soprano, was an incoming freshman music major. She studied both voice and clarinet privately throughout her high school career. Kathy was selected to the all-state band her junior and senior years, received superior contest ratings in voice and clarinet at the state level, sang in her high school's select choir, and performed the leading role in her school's production of *Oklahoma!* as a high school senior.

During the five-day intensive rehearsal week (IRW) conducted the week prior to the beginning of the fall semester, the students were involved in a total of seven to nine hours of rehearsals each day and were in a situation where a large amount of speech would be expected as the participants settled into campus, catching up with friends and making new acquaintances.

Procedures

The participants agreed to wear voice dosimeters for two baseline days during the week-end immediately prior to the intensive rehearsal week (prebaseline), for five days during the intensive rehearsal week, and for two baseline days one week after the intensive rehearsal week ended (postbaseline). In addition, the participants completed a daily voice health survey, kept a daily log of their activities, completed a Singing Voice Handicap Index evaluation at the end of each of the three study periods, and completed the Keirsey Temperament Sorter.

Phonation Monitors

Study participants wore the Ambulatory Phonation Monitor 3200 (PENTAX Medical, Lincoln Park, NJ). These APMs consisted of a small accelerometer transducer attached to the anterior base of participants' necks at the sternal notch (i.e., below the larynx and directly above the sternum). The accelerometer sensed phonation vibrations and captured raw data at a rate of 20 samples per second. A cable conveyed these data to a battery-powered microprocessor unit worn in a fanny-pack. The microprocessor stored and calculated (according to formulas established by Švec et al., 2003) information including dose time (Dt), distance dose (Dd), fundamental frequency (F_0) and voice amplitude as measured by sound pressure levels (SPL) in decibels (dB). Acceptable SPL levels were set at 35-130 dB, and acceptable frequency range was set at 130-1000 Hz (approximately C0-C3) (Colton et al., 2011). The accuracy of the APM 3200 has been evaluated, along with other dosimeters, in several studies (Bottalico et al., 2018; Carullo et al., 2015; Hillman et al., 2006; Švec et al., 2003).

Data were obtained over the entire course of each day. The participants met the researcher early each morning to download the previous day's data and attach and calibrate the APMs according to the manufacturer's protocols. The participants wore the monitors 13-15 hr each day, removing the monitors just before retiring for the evening. The one exception was the fifth and final day of the IRW, in which both participants sang in a short evening choral performance. At the participants' request, the APMs were removed for the evening immediately prior to their stage entrance. I remained available by phone throughout the study period in the event that APM units became unattached and needed reattachment and recalibration.

Prebaseline monitoring days ($N = 2$) occurred during the final summer weekend before the students moved into their dorm rooms to commence fall semester activities. Postbaseline monitoring days ($N = 2$) occurred one week after the IRW. Both students remained on campus during this weekend as they commenced their normal fall semester routines.

Activity Logs

In order to determine what activities occurred during each recorded phonation period, the participants completed daily activity logs. The logs were used to separate and calculate voice use during different activities.

Daily Vocal Health Surveys

At the end of each monitored day, both participants completed a vocal dosage case study daily survey (Appendix). The participants recorded their hours of sleep from the previous night, the time they left their home or dorm room, and the overall quality of their singing voice. They also responded to ten vocal health questions using a Likert scale with a range of one to seven, with one being *strongly disagree*, four being *not sure*, and seven being *strongly agree*. The questions ranged from "I am doing a good job taking care of my voice today" to various indicators of perceived vocal stress, including comfortableness of high range, throat clearing, airiness/breathiness, strain, fatigue, throat pain, hoarseness, wobble/shaky voice, and singing pain.

Singing Voice Handicap Index

The participants also completed the SVHI at the end of each of the three monitored periods of the study: prebaseline, IRW, and postbaseline. Cohen, et al. (2007) created and validated the SVHI as a tool for measuring self-perceived handicap in singing. The questions used a five-point Likert scale, with a continuum between *never* (score of zero) and *always* (score of four), and related to the physical, emotional, social, and economic impact of singing voice problems. The SVHI gave more complete and comparable indication of the participants' perception of vocal health. The SVHI was scored on a single scale of 0-100, with a higher score indicating more voice handicap. In a pilot study, a control group of singers ($N = 129$) reporting no dysphonia had a median SVHI score of 22, while singer

participants with a diagnosed vocal dysfunction ($N = 112$) had a median score of 61 (Cohen et al., 2007).

Keirsey Temperament Sorter

Both participants completed the Keirsey Temperament Sorter, one of the most widely administered personality tests and a readily available test completed by all freshman at the college (Keirsey, 1978/1998). The test asks 70 questions each with two possible answers and places individuals on continuums of introvert-extrovert, sensing-intuiting, thinking-feeling, and judging-perceiving and places individuals in one of sixteen personality categories based on test scores. The Keirsey Temperament Sorter has been validated and employed in numerous studies (Dodd & Bayne, 2007; Kelly & Jugovic, 2001).

Results

Results are reported in order of the research questions posed for this investigation.

Voice Use Data

Both participants wore the APM units for an average of more than 13 hours each day over the course of nine monitoring days. There was only one occurrence of the APM monitor becoming unattached from the skin, necessitating recalibration. This occurred on the first day of baseline monitoring when Melissa was at the mall trying on clothes. The APM was restarted about 1.5 hours after this occurrence and Melissa wore the monitor for the rest of the evening.

Table 1 on the next page displays overall phonation data for the prebaseline, IRW, and postbaseline periods. Both participants used their voices more frequently during the IRW nearly doubling their average daily phonation times. Following their final summer weekend at home, the students participated in an average of nearly eight rehearsal hours per day, including an average of 5.1 hours of musical rehearsal and 2.75 hours of choral rehearsal daily. As compared to recorded phonation time in the prebaseline period, both participants doubled their cycles of vibration per day and either tripled or nearly tripled their distance dose per day during the IRW. In terms of both Dt and Dd, Melissa used her voice more than Kathy throughout all monitored periods of time.

