

## A Method for Quantifying Voicing Periods and Short-term Vocal Recovery Index in Primary School Teachers

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### Abstract

Teachers form a large group of professional voice users and are thought to be at risk for voice problems than the general population. Primary school teachers report the common need to shout or raise the voice to make children heard in the classroom. Loud or prolonged vocalization contributes to voice problems in teachers. Measuring the amount of voicing performed by speakers over time may give valuable information on voice use and load. However, there are no commercially available gadgets in India to measure the same. To fulfill this need, an alternate simple method was proposed and tested. Two primary school teachers aged 32 and 42 years, having 12 and 20 years of teaching experience respectively participated in the study. A digital audiotape was used to record the voice from the teachers used on a regular working day (in the class & outside). The voicing periods from the recorded sample were extracted using PRAAT and the total voicing duration was summed up for the entire workday sample. The average voicing percentage was found to be around 26.91 % (i.e., 1 hour 34 minutes 28 seconds) and the average short-term vocal recovery index was 0.72. This study illustrates a simple method to quantify the amount of voice use on a single workday and calculate the short-term vocal recovery index in two primary school teachers.

Key words : Phonation, Vocal load, Accumulation, Vocal fatigue, Recovery index

There is a growing acceptance of the concept that healthy, effective voice use is an essential tool of trade not only for elite performers such as professional singers, actors, and broadcasters, but also for lawyers, telemarketers, receptionists, politicians, counselors, stockbrokers, and teachers. Of particular interest to researchers around the world are teachers. Teaching is one of the most vocally demanding occupations. In classroom, teachers need to speak frequently and often loudly in the presence of background noise, risking occupational damages to their voices. Loud speaking, increase of pitch and straining of voice may lead to vocal fatigue that eventually causes damage to vocal fold tissue. As many as 50% to 80% of teachers experience and have experienced voice problems according to several questionnaire studies (Pekkarinen, Himberg, & Pentti, 1992; Gotaas & Starr, 1993).

Smith, Kirchner, Taylor, Hoffman, and Lemke (1998) reported that over 38% of teachers studied complained that teaching had an adverse effect on their voice, and 39% of those had to reduce teaching activities as a result. Russell, Oates, and Greenwood (1998) reported that 22% of teachers surveyed experienced regular voice problems and 38.7% of teachers reported missing at-least 1 day of work in the past year as a result of their voice disorder. Sapir, Keidar, and Mathers-Schmidt (1993) reported that more than 50% of teachers reported multiple symptoms of vocal

attrition (gradual decline in vocal capabilities over time). Boominathan, Rajendran, Nagarajan, Seethapathy, and Gnanasekar (2008) reported that 49% of Indian school teachers (high and higher secondary) surveyed experienced voice problems.

Many voice disorders in teachers are thought to be associated with high vocal loading, i.e., how long and at what loudness level one speaks. The vocal loadings of teachers have been quantified thoroughly and systematically in the recent past. Voice accumulation and voice dosimetry devices have been developed for monitoring voice use at work (Airo, Olkinuora, & Sala, 2000; Buekers, Bierens, Kingma, & Marres, 1995; Cheyne, Hanson, Genereux, Stevens, & Hillman, 2003). Measures called 'vocal dose' have been proposed for quantifying voice usage (Svec, Titze, & Popolo, 2003). The three vocal doses identified so far are the time dose, the cycle dose and the distance dose. The time dose is equal to the voicing time and measures the total time the vocal folds are vibrating. The cycle dose measures the total number of cycles accomplished by the vocal folds (in the unit of thousands). The distance dose measures the total distance traveled by the vocal folds on their oscillatory trajectory. The simplest vocal dose is time dose, often called the voicing time, which accumulates the total time the vocal folds vibrate during speech. Rantala, and Vilkmann (1998)

reported that F0 time/voicing time is a bigger risk factor for vocal fatigue. They found reduced voicing time in teachers who had many voice complaints than in teachers with few voice complaints.

