

Original Study Article

DOI: <https://doi.org/10.17816/fopr677181>

EDN: DUHPIZ

Acoustic Voice Analysis in Different Menstrual Cycle Phases

Marina A. Ryabova, Maria S. Grigorieva

Pavlov First Saint Petersburg State Medical University, Saint Petersburg, Russia

ABSTRACT

BACKGROUND: The female body is under the constant influence of sex hormones. In this case, the larynx is no exception—sex steroid hormone receptors are located on the vocal folds. Thus, during the menstrual cycle, the voice also experiences cyclical changes, which is particularly important for professional voice users. Today, the use of hormonal contraceptives is increasing; they suppress hormonal peaks and it may cause cyclical voice changes.

AIM: To analyse acoustic voice changes in women with a natural menstrual cycle and hormonal contraception users.

METHODS: The voices of 15 females aged 21–28 years, including six females using hormonal contraception, were recorded at menstruation and late follicular and luteal phases. The menstrual cycle phases were determined using a calendar. Acoustic analysis was performed in the Praat software (6.4.21). The following parameters were studied: fundamental frequency, including the highest and the lowest pitch; voice intensity; perturbation measurements (jitter and shimmer); Harmonic-to-Noise-Ratio, and maximum phonation time.

RESULTS: Women with a natural menstrual cycle had cyclical voice changes, including a lower voice quality during menstruation and a higher voice pitch in the late follicular phase. There are no voice changes in hormonal contraception users during the menstrual cycle.

CONCLUSION: The study proves the influence of sex hormones on acoustic voice parameters.

Keywords: acoustic voice analysis; acoustic parameters; voice; menstrual cycle.

To cite this article

Ryabova MA, Grigorieva MS. Acoustic Voice Analysis in Different Menstrual Cycle Phases. *Folia Otorhinolaryngologiae et Pathologiae Respiratoriae*. 2025;31(1):34–39. DOI: 10.17816/fopr677181 EDN: DUHPIZ

Submitted: 15.03.2025

Accepted: 27.05.2025

Published online: 30.06.2025

Оригинальное исследование

DOI: <https://doi.org/10.17816/fopr677181>

EDN: DUHPIZ

Акустический анализ женского голоса в разные фазы менструального цикла

М.А. Рябова, М.С. Григорьева

Первый Санкт-Петербургский государственный медицинский университет им. акад. И.П. Павлова, Санкт-Петербург, Россия

АННОТАЦИЯ

Обоснование. Женский организм находится под постоянным влиянием половых гормонов. При этом гортань не исключение — на голосовых складках расположены рецепторы к половым стероидам. Следовательно, в течение менструального цикла также можно ожидать наличие циклических изменений голоса, что особо актуально для лиц голосоречевых профессий. В настоящее время растет частота применения гормональных контрацептивов, механизм действия которых сопряжен с подавлением гормональных пиков, что может оказывать влияние на наличие циклических изменений голоса.

Цель — анализ изменения акустических параметров голоса среди женщин с естественным менструальным циклом и женщин, использующих гормональные контрацептивы.

Методы. Голоса 15 женщин в возрасте 21–28 лет, из которых 6 использовали гормональную контрацепцию, были записаны в фазу менструации, позднюю фолликулярную и лютеиновую фазы. Фазы менструального цикла определяли календарным методом. Акустический анализ данных проводили в программе Praat (6.4.21). Исследовали следующие параметры: частота основного тона, в том числе минимальная и максимальная, сила голоса, частотная нестабильность голоса и амплитудная, соотношение гармонических и шумовых компонентов, время максимальной фонации.

Результаты. У женщин с естественным менструальным циклом отмечены изменения голоса в течение цикла: снижение качества голоса в период менструации, более высокий голос в позднюю фолликулярную фазу. У женщин, использующих гормональную контрацепцию, изменения голоса в течение менструального цикла отсутствуют.

Заключение. Полученные результаты доказывают наличие влияния уровня половых гормонов на акустические параметры голоса.

Ключевые слова: акустический анализ голоса; акустические параметры голоса; менструальный цикл; голос.