Over the course of the IRW, the participants participated in a total of at least 39 hours of rehearsals, with 13.7 hr in choir rehearsals and 25.5 to 26.5 hr in musical rehearsal. By comparison, 24-26.5 hr of non-rehearsal hours were recorded, consisting of the majority of the remaining time both participants were awake. Table 2 on the next page shows the APM data for the different activity periods throughout the IRW. Dose time was the highest during choir rehearsals, with Dts of 31.93% and 27.86%. Musical rehearsals, which combined singing, choreography, and blocking, necessitated less Dt (12.74% and 11.28%). The participants used their voices differently in non-rehearsal times than choir rehearsal times, with Melissa's Dt and Dd approximately doubling that of Kathy's during non-rehearsal

Table 1*APM Data – Baseline and Intensive Rehearsal Week (IRW) Weighted Averages*

Measure	Melissa			Kathy		
	Pretest baseline (2 days)	Intensive week (5 days)	Posttest baseline (2 days)	Pretest baseline (2 days)	Intensive week (5 days)	Posttest baseline (2 days)
Duration of monitoring (hh:mm)	13:37	13:08	12:14	14:14	13:08	14:16
Phonation %	10.86%	18.53%	12.95%	6.94%	13.76%	7.31%
F ₀ Mode -Hz	253	244	195	229	300	229
F ₀ Average - Hz	297	311	248	316	354	301
Amplitude Avg - dB	64.01	74.36	69.91	62	70.61	65.52
Vibratory Cycles (Dc)	1,357,375	2,708,560	1,416,918	1,169,842	2,336,635	1,212,575
Dc - Per Hour	99,685	206,236	115,824	82,190	177,916	84,994
Distance dose (Dd) - m	3,468	10,608	5,236	2,469	7,216	3,297
Dd – Per Hour	255	808	428	173	549	231

Table 2*APM Data - Intensive Rehearsal Week Breakdown by Activity*

Measure	Melissa			Kathy		
	Choir rehearsal	Musical rehearsal	Non-rehearsal time	Choir rehearsal	Musical rehearsal	Non-rehearsal time
Duration of monitoring* (hh:mm)	13:40	26:34	24:02	13:42	25:30	26:39
Phonation % (Dt)	31.93%	12.74%	17.30%	27.86%	11.28%	8.92%
F ₀ Mode - Hz	362	266	210	368	341	249
F ₀ Average - Hz	374	298	267	376	364	303
Amplitude Avg - SPL dB	76.88	75.89	70.95	70.75	75.36	64.76
Vibratory Cycles (Dc)*	5,729,748	3,652,626	4,013,007	5,168,382	3,735,593	2,602,170
Dc - Per Hour	19,250	137,489	166,977	377,254	146,494	97,642
Distance dose (Dd) - m*	21,894	15,318	15,343	14,975	13,887	7,239
Dd – Per Hour	1602	577	638	1093	545	272

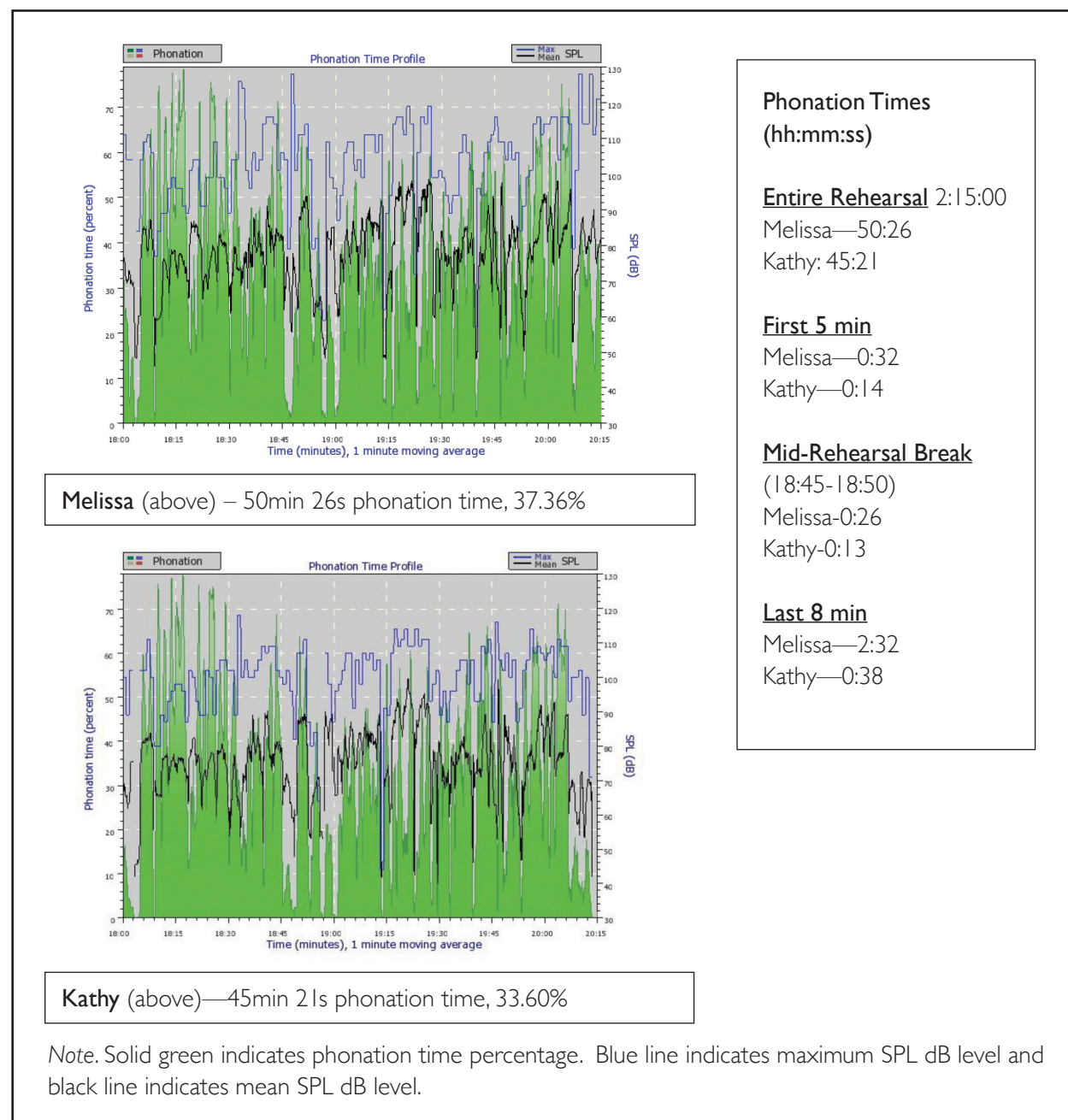
Note. * Indicates total of entire period. Other measures represent weighted averages.

periods throughout the IRW.