Voice accumulation time and the voicing percentages relative to total time at work have been found to be higher in teachers than in other professions. Masuda, Ikeda, Manako, and Komiyama (1993) reported a voicing percentage of 21% for teachers in an 8 hours workday, compared to 7% for office workers. Sala et. al, (2001) reported that the average speaking time of day care teachers was 40 % of the time at work, compared to 28% for nurses. In these studies, the primary focus was on the accumulated phonation time, also referred to as 'vocal load'. Titze (2002) reported the effects of short- and long-term vocal recoveries. The short-term vocal recovery index ( $I_s$ ) is defined as the ratio of the total resting time (or) rest periods to the actual performance (voicing) time. Shorter the  $I_s$  value, greater the vocal injury. Vocal recovery index can be used to recognize the mechanism of recovery and one has to be conscious enough to keep away from permanent tissue injury. Repair of extra-cellular matrix, blood vessels, basement membrane and growth of epithelial cells are some of the long-term vocal recoveries that are reported by Titze (2002). On the other hand, the short-term vocal recoveries are restoration of circulation, water to tissue, calcium and removal of lactic acid. Phonation times are essential to know about the vocal recoveries. There is dearth of studies on vocal recovery index in Indian (primary) school teachers.

Voice loading investigations have been usually conducted in laboratory settings (Gelfer, Andrews, & Schmidt, 1991; Stemple, Stanley, & Lee, 1995). Subsequently, questions about the generalisability of the results to real-life situations remain unresolved. Only a very few studies have been conducted in work environments/real-life situations (Novak, Dlouha, Capkova, & Vohradnik, 1991; Ohlsson, 1988). Unlike laboratory studies, field studies involve many practical and technical problems like impossibility to control many variables (Rantala, Vilkmann, & Bloigu, 2002), which probably explain the less number of these investigations. There have been difficulties to prove the relationship of vocal loading and voice disorders in an epidemiological study due to

lack of a reliable method to measure vocal loading during workday.

A few efforts to measure vocal loading have been reported. These methods used certain devices that have mostly been made exclusively by research groups or otherwise to measure fundamental frequency and sound pressure level but not the duration aspects (Airo, Olkinuora, & Sala, 2000; Buekers, Bierens, Kingma, & Marres, 1995). However, such devices are not commercially available and some are being modified for commercial use (Popolo, Svec, & Titze, 2005). To fulfill the need for a method to measure vocal loading, the present study proposed and tested an alternate simple method to quantify the voice use in the work-place. Quantitative data dealing with vocal load and vocal use in Indian school teachers at primary level are less. In this context, the present study tested the proposed method in Indian conditions. Specifically, the objectives of the study were (1) to develop an alternate simple method for work-place measurement of voice use (voicing periods), (2) to test the method on a regular workday of two primary school teachers, and (3) to measure the short-term vocal recovery index ( $I_s$ ) in two primary school teachers. The operational definition of voicing periods is, 'the periods during which the vocal folds are vibrating'.

## Method

### *Participants*

Two primary school teachers (both females) volunteered for the study. Teacher A (32 years) had 12 years of teaching experience and taught Kannada, Science, and English to second and/or third grade children. Teacher B (42 years) had 20 years of teaching experience and taught Kannada, Science, English and Maths to fourth and fifth grade children in the same school as of Teacher A. The average number of students in each grade was about 30 to 35. The number of classes taken by the teachers per day was around five and the duration of each period was 45 minutes. The teachers took 5-10 minutes break in the morning session after second period, but not in the afternoon session. Both the participants were free from hypertension, high blood sugar, allergies, asthma and gastro-esophageal reflux disorder and did not report of any speech, language, hearing or voice problems at the time of the study.

### **Instruments used**

A portable, light-weight digital audio tape (DAT) recorder (Olympus digital voice recorder WS-100, Japan) was used. The recorder had in-built condenser microphone (ME 15) and the weight of the device was about 54 grams (including battery). The overall frequency response of the microphone was 100 Hz to 5000 Hz and size of the DAT recorder was about 94(L) x 40(W) x 15.1(T) mm. The sampling frequency was 12 kHz and the maximum power consumption of the DAT recorder was 100mW. PRAAT (Boersma, & Weenink, 2009) software was used to extract voicing periods. Figure 1 shows the subject wearing the DAT recorder and figure 2 depicts the Olympus DAT recorder, WS-100 model.



Fig. 1. Subject wearing the digital audio tape recorder.