Как цитировать

Рябова М.А., Григорьева М.С. Акустический анализ женского голоса в разные фазы менструального цикла // Folia Otorhinolaryngologiae et Pathologiae Respiratoriae. 2025. Т. 31. № 1. С. 34–39. DOI: [10.17816/fopr677181](https://doi.org/10.17816/fopr677181) EDN: DUHPIZ

BACKGROUND

The female body is under the constant influence of sex hormones: in early days of the menstrual cycle, low levels of estradiol and progesterone are observed, whereas the late follicular phase is characterized by high estradiol levels, and the luteal phase by high progesterone levels [1]. In this case, the larynx is no exception—sex steroid hormone receptors are located on the vocal folds: estrogen and progesterone receptors are located in the epithelium and *lamina propria* of the vocal folds, whereas androgen receptors are also present in the muscle layer [2]. It is postulated that histological changes in the endometrium are similar to those in the larynx: estrogens promote cellular proliferation, influence the vascular tone and gland secretion, making it waterier and the mucous membranes more elastic. As for progesterone, it has an anti-proliferative effect, reduces gland activity and mucus secretion (making it thicker), contributes to mucosal edema, and decreases smooth muscle tone [3]. At periods of low estrogen and progesterone levels (menstruation), blood vessel spasms occur in the endometrium, leading to the desquamation phase.

Therefore, cyclical voice changes can also be expected during the menstrual cycle. These changes are particularly relevant for professional voice users. A study was conducted, in which professional singers recorded their mood and voice quality changes throughout a menstrual cycle: along with decreased mood in early days of the cycle, they also observed a decline in voice quality and the need for extra effort to reach higher registers. However, vocal coaches did not detect any noticeable differences in performance during the same period [4].

Today, the use of hormonal contraceptives is increasing; they suppress hormonal peaks, which may cause cyclical voice changes [5].

It has been proven that excess androgens reduce the fundamental frequency, but there is still no consensus regarding the acoustic parameters affected by changes in estrogen and progesterone levels [6].

The study is aimed at analyzing acoustic voice changes in women with a natural menstrual cycle and hormonal contraception users.

METHODS

The study involved 15 women aged 21–28 years, with no respiratory or ENT pathologies, non-smokers, and not professional voice users. The first group was made up of 9 women with a natural, regular menstrual cycle, whereas the second group included 6 women using monophasic hormonal contraceptives.

Voices were recorded every 4 days, with subsequent determination of menstrual cycle phases using the calendar

method, assuming an average cycle duration of 28 days. For further analysis, recordings corresponding to the menstrual phase (first 4 days of the cycle), late follicular phase (days 10–14), and luteal phase (days 19–24) were selected. Only women without signs of acute respiratory infections were allowed to participate in voice recording. The study was conducted in a relatively soundproof room using a microphone with the frequency range of 50 to 15,000 Hz at the distance of 25 cm. The participants pronounced five words: “par” (пар), “ghen” (ген), “tik” (тик), “lyuk” (люк), and “tok” (ток).

Acoustic analysis was performed in the Praat software (version 6.4.21). The following parameters were studied: fundamental frequency (F_0), including the lowest ($F_{0\ min}$) and the highest ($F_{0\ max}$) pitch; voice intensity for the sequence of five words; frequency perturbation (jitter) and amplitude perturbation (shimmer); Harmonic-to-Noise Ratio (HNR) for the vowel [a] in the word “par”; maximum phonation time (MPT) for the vowel [i] in the word “tik” during expiratory phonation [7, 8].

Statistical analysis was performed using the Microsoft Excel software. The Shapiro–Wilk test was used to assess the normality of distribution. Separate analyses were conducted for each group using the Student’s *t*-test. For inter-group comparisons, the Welch’s *t*-test was used. The level of $p \leq 0.05$ was considered as statistically significant.

RESULTS

The study revealed that women with a natural menstrual cycle showed an increase in $F_{0\ min}$ during the late follicular phase versus the menstrual phase ($p = 0.03$); during the menstrual phase, they demonstrated decreased HNR values relative to both the late follicular ($p = 0.031$) and luteal phases ($p = 0.034$), along with reduced MPT ($p = 0.036$) (see Table 1).

In contrast, there were no voice changes in hormonal contraception users during the menstrual cycle (see Table 2).

Comparative analysis between the two groups revealed the following differences: women with a natural menstrual cycle demonstrated higher $F_{0\ max}$ and $F_{0\ min}$ values during the follicular phase than hormonal contraception users ($p = 0.022$ and $p = 0.05$, respectively), whereas women with a natural menstrual cycle showed slightly lower HNR values during menstruation ($p = 0.059$) relative to the second group.