It is notable that Melissa displayed consistently more Dt than Kathy during choir rehearsals, a period during which both students were singing the same voice part. Kathy reported that she talked very little in and around rehearsal, while Melissa reported that she made regular comments during rehearsals and talked and hummed frequently during rehearsal breaks. By identifying periods of time in choral rehearsals where the APM registered F_0 levels consistent with speech, non-singing periods during choir rehearsals were identified and confirmed by the choral conductor. The data revealed that Melissa used every rehearsal break opportunity to phonate. As an example, Figure 1 displays the phonation time of each singer during the same choral rehearsal. Though Melissa used her voice more

Figure 1

Comparison of Phonation Activity by Melissa and Kathy in a Choir Rehearsal



than Kathy, Kathy’s average amplitude in choir rehearsal decreased in the final two days of the IRW, while Melissa’s stayed consistent (Figure 2).

Non-rehearsal times consisted of different activities, ranging from sleeping to organized social events, some of which occurred after long days of rehearsals. Wednesday evening of the IRW, for example, ended with a choir bonding time of games and sharing. This activity followed a day that included 6.5 hours of musical rehearsal and 2.25 hours of choir rehearsal. Melissa and Kathy ended this day with a social activity that yielded the phonation data found in Table 3.

Figure 2
Average amplitude (SPL dB) in intensive week choral rehearsals.

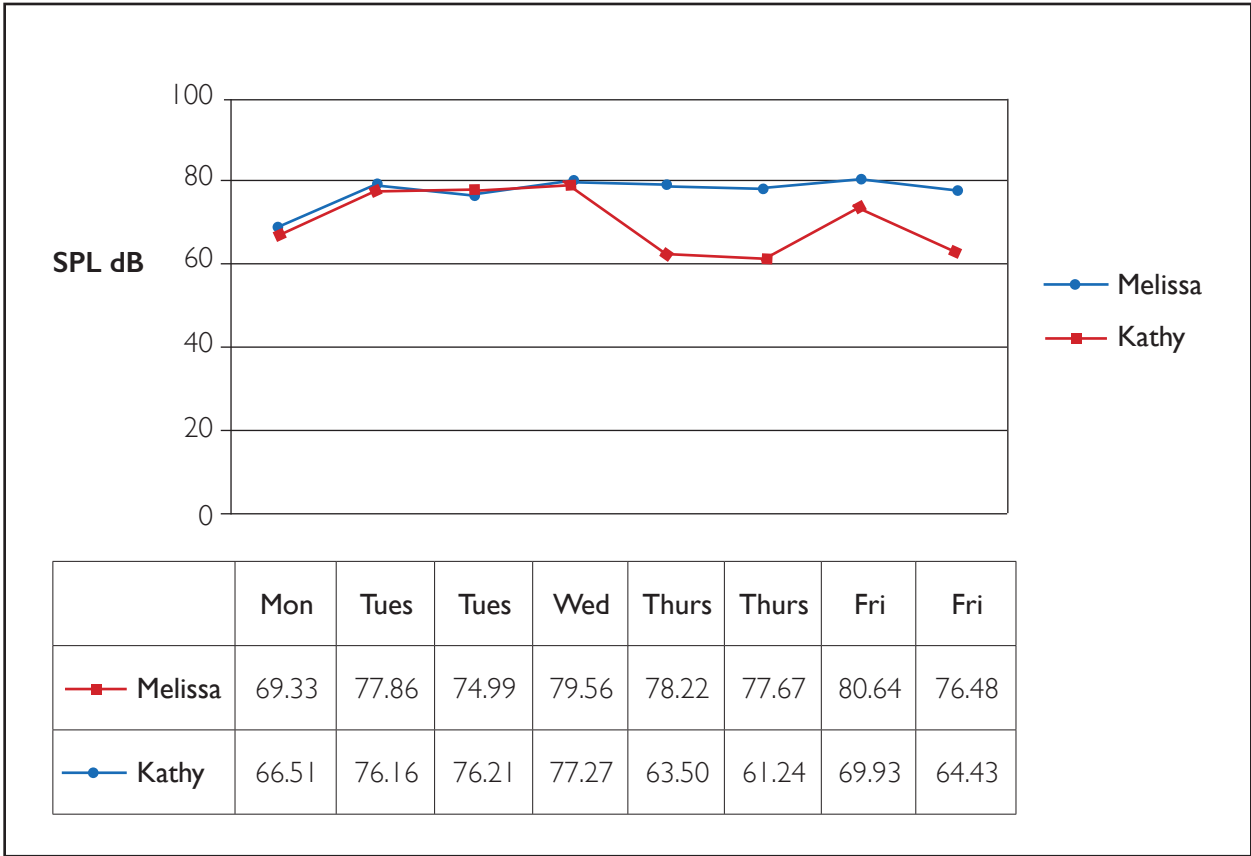


Table 3
Voice Use Data for Melissa and Kathy during a 3 Hr Non-Singing Choir Social

Measure	Melissa	Kathy
Phonation %	19.44%	15.21%
SPL Level	80.76 dB	73.82 dB
Distance Dose	3339m	2071m

Voice Survey Data

In response to the 11 vocal health questions in the daily survey, both singers reported a decline in nearly every vocal health category between Monday and Friday of the IRW. Kathy reported declines in each category, and Melissa in all but two (straining and throat hurts) (Figure 3). Kathy's scores declined an average of 3.11 points on the seven-point scale and Melissa's scores decreased an average of 0.88 points.