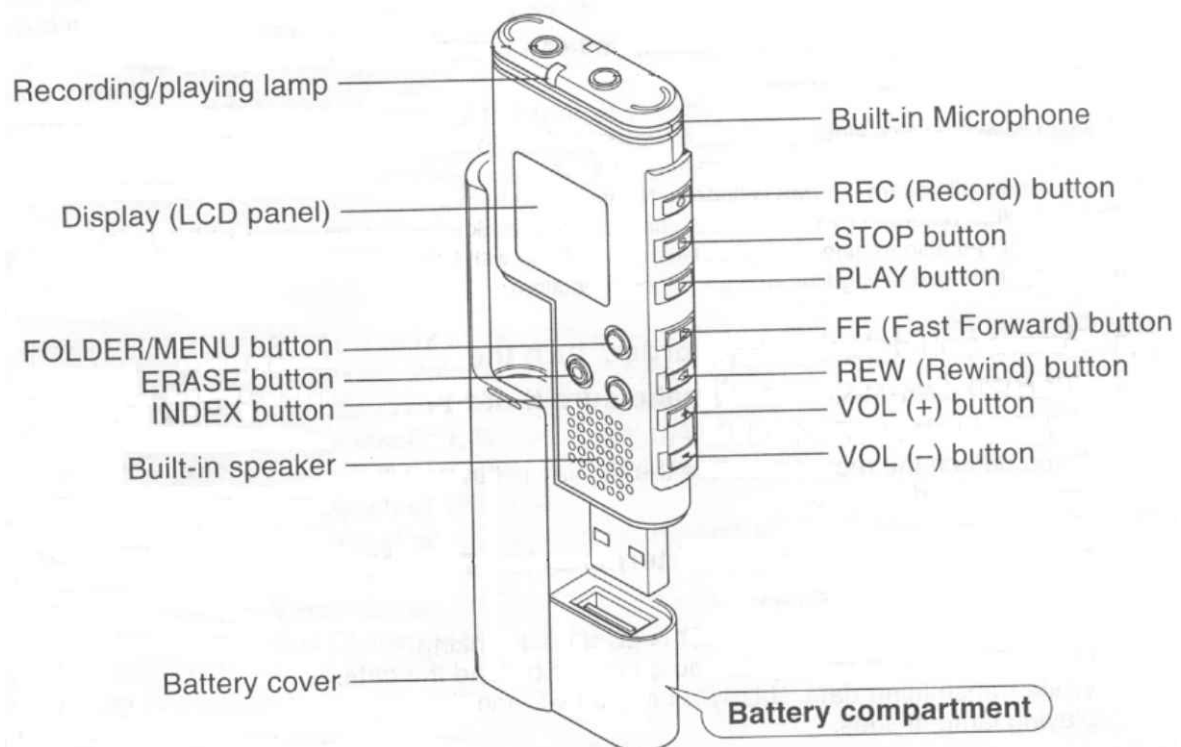


Fig. 2. Olympus digital audio tape recorder (WS-100).

### **Recording procedures**

The teachers in the study were ensured about the research objectives and confidentiality of the data. The recording of voice samples was done on a regular workday (Monday) after a relaxed week end. The teachers were instructed not to

over use the voice on the previous day (Sunday) and spend the day with more voice rest. The teachers were instructed to teach in a regular workday manner and not to over/under react due to the presence of recorder. They were asked to maintain a log-sheet where they made a 'note' about the voice usage of the day. It also included

the time at which voice activities taken place. Table 1 shows the teaching schedule followed by the teachers on a workday. During leisure time, teachers were engaged in correcting notebooks of students of the subjects they taught during which they indulged in less voice use. Also, the

software. The authors first listened to the speech sample and edited the children's speech/voice, if any. Extraction of pitch contour was done from 'pitch menu' and then, voicing percent was provided from voice report under 'pulses menu' for the displayed window duration. Figure 3

Table 1. *Teaching schedule followed by the teachers*

Teacher A	Class schedule (on Monday)	Teacher B
Leisure hour	10.00 – 10.45	Leisure hour
Taught Kannada lessons (III std)	10.45 – 11.30	Taught Kannada lessons (IV std)
Taught Kannada lessons (II std)	11.30 – 12.15	Taught English lessons (IV std)
P.T (Games) II & III std	12.15 – 1.00	P.T (Games) IV std
Lunch	1.00 – 1.45	Lunch
Taught Maths (statement sums) II std	1.45 – 2.30	Taught science lessons (IV std)
Taught Kannada lessons (question and answer) II std	2.30 – 3.15	Taught Kannada lessons (V std)
Leisure hour	3.15 – 4.00	Leisure hour

teachers' responsibility was to monitor or supervise the students in the play ground and by being not involved in teaching/participating in any games during such times, their voice usage was minimal.

