

# The Effects of the Menstrual Cycle on Vibratory Characteristics of the Vocal Folds Investigated With High-Speed Digital Imaging

\*Melda Kunduk, \*Mathew B. Vansant, †Takeshi Ikuma, and †Andrew McWhorter, \*Baton Rouge and †New Orleans, Louisiana

**Summary: Objectives.** This study investigated the effect of menstrual cycle on vocal fold vibratory characteristics in young women using high-speed digital imaging. This study examined the menstrual phase effect on five objective high-speed imaging parameters and two self-rated perceptual parameters. The effects of oral birth control use were also investigated.

**Methods.** Thirteen subjects with no prior voice complaints were included in this study. All data were collected at three different time periods (premenstrual, postmenstrual, ovulation) over the course of one menstrual cycle. For five of the 13 subjects, data were collected for two consecutive cycles. Six of 13 subjects were oral birth control users. From high-speed imaging data, five objective parameters were computed: fundamental frequency, fundamental frequency deviation, harmonics-to-noise ratio, harmonic richness factor, and ratio of first and second harmonics. They were supplemented by two self-rated parameters: Reflux Severity Index and perceptual voice quality rating. Analysis included mixed model linear analysis with repeated measures.

**Results.** Results indicated no significant main effects for menstrual phase, between-cycle, or birth control use in the analysis for mean fundamental frequency, fundamental frequency deviation, harmonics-to-noise ratio, harmonic richness factor, first and second harmonics, Reflux Severity Index, and perceptual voice quality rating. Additionally, there were no interaction effects.

**Conclusions.** Hormone fluctuations observed across the menstrual cycle do not appear to have direct effect on vocal fold vibratory characteristics in young women with no voice concerns. Birth control use, on the other hand, may have influence on spectral richness of vocal fold vibration.

**Key Words:** High-speed videoendoscopy–Menstrual cycle–Vocal fold vibration–Voice–Birth control.

## INTRODUCTION

Premenstrual voice syndrome is a term often used to refer to a set of adverse symptoms reported by women during the menstrual cycle.<sup>1,2</sup> This syndrome, which has been reported to affect 33% of women, is described as a set of characteristics including loss of vocal power, decreased vocal range and flexibility, vocal fatigue, loss of harmonics, and reduction of overall quality.<sup>3</sup> Anatomic or physiological changes including edema, varices, congestion, and decreased vocal fold adduction power have also been described in premenstrual syndrome (PMS).<sup>1</sup> The relationship between the menstrual cycle and the female voice has been studied over the previous decades.<sup>1–10</sup>

The menstrual cycle is an event that occurs naturally in women as the result of hormonal changes, and one cycle is typically experienced every 28 days.<sup>11</sup> This cycle is regulated by an increase or decrease of sex hormones, with the principal hormones being estrogen and progesterone.<sup>11</sup> A visual reference illustrating the typical rise and fall in these hormones, corresponding days of the cycle, and related receptors is provided in [Figure 1](#). Increases in estrogen levels produce a hypertrophic effect (which

may increase the mass of affected tissues), increase capillary permeability (which may increase the risk of bleeding), and increase the flow and thickening of mucous secretions.<sup>1</sup> The concentrations of estrogen are reduced during the premenstrual phase (days 23–28), postmenstrual phase (days 5–10), and the menses period (days 1–4).<sup>12</sup> A decrease in the concentration of estrogen may also result in edema of the tissues via increased tissue permeability, and this effect occurs at the beginning of and following menses (days 1–10).<sup>13</sup> Progesterone acts as an estrogen antagonist and inhibits capillary permeability, thus increasing cellular congestion by trapping intracellular fluids created by the effects of estrogen.<sup>1</sup> Progesterone increases following ovulation and decreases before menses (days 15–28)<sup>11</sup> and also has a potential diuretic effect due to its chemical actions on sodium metabolism, thus having the potential to reduce secretions resulting in dryness.<sup>1</sup> Hormone receptors have been identified in the larynx and true vocal fold tissues through the use of tissue staining techniques.<sup>5</sup> Changes in sex hormone levels and their effects on the tissues have also been observed in the larynx and vocal folds using videostroboscopy, tissue staining, and cytologic smears of vocal fold and laryngeal tissues.<sup>3,14</sup> Additionally, animal modeling has indicated that sex hormones may also reduce the amount and function of neurotransmitters, effectively decreasing the rate of muscle activation in the larynx and vocal folds and potentially reducing the level of muscular precision and tissue sensation.<sup>4,15–17</sup>

Due to the cyclical pattern and changing hormone concentrations during the female menstrual cycle, it is assumed that any effect on the vibratory characteristics of the vocal folds will be

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From the \*The Department of Communication Sciences and Disorders, Louisiana State University, Baton Rouge, Louisiana; and the †Department of Otolaryngology-Head and Neck Surgery, Louisiana State University Health Sciences Center, New Orleans, Louisiana.