In comparing the average daily survey responses of the prebaseline and postbaseline periods with the average responses during the IRW (Figure 4 on the next page), Kathy reported declines in every area of vocal health, while Melissa reported improvements in some areas. Compared to the mean survey scores of the baseline periods, Melissa reported overall IRW averages that were more positive in terms of breathiness, strain, throat hurts, shake/wobble, and pain. She reported overall declines only in the areas of fatigue and "Today, I can comfortably sing the higher notes of my voice range." Kathy's mean daily survey scores were 1.68 points higher (with higher scores indicating greater vocal difficulty) in the IRW than in the two prebaseline days, while Melissa's mean daily survey scores were 0.48 points lower.

Both singers reported similar amounts of sleep, with Kathy averaging 7 hr nightly and Melissa 7.5 hr nightly during the IRW. In response to the prompt "I am doing a good job taking care of my voice today," Melissa answered *agree* or *somewhat agree* all nine days of the study, while Kathy noted some decline throughout the IRW (Figure 5 on the next page).

Figure 3

Responses to vocal health questions on a daily survey of vocal health on the first and last days of an intensive rehearsal week.

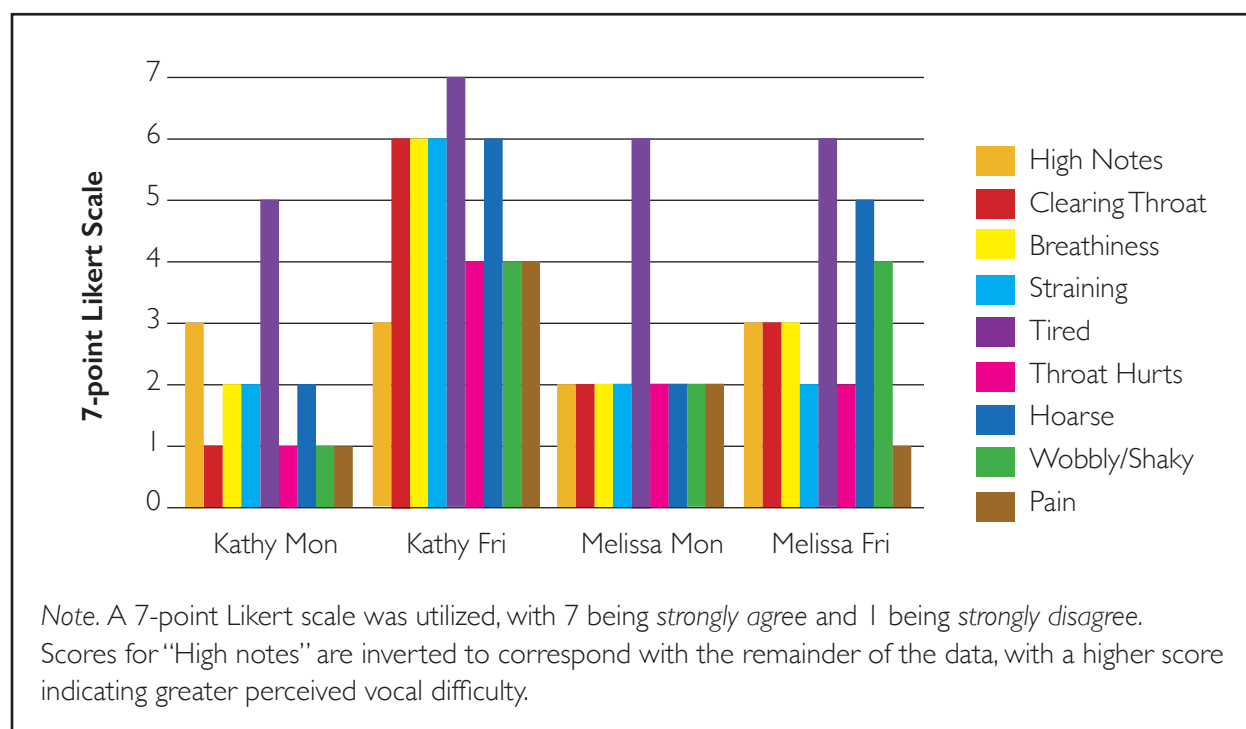


Figure 4
Average of responses to vocal health questions on a daily survey of vocal health.