The participants wore the recorder around the neck continuously throughout the working day and switched it 'on' when they started the first period. The distance between microphone and mouth of 10-12 cm was maintained throughout the day. As the recorder was small, it allowed the teacher to move, walk freely in the classroom. An entire workday speech/voice was audio recorded from first to last period of teaching.

### **Analyses**

*Voicing Periods (Pitch Periods):* The recorded six hours voice/speech sample of each teacher was transferred onto the computer memory. The entire day speech/voice sample was truncated into ten minute tokens and a total of 36 ten minutes tokens were made for each teacher. Each of the ten minute samples were displayed (window duration of 8-10 seconds) as waveform on PRAAT

illustrates the voicing duration (in ms) measured in PRAAT [total window display duration on the screen of 5.3 seconds, unvoiced is 27.2 % and 72.8 % is voiced]. Otherwise, the duration of all instances of 'V' portion (pitch curve/periods) was summed up for all the tokens frame by frame which resulted accumulated voicing periods. In addition, the voicing periods or F0 time was calculated for two instances where voicing occurred: (1) in classroom teaching/at work, and (2) outside of classroom/not at work. Classroom teaching is operationally defined as any voice use during teaching inside classroom (i.e. at work) and outside of classroom teaching is defined operationally as any voice use other than teaching and/or outside of classroom (i.e. not at work). Inclusion of voicing duration outside of classroom teaching definitely capitulate the entire voice use in the school circumstances. Interactions with colleagues during leisure time, lunch time and advising students /guiding parents were some of the activities indulged by the teachers outside of classroom. The voicing percentage was calculated from the formula.

$$\text{Voicing percentage} = \frac{\text{Total voicing periods}}{\text{Total duration of recorded speed sample}} \times 100$$

Teacher B, it was 22.36% (about 1 hour 18 minutes, 8 seconds). The average percent voicing in among the two teachers was 26.91%. Table 2 shows voicing periods and percent voicing for both the teachers.

**Short-term vocal recovery index (I<sub>s</sub>)** : It was calculated from the formula given by (Titze, 2002) as follows, (performance time-phonation time) /

Further, the results were analyzed to find out the voicing used for teaching purpose by the teachers in the classroom. The results indicated

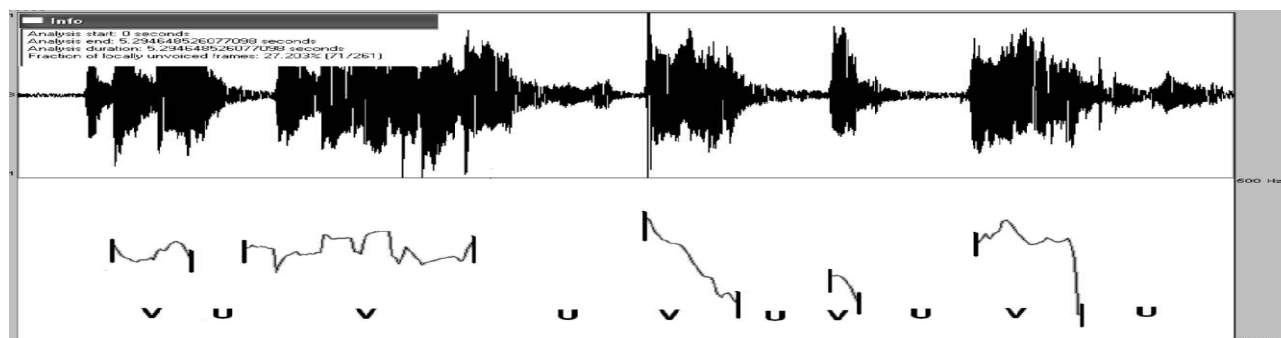


Fig. 3. Voicing duration (ms) measured in PRAAT (V: pitch curve/periods; U: silence).