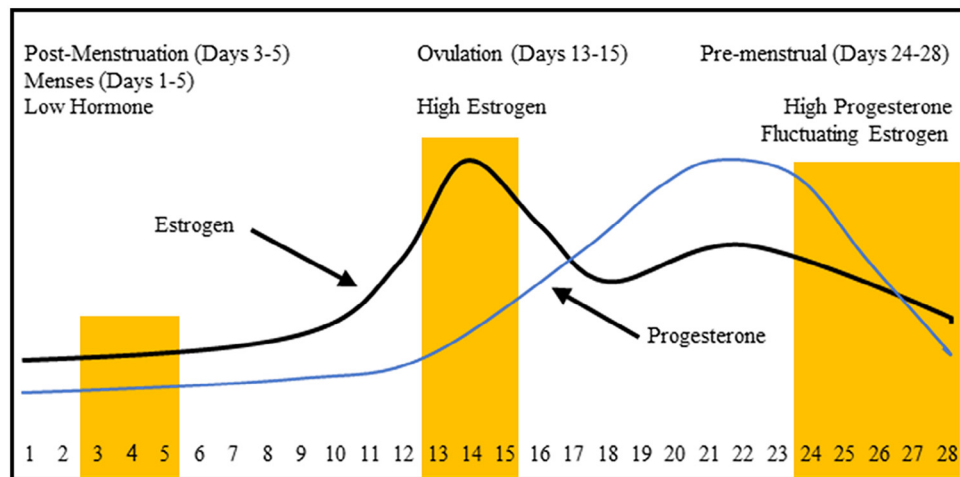
Address correspondence and reprint requests to Melda Kunduk, The Department of Communication Sciences and Disorders, Louisiana State University, 68 Hatcher Hall, Field House Drive, Baton Rouge, LA 70803. E-mail: [mkunduk@gmail.com](mailto:mkunduk@gmail.com)

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**FIGURE 1.** Visual representation of the menstrual cycle and fluctuation of hormone levels.

transient and more likely to occur during specific time periods of the cycle. Higgins and Saxman<sup>4</sup> examined both women (all of whom were not on birth control) and men using acoustic measurements taken from voice recordings across a 33-day period. They found that men's vocal fold function was stable across time, but women had noticeable increases in perturbation (jitter) only at the ovulation phase of the menstruation cycle. The evidence of micro varices and edema on true vocal folds were reported at the premenstrual phase.<sup>3</sup> Another study reported the effects of different periods during the menstrual cycle on perceptual voice characteristics.<sup>9</sup> Chae and colleagues reported differences in voice characteristics during premenstrual and ovulation phases only for those women reporting positive non-voice-related premenstrual symptoms as measured by the Diagnostic and Statistical Manual of Mental Disorders.<sup>6</sup> Ryan and Kenny<sup>8</sup> examined the perceived effects of the menstrual cycle on the female singer's voice. Results of the study indicate that the singer's perceived voice quality was rated lower during days 24–4 (premenstrual and during menses) of the menstrual cycle. Studies have also reported the potential positive influence of oral contraceptives on voice characteristics<sup>7,18–21</sup>, and there were no differences in the voice characteristics based on oral birth control type.<sup>20</sup>

It appears that, as a result of sex hormone fluctuations during a menstrual cycle, anatomic or physiological changes in the vocal folds may occur. However, the current literature presents minimal objective quantification of vocal fold vibratory characteristics during a menstrual cycle. The primary aim of the current study was to determine the effect of hormonal fluctuations on vocal fold vibratory characteristics within and between the menstrual cycle in young women via high-speed videoendoscopy (HSV). The study was designed to seek for the presence and degree of change of vocal fold vibratory characteristics due to natural fluctuations of hormones. HSV allows an objective quantitative investigation of vocal fold vibratory characteristics with its ability to capture the vibratory characteristics within a glottic cycle. This imaging tool enables observations of subtle changes, which may not be observable with other laryngeal imaging tools such as videostroboscopy. The study also investigated if the vocal fold vibratory characteristics would be different for subjects using

birth control. Additionally, self-reported perceptual voice quality and reflux measures were included due to perceptual voice changes reported during the menstrual cycle, and the potential for interaction between reduced vocal fold function and reflux.<sup>22</sup>

## METHODS

### Subjects

Fifteen female subjects between 20 and 28 years of age from Louisiana State University (LSU), all postpubescent, were recruited into the study. The study was approved by the LSU-Institutional Review Board. Inclusion criterion was no complaint of dysphonia (voice problems) before the study. Of the 15 subjects, 13 were included in the study analysis for completing a full cycle of data; 2 subjects were excluded from the study analyses due to incomplete data. Five subjects returned for data collection for a second cycle. Six of the 13 study subjects were using oral contraception. These factors are summarized in Table 1. Subjects on birth control had all been using oral contraception for at least 3 months before study enrollment.

### Data collection

Following the consent from subjects, the beginning of their last menstruation date was determined, and the data collection timeline was established on the calendar. Each subject was asked to visit LSU for HSV data collection three times during each menstrual cycle: premenstruation (1–5 days before expected onset of menses, ie, days 24 through 28 of the menstrual cycle); at ovulation (between days 13 and 15 of the menstrual cycle); and postmenstruation (post onset of menses, days 3–5 of the menstrual cycle). The premenstruation phase is the time associated with PMS and premenstrual voice syndrome,<sup>1</sup> whereas the ovulation phase is when hormone levels are high and may fluctuate rapidly.<sup>4</sup> Lastly, the postmenstruation phase is when estrogen and progesterone levels are typically low.<sup>23</sup>

All data were collected by two trained and experienced speech-language pathologist with knowledge and experience using the HSV equipment. HSV data were collected with a 70° rigid laryngoscope (Model 9106, KayPentax, Montvale, NJ) with HSV

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