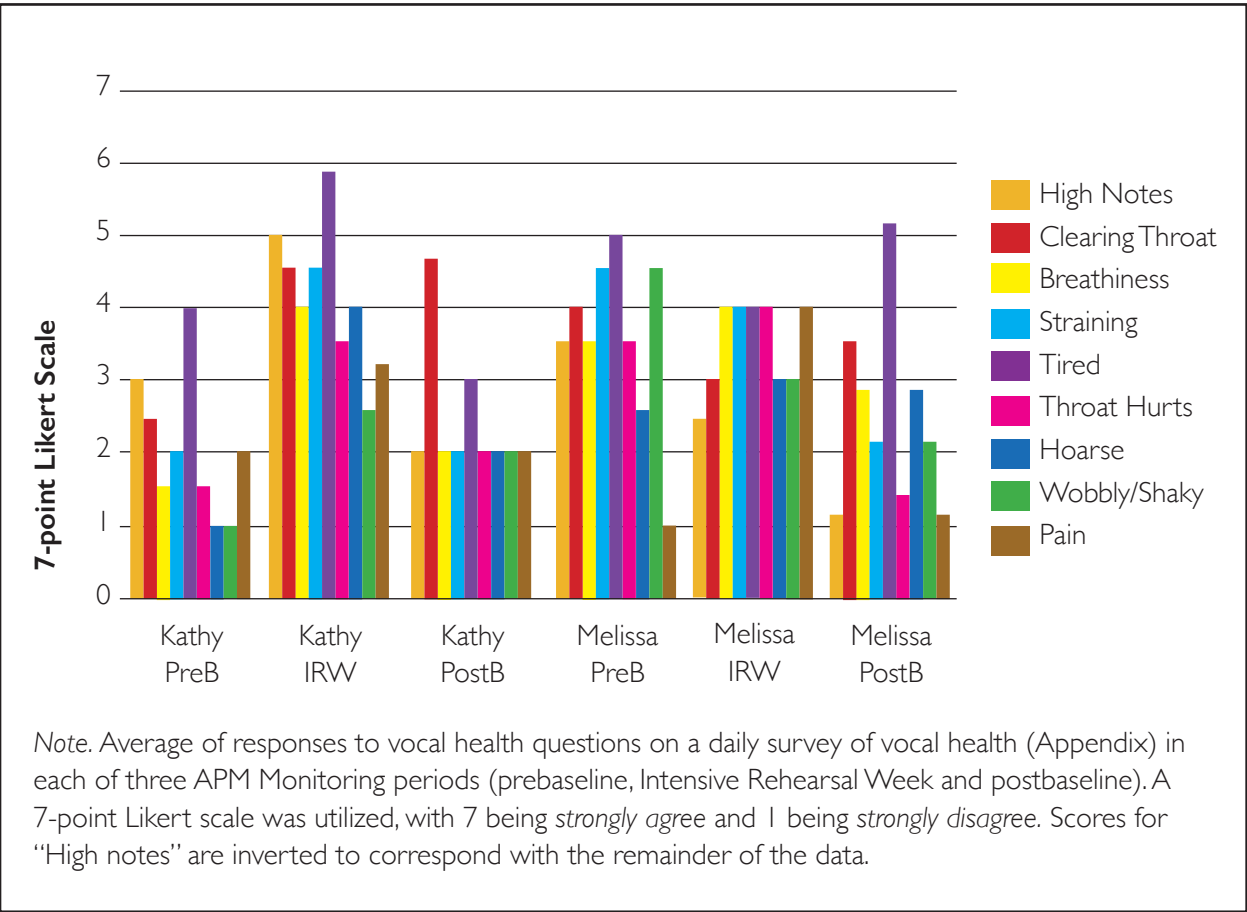
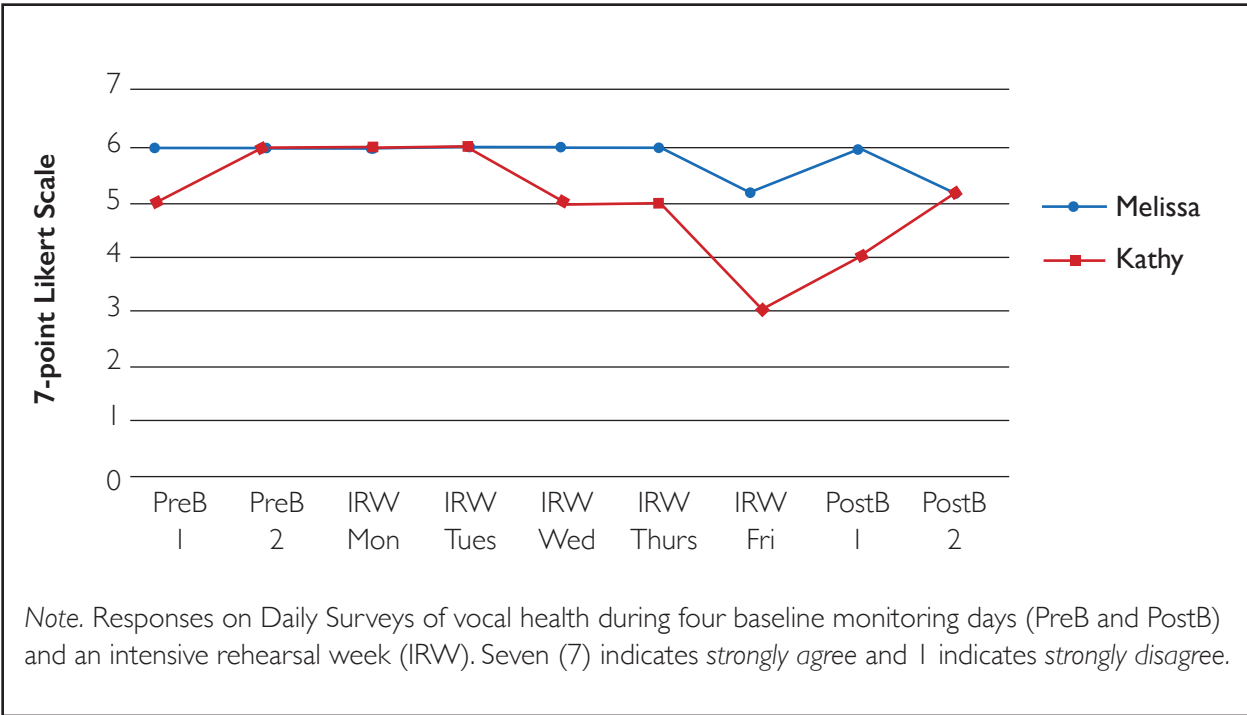


Figure 5
Responses to the question “I am doing a good job taking care of my voice today”



Singing Voice Handicap Index

SVHI responses are compiled and placed on a continuum of 0-100, with a higher score indicating greater perceived vocal difficulty (Figure 6). The SVHI indicated that Kathy perceived more vocal difficulties during the IRW than during the baseline periods, with a decline of 26.4 points. During the prebaseline and postbaseline periods, Kathy reported no scores of *always* or *almost always*. By contrast, Kathy answered *almost always* to 11% of the questions and *sometimes* to 47% of the questions immediately following the IRW (Figure 7 on the next page). She responded *almost always* to the following questions: (a) it takes a lot of effort to sing, (b) I have to “push it” to produce my voice when singing, (c) my speaking voice is hoarse after I sing, and (d) my singing voice tires easily. In the post-baseline-SVHI after a week of rest, Kathy reported no *always* or *almost always* problems, though her overall SVHI score was 9.7 points higher than her pre-SVHI score.