DISCUSSION

The study identified cyclical changes in acoustic parameters in women with a natural menstrual cycle. During menstruation, when estradiol and progesterone

Table 1. Acoustic voice parameters during menstrual cycle in women with natural menstrual cycle**Таблица 1.** Акустические параметры голоса в течение менструального цикла среди женщин с естественным менструальным циклом

Parameters	Menstrual phase		Late follicular phase		Luteal phase	
	<i>M</i>	95% CI	<i>M</i>	95% CI	<i>M</i>	95% CI
F_0 , Hz	217.05	206.74–227.36	214.16	203.83–224.49	210.37	200.13–220.62
$F_{0\text{ min}}$, Hz	143.47	109.99–176.95	179.50	169.74–189.25	172.45	165.45–179.44
$F_{0\text{ max}}$, Hz	294.82	285.80–303.84	283.14	262.29–303.99	279.55	255.12–303.99
Intensity, dB	69.16	66.64–71.67	66.82	64.63–69.02	68.32	66.27–70.36
Jitter, %	1.10	0.89–1.31	1.03	0.79–1.26	1.12	0.94–1.30
Shimmer, dB	0.567	0.463–0.670	0.522	0.416–0.629	0.506	0.374–0.638
HNR, dB	17.36	15.01–19.71	20.34	18.61–22.08	20.25	18.54–21.96
MPT, s	16.78	14.80–18.76	19.11	17.79–20.44	19.00	17.4–20.6

Note (and hereinafter in the tables). F_0 means the fundamental frequency, including the lowest ($F_{0\text{ min}}$) and the highest ($F_{0\text{ max}}$) pitch; Intensity means the voice intensity; Jitter means the frequency perturbation; Shimmer means the amplitude perturbation; HNR means the Harmonic-to-Noise Ratio; MPT means the maximum phonation time; *M* means the mean value; 95% CI means the mean confidence interval.

Table 2. Acoustic voice parameters during menstrual cycle in hormonal contraception users**Таблица 2.** Акустические параметры голоса в течение менструального цикла среди женщин, использующих гормональную контрацепцию

Parameters	Menstrual phase		Late follicular phase		Luteal phase	
	<i>M</i>	95% CI	<i>M</i>	95% CI	<i>M</i>	95% CI
F_0 , Hz	201.58	193.67–209.48	206.09	197.57–214.60	211.28	206.34–216.21
$F_{0\text{ min}}$, Hz	129.23	93.83–164.63	156.13	137.40–174.85	158.33	135.62–181.05
$F_{0\text{ max}}$, Hz	251.15	237.70–264.61	249.58	232.59–266.57	257.23	246.03–268.42
Intensity, dB	66.03	63.95–68.12	67.38	64.99–69.77	69.05	66.52–71.58
Jitter, %	1.04	0.74–1.34	0.88	0.80–0.96	0.94	0.81–1.07
Shimmer, dB	0.540	0.413–0.666	0.505	0.437–0.573	0.514	0.398–0.631
HNR, dB	19.62	18.71–20.52	20.85	18.63–23.08	20.48	18.58–22.39
MPT, s	16.63	15.33–17.94	17.83	16.79–18.88	17.50	15.97–19.03

levels are low, the voice becomes somewhat lower-pitched (decreased minimum fundamental frequency), and the voice quality is reduced (diminished HNR values, shorter MPT). In contrast, the late follicular phase—marked by elevated estradiol levels—was associated with an increased minimum fundamental frequency, resulting in a higher-pitched voice. A higher-pitched voice is perceived as more feminine and attractive; during the follicular phase, the conception probability is known to be higher, which may represent a biological mechanism that promotes reproductive success through acoustic voice parameters. Notably, the participants reported no subjective awareness of voice changes, though this group omitted professional voice users.

Account of these cyclical changes should be taken when comparing and evaluating the efficacy, including through acoustic analysis, of various laryngeal treatment methods: observations need to be conducted during identical menstrual cycle phases.

The study found no cyclical changes in acoustic parameters among hormonal contraception users during the menstrual cycle, which is accounted for by the absence of sex hormone level fluctuations typical for a natural menstrual cycle. Comparative analysis revealed that women with a natural menstrual cycle demonstrated higher maximum and minimum fundamental frequency values. Whether this constitutes an advantage of a natural menstrual cycle remains debatable, as the authors established that acoustic parameters of hormonal contraceptive users are relatively stable and—considering the HNR value, which was slightly higher during menstruation in the second group—even more consistent.

