

Acoustic and Aerodynamic Measures of the Voice During Pregnancy

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Summary: Background. Known influences of sex hormones on the voice would suggest pregnancy hormones could have an effect, yet studies using acoustic measures have not indicated changes. Additionally, no examination of the voice before the third trimester has been reported. Effect of pregnancy on the voice is relatively unexplored yet could be quite relevant to female speakers and singers.

Objectives/Hypothesis. It is possible that spectral and aerodynamic measures would be more sensitive to tissue-level changes caused by pregnancy hormones.

Design/Methods. In this first longitudinal study of a 32-year-old woman's pregnancy, weekly voice samples were analyzed for acoustic (fundamental frequency, perturbation ratios of shimmer and jitter, Harmonic-to-Noise Ratio, spectral measures, and maximum phonation time) and aerodynamic (average airflow, peak flow, AC/DC ratio, open quotient, and speed quotient) parameters.

Results. All measures appeared generally stable during weeks 11–39 of pregnancy compared with 21 weeks postpartum. Slight decrease in minimum airflow and open speed quotient may reflect suspected vocal fold tissue changes.

Conclusions. It is recommended that future studies monitor and test correlations among hormone levels, visual analyses of vocal fold mucosa, aerodynamic function, and glottal efficiency.

Key Words: Voice–Pregnancy–Hormone–Longitudinal.

Estrogen and progesterone fluctuations affect vocal fold histology and voice quality to some degree. Increased estrogen levels have been shown to reduce mucosal viscosity, increase mucus production, and increase blood vessel dilation, whereas increased progesterone levels tend to increase mucosal viscosity, reduce mucosal production, and cause dehydration and thinning of vocal fold mucosa.¹ In women, progesterone is absent before puberty, peaks for childbearing years when it is associated with premenstrual syndromes, and then disappears during menopause. Estrogens contribute to the regulation of menstrual cycles, peaking just before ovulation. The cyclic pattern of these hormones levels disappears during pregnancy. Relatively little is known about any changes in voice that may be associated with overall elevated hormonal levels during pregnancy.

Vocal changes related to hormones have been studied in context of the menstrual cycle, oral contraceptive use, menopause, and third trimester of pregnancy. Within one menstrual cycle, vocal fold epithelial thickness and muscle mass change, resulting in vocal fatigue and reduced vocal intensity, vital capacity, and maximum phonation duration. The ovulatory phase (days 13–15) have the highest level of estrogen and are associated with the best voice quality.² Vocal premenstrual syndrome occurs when estrogen is least and progesterone increases. It can present with edema on the posterior third of the vocal folds, posterior chink, less supple epithelium with decreased vibratory amplitude and symmetry,

and perceptions of a huskier voice, vocal fatigue, loss of high tones, and vocal power.^{1–3} Oral contraception is associated with a more stable voice, perhaps because it eliminates abrupt hormone shifts associated with premenstrual symptoms. However, Morris et al⁴ observed changes in the differences in amplitudes of first and second harmonic (H1-H2), and the differences in amplitudes of the first harmonic and first formant (H1-A1), which correlate to closed quotient and glottal width, respectively, after a 23-year-old woman initiated oral contraceptive medication. The authors concluded that the vocal fold tissue does change during the menstrual cycle, even when oral contraception eliminates natural estrogen spikes.

Two situations do eliminate the hormonal cycle regulating menstruation and therefore may impact the voice: menopause (ie, no progesterone and declining estrogen levels) and pregnancy (ie, elevated hormones and no cyclic pattern). When little to no estrogen is present, vocal fatigue, reduced vocal intensity and range into the high tones, and loss of timbre can occur, as it did for 17 of 100 menopausal women receiving no replacement hormone therapy. Examination of these 17 women revealed thinning of the vocal fold mucosa, reduced amplitude and symmetry, and either unilateral or bilateral atrophy.¹ On the other hand, pregnancy involves major physiologic and anatomic adaptations due to a dramatic increase in hormone levels. Hamdan et al⁵ lists “mucosa, muscles, bone tissue, cerebral cortex, and larynx” as being directly affected by pregnancy hormones. During pregnancy, there is a surge of estrogen and progesterone with loss of the periodic vocal changes typically associated with a menstrual cycle. As pregnancy progresses, changes in posture and lung capacity as well as dehydration, reflux, and swollen vocal folds impact the voice.⁶ Vocal fatigue, hoarseness, decrease in vocal agility, and contracted frequency range are noted by pregnant women, particularly professional voice users who notice and are affected by even subtle changes to their voice.⁵

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The consequences of these changes vary from minute to potentially significant in the case of singers who are often advised to avoid strenuous vocal training or performances during pregnancy. La and Sundberg⁷ conducted a longitudinal study of a 28-year-old classically trained soprano singer during her last trimester of pregnancy and for 11 weeks after the birth of her child. An increase in phonatory threshold pressure and collision threshold pressure were observed during the last trimester of this singer's pregnancy and associated with elevated estrogen and progesterone hormones, which indicate an increase in vocal fold epithelium thickness and tissue viscosity.⁷ Reduced vocal fold motility and increased glottal adduction as the birth approached were associated with perceptible changes in the singer's vocal "brightness."⁷ These changes may not be found in the standard assessment measures of nonsinger speaking voice.