Melissa’s SVHI score improved 4.9 points between the prebaseline period and the end of the IRW. At the end of the IRW, Melissa responded *never* or *almost never* to all 36 vocal health questions. She responded *sometimes*, *almost always*, or *always* to 25% of the questions following the prebaseline period and 9% of the questions in the postbaseline period. The one question to which Melissa responded *almost always* or *always* following both baseline periods was “My speaking voice is not normal.”

Figure 6

Adjusted SVHI scores for Melissa and Kathy following each of the three study periods

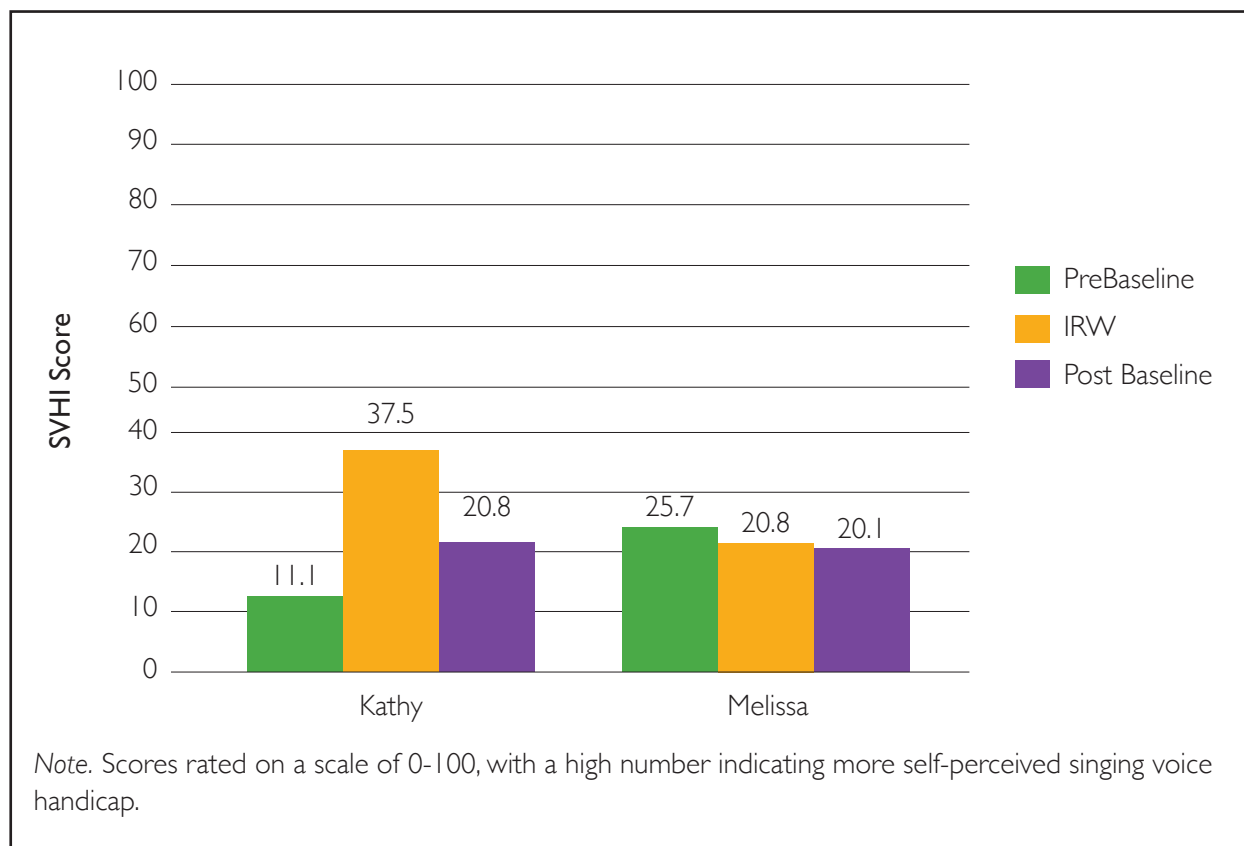
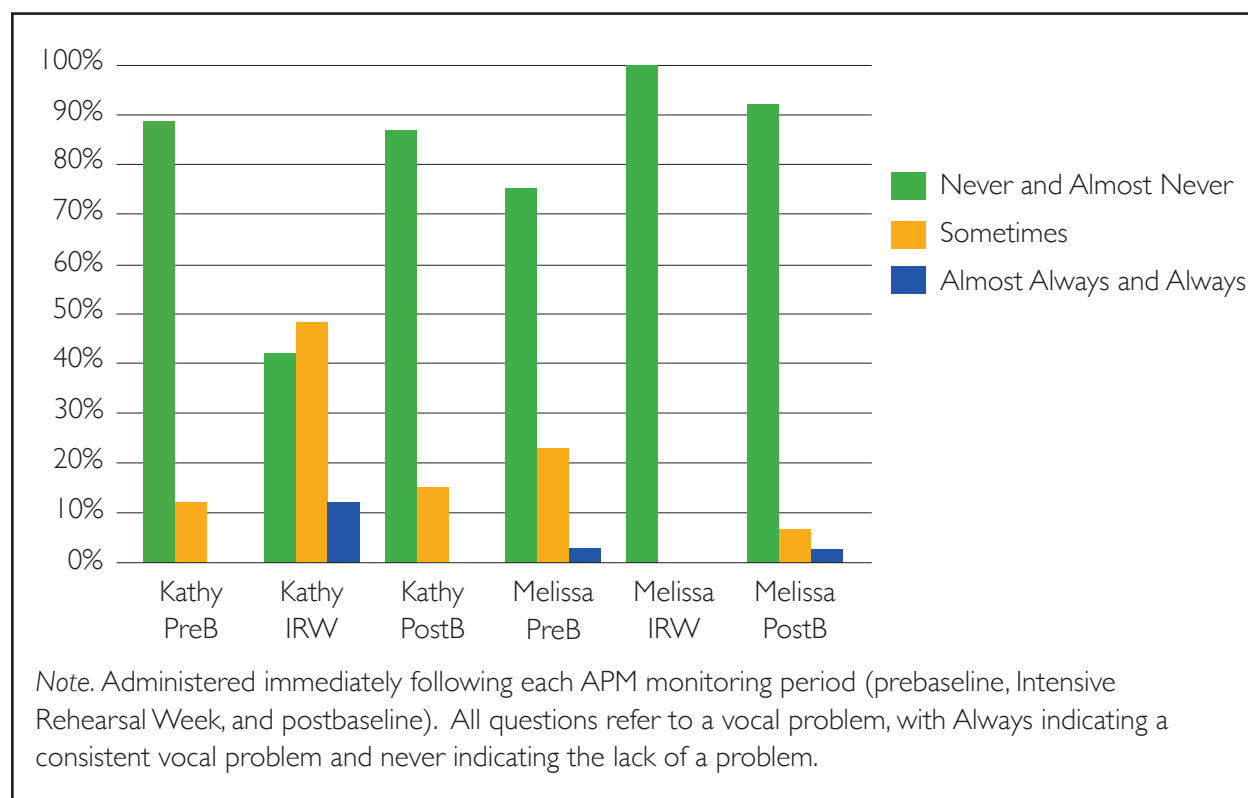