Table 2. Voicing periods and percentage of voicing of teachers

	Teacher A	Teacher B	Average
Duration of voice/speech sample recorded	20880 seconds (5 hr 48 minutes)	20843 seconds (5 hr 47 minutes 23 seconds)	20861.5 seconds (5 hr 47.5 minutes 11.5 seconds)
Voicing periods	6568.94 seconds (1 hr 49 minutes 48 seconds)	4661.34 seconds (1 hr 18 minutes 8 seconds)	5615.14 seconds (1 hr 34 minutes 28 seconds)
% of voicing	31.46 %	22.36 %	26.91 %

performance time. The performance time represents the total recorded duration of speech sample on a workday and the phonation time represents the total voicing periods/voicing time.

### Results and Discussion

#### Voicing periods

The total time of the recorded sample was 5 hours 48 minutes i.e., 20,880 seconds for teacher A and 5 hours 47 minutes 23 seconds for teacher B i.e. 20843 seconds. The results indicated that the voicing time was 6568.94 seconds in teacher A and 4661.34 seconds in Teacher B. Teacher A's vocal folds were vibrating for an average of 31.46% (voicing percentage) of her time at school i.e. about 1 hour 49 minutes, 48 seconds. And in

that the Teacher A's vocal folds were vibrating a cumulative average of 83.42% in classroom teaching (about 1 hour 31 minutes, 33 seconds), and a cumulative average of 16.57% outside of classroom (about 18 minutes 14 seconds). Whereas 82.28% of the time Teacher B used her vocal folds in classroom teaching and 17.71% of the time, outside of classroom. Table 3 shows the cumulative vocal fold vibration time (F0 time) and percentage of voicing in classroom teaching and outside of classroom. Although the number of periods of teaching was the same for both teachers, the voicing percentage was relatively high in Teacher A compared to Teacher B. This may be attributed to teaching to lower grade to lower grade which requires more reiterations, examples and demonstrations compared to

Table 3. *Voicing time and percentage of voicing in classroom and outside classroom*

	Teacher A		Teacher B	
	Voicing periods (seconds)	Percentage of voicing (%)	Voicing periods (seconds)	Percentage of voicing (%)
Classroom teaching	5479.99	83.42	3835.68	82.28
Outside classroom	1088.95	16.57	825.66	17.71
Total	6568.94	99.99	4661.34	99.99

teaching to higher grade children. Teacher A taught children in lower grades (II and III grades) and Teacher B taught children in the higher grades (IV and V grades). Also, the difference in voicing percentage of two participants may probably be attributed to the differences in the teaching methodology adopted by them or age of the participants or years of teaching experience or the subjects handled on the workday.

The results of this study are in partial agreement with Masuda et al. (1993) who reported that the voicing percentage was 21% in an eight hours workday, considering a somewhat different teacher population. In this study, the obtained average voicing duration of 1 hour 34 minutes is in agreement with the result of Titze, Hunter and Svec (2007) who found in their teachers that the voicing duration was about 1 hour 50 minutes for 8 hours of working day. The comparison indicates that the teachers in this study used their voice the longest duration within shorter period of nearly 6 hours. They used their vocal folds for not less than 82% of their time at classroom teaching and for not more than 17% of their time for non-teaching purposes. It indicates that the voice usage was at maximum inside classroom teaching than outside classroom.