Two studies examined acoustic parameters of the voice during pregnancy in final stage, presumably the time the voice is most impacted by hormonal and physical changes. In a comparison study of 44 third-trimester pregnant women and 45 nonpregnant controls, the pregnant women experienced more breathiness and hoarseness, shorter maximum phonation time (MPT), and an increase in speech intensity.⁶ The control subjects had significantly longer MPT (17.4-second average) compared with the pregnant women (7.5 seconds), even after delivery (8.7 seconds).⁵ However, no differences were found for fundamental frequency, vowel intensity, or perturbation measures. The second study was a within-subject study comparing 25 women's voice samples immediately pre- and postdelivery. Hamden et al⁵ found a decrease in voice turbulence index and increase in MPT occurred in the 12–24 hours after giving birth, but no changes in fundamental frequency or other perturbation measures were significant in this study either.

Evidence of voice changes in pregnancy may appear inconsistent. Known influences of sex hormones on the voice would suggest pregnancy hormones could have an effect, yet studies using acoustic measures have not captured changes, if they exist. La and Sundberg's case⁷ indicating changes in vocal fold tissue and function used aerodynamic measures. Therefore, it is possible that vocal changes during pregnancy

should continue to be explored but using a variety of other measures. The use of spectral measures to indicate glottal function, as described by Hanson⁸ and used by Morris et al⁴ in a study of oral contraception, would provide new information and potentially offer a measure easily obtained in most clinical settings. Additionally, there is no information about the voice before the third trimester.

Understanding how pregnancy affects the voice and the periods when voice is most affected will allow speakers and singers to be informed of why these difficulties are occurring and when a more careful voice habituation is required. Therefore, the purpose of this study is to monitor the voice during pregnancy. Specifically, we ask, "How do acoustic and aerodynamic parameters of voice change over the course of a pregnancy?" We hypothesize that pregnancy will have minimal effect on the acoustic parameters (fundamental frequency and perturbation measures) but measures of airflow reflecting glottal physiology are more likely to reveal effects.

METHODOLOGY

During data collection the participant was a generally healthy 32-year-old woman with normal vocal quality. She had no history of voice problems and never smoked. She was employed as a professor of speech-language pathology, which included teaching lectures and speaking often. She had stopped taking oral contraception 8 months before conception and experienced regular menstrual cycles. During pregnancy she experienced nausea throughout the day, vomiting daily until week 14, and approximately weekly until week 20. She used prescribed Zofran (GlaxoSmithKline, London, UK) from week 8–22. Her food intake was limited, but she aimed to maintain hydration by drinking water. In the last trimester she experienced occasional reflux but only took over-the-counter medication (ie, Tums; GlaxoSmithKline, St. Louis, MO). This was her first pregnancy and she delivered a baby girl at estimated 40 weeks and 1 day gestation. The woman was still breastfeeding at the 21 weeks postpartum recording.

Voice samples were collected from this woman on a weekly basis for the last 30 weeks of her normal pregnancy and at 21 weeks postpartum. With the exception of 3 weeks missed

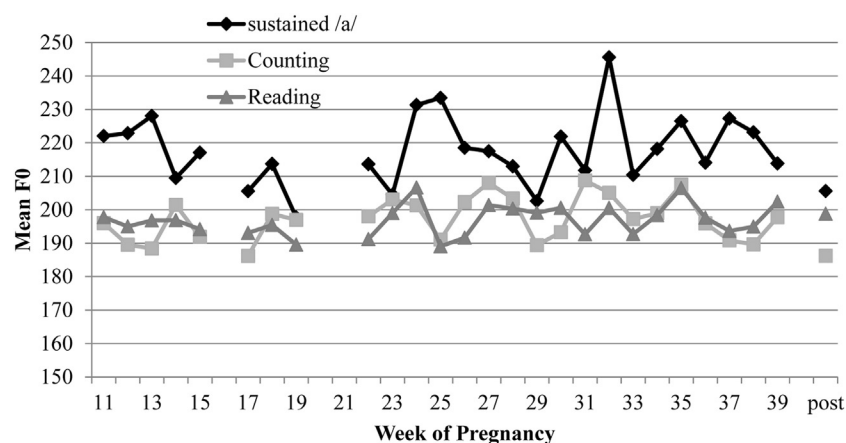


FIGURE 1. Mean fundamental frequency in three speech contexts across the duration of pregnancy and 21 weeks postdelivery.

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