Figure 7
Responses to 36 questions in the Singing Vocal Health Index



Additional Perceptions

The participants described their perception of vocal health and recovery several weeks following the IRW via e-mail:

Melissa:

My voice was tired at the end of that crazy week but it wasn't anything I had never experienced before.... My voice has grown stronger and more efficient. My voice has also learned to endure a lot so it honestly didn't take extremely long to get back to normal. After 3 or so days of regular/no singing, it was fine. I think all that singing probably did help to keep building my endurance.

Kathy:

After [the intensive rehearsal week] I was very relieved to cut back on the amount of singing I did in a day. My voice felt a lot better right away ... but I know for about a week I didn't use my full voice in practice ... I felt like I couldn't get my voice to come out and I had a lot of trouble singing loud. After that first week of normal classes, however, I was for the most part back to normal ... [The intensive rehearsal week left my voice] tired and my singing did not sound as good.

These comments corresponded with the Voice Survey and SVHI data, with Melissa perceiving that the IRW helped develop her vocal endurance and Kathy perceiving a temporary decline in vocal efficiency.

Keirseey Temperament Sorter

Kathy tested as an INFJ (Introverted, Intuitive, Feeling, and Judging), which is categorized as an Idealist-Counselor. As introverts, INFJs are characterized as private and introspective. Melissa tested as an ESFJ (Extraverted, Observant, Feeling, and Judging), which is categorized as a Guardian-Provider. As extroverts, ESFJs are considered to be among the most sociable of personality types. In short, the results of the temperament sorter affirmed participants' self-perceptions.

Discussion

The purpose of this study was to document in detail the voice use of singing students at a liberal arts college during an IRW. Acquired data confirmed that the singers used their voices much more during the IRW than they did during the baseline periods. While the singers used their voices differently and perceived different levels and types of decline in voice health, both appeared to reach their physical limits by the end of the IRW, marking *somewhat agree*, *agree*, or *strongly agree* in response to the questions "Today, my voice feels tired," "Today, my voice is hoarse," "Today, I find myself clearing my throat more than I typically do," and "Today, I sense airiness/breathiness in the sound of my voice." While the circumstances surrounding the IRW were not the norm at this institution, the data suggest that the vocal expectations placed on these young singers may have been excessive, especially at the beginning of the school year before the singers developed stamina from daily singing activities.

These singers' overall vocal doses of 18.53% Dt (Melissa) and 13.76% Dt (Kathy) generally exceeded the doses of university singers in several other small dosimeter studies. (Gaskill et al., 2013; Manternach, 2014; Manternach & Schloneger, 2019; Schloneger, 2011; Schloneger & Hunter, 2017; Toles et al., 2020) Gaskill et al. (2013) did record two undergraduate voice majors exceeding 17% overall Dt for a full week of classes, and Schloneger and Hunter (2017) did record an overall Dt of a voice major exceeding 20% Dt over three-semester weekdays. These two studies showed mean Dts 12.9% over five days ($N = 6$) and of 11.92% over three days ($N = 19$) respectively and did not compare singers to baseline periods. Additional studies covering a full semester, following the methodology of Sandage and Hoch (2019), would be helpful in learning more about the development of vocal stamina over a period of practice.

The appropriate amount of vocal dose for student singers in choral rehearsals needs further analysis. Vocal dose in the choral rehearsal is largely in the hands of the conductor, and all conductors work differently. In choral rehearsals throughout the IRW, the participants in

this study averaged approximately double the phonation percentage of all other activities, leading to the highest distance doses in the study. This difference was consistent with other dosimeter studies of choral singers (Daugherty et al., 2011; Gaskill et al., 2013; Manternach & Schloneger, 2019; Schloneger, 2011; Schloneger & Hunter, 2017). Numerous and more extensive replications of studies such as this could help conductors learn optimal levels of vocal dose in rehearsal settings. It is notable that in 13.7 hr of choral rehearsal, Melissa's Dd exceeded that of Kathy's by 6,919 m/day, even though both students were singing the same voice part. Distance dose is heavily influenced by amplitude, so this difference is attributable in part to the fact that Melissa's mean amplitude level in choir rehearsal exceeded Kathy's by 6.13 Db. This difference also occurred because Melissa talked, sang, and hummed frequently in and around rehearsal times while Kathy did not.

The two participants had different vocal doses and different levels of perceived fatigue. Melissa used her voice more frequently with higher amplitude levels and a lower fundamental speaking frequency than Kathy. Nevertheless, while Melissa did report some fatigue by the end of the IRW, she appeared to retain a perception of relatively good vocal health. Kathy, on the other hand, experienced more substantial symptoms of vocal fatigue by every measure. Data suggest that Kathy continued to consistently sing near full-voice during rehearsals through the end of the IRW, even though she reported symptoms that should have led her to mark or simply stop singing. These diverging results support ongoing research that suggests that voices respond to vocal demands differently due to a complex array of factors, including their vocal demand response and their individual vocal effort, both functional and perceived (Nanjundeswaran et al., 2017; Sandage & Hoch, 2019; Smith et al., 2017).