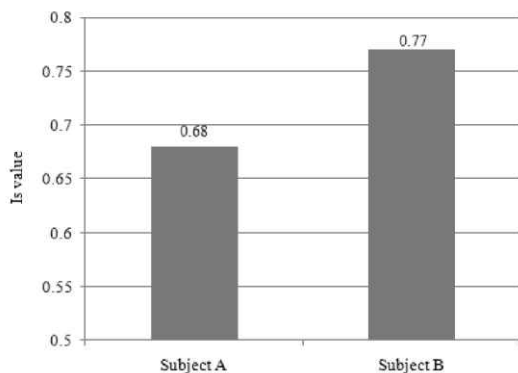


Fig. 4. Short-term vocal recovery index ( $I_s$ ) of Teacher A and B

#### **Short-term vocal recovery index ( $I_s$ )**

The short-term vocal recovery index was 0.68 in teacher A and 0.77 in teacher B. The average short-term vocal recovery index among the two teachers was 0.72. Figure 4 shows the short-term vocal recovery index of teachers A and B. Titze (2002) reported that the short-term vocal recovery index in basketball players was 0.75, boxers was 0.25, opera singers was 0.8, teachers was 0.67, and telephone marketers, 0.3. The results of the present study are in consonance with the findings of Titze (2002). In this study, one has to observe that the lesser the voicing periods, more was the index value (in case of teacher B). The presence of environmental noise was not a problem inside the classroom condition as the external noise was minimal in the classroom. The students maintained silence when the lessons were going on and the classroom was away from sources of noise (traffic, generator, playground etc.). The environmental noise was found to be higher in outside classroom conditions in comparison to the conditions inside the classroom. However, the influence of external noise in the outside class room condition was eliminated by use of the DAT recorder as the microphone of the recorder was close to the mouth of the teachers than the noise sources. The recording focused on the teachers' voice allowing for clear demarcation of the teacher's voice from the external noise in the pitch curve. Figure 5 depicts the waveform and pitch curve of voice/speech sample of teachers in different conditions, where the voicing of the teachers are distinct from the students in the classroom. It can be observed that the recorded speech/voice sample of teachers was not influenced much by external noise. Figure 5 a, b, c, and d depict the voicing periods clearly.

Different equipments for measuring vocal loading with their specifications are shown in

Table 4. The frequency response of the DAT recorder was 100-5000 Hz and it was relatively

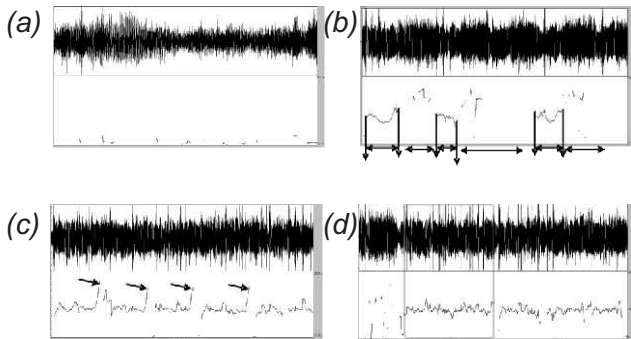


Fig. 5. (a) Background noise when teacher was not speaking in class, (b) Pitch level of teacher (1) and children (2) in the class room, (c) Pitch rising pattern at the word final position of teachers in classroom, and (d) Example of a longer pitch periods (5.597 seconds).

whose frequency response was 50-2000 Hz and Ohlsson, Brink, and Lofquist's (1989) 'voice accumulator' whose frequency response was 60-600 Hz. Voice dosimeter developed by Titze, Hunter, and Svec (2007) picked the laryngeal movements during non-vocalization activities like swallowing, head movement and walking. Another problem reported with the voice dosimeter is (a) the artifact cannot be eliminated from dosimeter and (b) mis-match in impedance between the accelerometer and pocket PC. The proposed method is not an automatic method like the – voice dosimeter, voice accumulator, and speech intensity/time accumulator. The proposed method used a portable DAT recorder suitable for long hours of recording and PRAAT software to extract pitch contours. The total voicing periods were accumulated. This method is time consuming. However, the total duration of recording is the highest in the present method compared to others. Also, the weight of the recorder used in the present study was lighter in comparison to the other devices (Table 4).

better than devices used by Masuda et al.'s (1993), 'speech time/intensity accumulator'

Table 4. Specification of different speech measurement devices

	<i>Present study</i>	<i>Masuda et al. (1993)</i>	<i>Buekers et al. (1995)</i>	<i>Airo et al. (2002)</i>	<i>Popolo et al. (2005)</i>
Maximum measurement duration (hrs)	27	12	12	8	10
Signal pick	condenser microphone (monoaural and omnidirectional)	contact microphone	directional microphones	two dynamic microphones	accelerometer
Weight, (gm)	54 (including battery)	400	600	240	150

### Conclusions

The DAT recorder is easy to use; the device is lightweight and small enough to allow regular workday activities of the teachers. Also, prolonged voice use can be recorded and transferred to PRAAT software where the duration of pitch contours is summed up for the entire sample to get cumulative voicing periods. Truncating and listening to the samples in a window duration of 8-10 seconds and then for the entire 6 hours (21600 seconds) of one workday consumes lot of time. From the results of the present study, one can conclude that the method described in the study is an alternate (low-tech) method of measuring the percentage of voicing duration (the amount of voice use over a period of time) at workplace in contrast to high tech and expensive devices like voice dosimeter, voice accumulator, speech intensity/time accumulator. This procedure can also be used clinically as baseline in voice therapy or vocal abuse reduction programs. Further investigation on the amount of voice usage in other levels of professional voice users is warranted.

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