Personality type may have played a part in the differences in phonation activity between the two participants. As indicated by the Keirsey Temperament Sorter, Kathy was an introvert, and Melissa was a strong extrovert. While this personality trait may have contributed to the difference in voice use between the two participants, further study could further explore the findings of Koojman et al. (2006) regarding the relationship of psychological factors to vocal dysfunction. Relationships among personality type, vocal production, and tendencies for vocal fatigue or dysphonia could be examined.

Voice use outside of rehearsal is important to overall voice use and care, and acquired dosimeter data revealed vocal habits of concern for both students. Melissa's 17.3% Dt for non-rehearsal times exceeded her 12.74% Dt in musical rehearsal. By contrast, the more experienced participants in Schloneger (2011) companion study of graduate voice students appeared to be cognizant of their heavier rehearsal demands and used their voice outside of rehearsal less during their IRW than they did during the baseline periods. Voice education regarding vocal warning signs, healthy speaking levels, and attention to voice use outside of rehearsals during intense periods could help young students like Melissa and Kathy keep their voices healthy in demanding situations. Such vocal health education should take place from the first day classes for freshmen and be reinforced regularly prior to IRW. Music faculty could benefit from careful planning that encourages or schedules quiet activities

following intense periods of voice use, rather than activities like the vocally-intensive choir social that took place Wednesday evening of the IRW.

Over the course of nine full days ranging from 10-14+ hours of monitoring, both of the APMs performed without fail and gathered consistent daily data. Both participants recorded a consistent F_0 Mode for speech periods throughout all nine days - 207 Hz for Melissa and 229 Hz for Kathy. The transducers remained attached until voluntarily removed for all but one instance. The only unforeseen difficulty was that by the end of seven consecutive days of monitoring, both participants had developed skin irritation at the location of the transducer (the thyroid notch). This risk should be noted for future studies that employ a glued transducer.

Limitations

Due to the intensive time requirements for both the participants and the investigator, the extensive manual data analysis requirements, and the fact that only two APMs were available, this study was limited to two participants. As such, these data cannot be generalized beyond the present participants. We were also unable to conduct pre- and post-stroboscopies of the vocal folds and as such were able to rely only on perceptual data regarding the vocal health of the participants due to the lack of a nearby research partner with the required skills or equipment.

Regarding the APM equipment, the acquired amplitude and related distance dose data appeared high compared to other studies of this type. While the vocal doses recorded were unusually high, it is possible that the APM overestimated mean amplitude (and thereby also D_d) as was suggested by Bottalico et al. (2018). While there were currently no commercial voice dosimeters available for purchase in 2021, future studies, employing continually improving technology such as the analysis of the full accelerometer signal developed and employed by Hunter (Hunter, 2013; Schloneger & Hunter, 2017), would allow for increased assurance of accuracy in dosimeter measurements. The development of affordable, accurate commercial voice dosimeter technology and many more ambulatory field studies of singer behavior are needed to acquire normative vocal dose data and to determine safe and appropriate vocal demand levels for developing voices.

Conclusion

Two female collegiate voice students in this case study of an intensive five-day rehearsal week at a small liberal arts college, which included nearly 40 hours of combined choral and musical rehearsals, acquired higher vocal doses than recorded in similar studies of college/university singing students during periods of typical collegiate activities. One participant, an extrovert, recorded higher vocal doses and less perception of vocal decline than did the other student, an introvert, who recorded lower vocal doses and greater perception of vocal

decline. Both participants experienced a perception of less efficient vocal function at the end of the rehearsal week compared with baseline readings.

Collegiate faculty focused more on perceived departmental rehearsal needs during this week than the vocal health of the students, resulting in declines, rather than improvement, in perceived vocal function. Scheduling based on these supposed needs without sufficient thought and care to student vocal demands and vocal conditioning could not only put students at risk of vocal injury, but could also result in an inferior final performance product. University performing arts faculty could work carefully to put student vocal health first by avoiding excessive vocal demands on students, providing ongoing vocal health education, and building in vocal-rest activities during intensive periods. Faculty could put vocal health at the forefront by keeping students' overall vocal demands in mind when making casting decisions, scheduling less overall choral rehearsal time (acknowledging that fewer rehearsal hours with fresh voices may yield similar or improved results to more rehearsal hours that lead to tired voices), building effective nonperformance-volume singing into the choral rehearsal, scaling rehearsal time throughout the semester to increase vocal conditioning, and avoiding the scheduling of loud social activities in the midst of intensive periods. By placing such considerations of student vocal health first, faculty could ensure positive student outcomes, improved performance outcomes, and long-term vocal development.

Appendix: Vocal Dosage Case Study Daily Survey

Your responses to this anonymous survey will college faculty assess various aspects of the opening week schedule. Please respond **HONESTLY** and **CANDIDLY**.

PART ONE: Name: _____ Age: _____

Last night I got _____ hours of sleep. I left my home at _____ a.m. today.

PART TWO:

For statements 1-7 below, please circle your agreement or disagreement with each statement, using the following scale:

1	2	3	4	5	6	7
strongly	disagree	somewhat	not sure	somewhat	agree	strongly
disagree		disagree		agree		agree

1. I am doing a good job taking care of my voice today.

1 2 3 4 5 6 7

2. Today, I can comfortably sing the higher notes of my voice range.

1 2 3 4 5 6 7

3. Today, I find myself clearing my throat more than I typically do.

1 2 3 4 5 6 7

4. Today, I sense airiness/breathiness in the sound of my voice.

1 2 3 4 5 6 7

5. Today, I feel like I'm straining when I sing.

1 2 3 4 5 6 7

6. Today, my voice feels tired.

1 2 3 4 5 6 7

7. Today, my throat hurts when I sing.

1 2 3 4 5 6 7

8. Today, my voice is hoarse.

1 2 3 4 5 6 7

9. Today, my voice feels wobbly/shaky.

1 2 3 4 5 6 7

10. Today, I feel pain when I sing.

1 2 3 4 5 6 7

11. Right now, the overall quality of my singing voice is (circle one):

Very Poor Poor Average Good Excellent

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