Future studies need to focus on professional voice users, as the existing survey data indicates that they demonstrate greater sensitivity to vocal changes [9, 10]. On top of that, incorporating laryngoscopy and laryngostroboscopy would provide valuable visualization of potential changes and vibration patterns of the vocal folds [11].

CONCLUSION

Women with a natural menstrual cycle demonstrate cyclical voice changes, including a lower voice quality during menstruation and a higher voice pitch in the late follicular phase. There are no voice changes in hormonal contraception users during the menstrual cycle. The study proves the influence of sex hormones on acoustic voice parameters.

ADDITIONAL INFORMATION

Author contributions: M.A. Ryabova: conceptualization, investigation, formal analysis, validation, writing—review & editing; M.S. Grigorieva: formal analysis, investigation, writing—review & editing, writing—original draft. All authors approved the version of the manuscript to be published, and agreed to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of it are appropriately reviewed and resolved.

Ethics approval: The study was approved by the local Ethics Committee of the Pavlov First Saint Petersburg State Medical University (Protocol No. 303 dated June 30, 2025). The study and its protocol were not registered.

Consent for publication: All participants provided written informed consent for the publication of their medical data.

Funding source: The authors declare no external funding was received for conducting the study or publishing the article.

Disclosure of interests: The authors have no relationships, activities, or interests over the past three years related to for-profit or not-for-profit third parties whose interests may be affected by the content of the article.

Statement of originality: The authors did not use any previously published information (text, data) in this work.

Data availability statement: All data generated during this study are included in this article.

Generative AI: Generative AI technologies were not used for this article creation.

Provenance and peer-review: This work was submitted unsolicited and reviewed following the standard procedure. The peer review process involved two in-house reviewers.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. М.А. Рябова — проверка критически важного содержания, редактирование, внесение окончательной правки, утверждение рукописи для публикации, сбор и обработка материала, концепция исследования; М.С. Григорьева — анализ полученных данных, обзор литературы, внесение окончательной правки, написание текста. Все авторы одобрили рукопись, а также согласились нести ответственность за все аспекты работы, гарантируя надлежащее рассмотрение и решение вопросов, связанных с точностью и добросовестностью любой ее части.

Этическая экспертиза. Проведение исследования одобрено локальным этическим комитетом Первого Санкт-Петербургского государственного медицинского университета имени академика И.П. Павлова (протокол № 303 от 30.06.2025). Исследование и его протокол не регистрировали.

Согласие на публикацию. Авторы получили письменное согласие пациентов на публикацию медицинских данных.

Источники финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Раскрытие интересов. Авторы заявляют об отсутствии отношений, деятельности и интересов за последние три года, связанных с третьими лицами (коммерческими и некоммерческими), интересы которых могут быть затронуты содержанием статьи.

Оригинальность. При создании настоящей работы авторы не использовали ранее опубликованные сведения (текст, данные).

Доступ к данным. Все данные, полученные в настоящем исследовании, доступны в статье.

Генеративный искусственный интеллект. При создании настоящей статьи технологии генеративного искусственного интеллекта не использовались.

Рассмотрение и рецензирование. Настоящая работа подана в журнал в инициативном порядке и рассмотрена по обычной процедуре. В рецензировании участвовали два внутренних рецензента.

REFERENCES

1. Ailamazyan EK, Ryabtseva IT, Yakovlev VG. *Gynecology*. Saint Petersburg: SpetsLit; 2013. P. 22–30. ISBN: 978-5-299-00527-12 (In Russ.)
2. Pu S, Johnson S, Martin L, et al. Cellular and molecular effects of steroid sex hormones on the vocal folds: A scoping review. *Laryngoscope*. 2025;135(2):540–554. doi: 10.1002/lary.31771 EDN: ICVZUF
3. Amir O, Biron-Shental T. The impact of hormonal fluctuations on female vocal folds. *Curr Opin Otolaryngol Head Neck Surg*. 2004;12(3):180–184. doi: 10.1097/01.moo.0000120304.58882.94 EDN: MDJIQV
4. Ryan M, Kenny DT. Perceived effects of the menstrual cycle on young female singers in the Western classical tradition. *J Voice*. 2009;23(1):99–108. doi: 10.1016/j.jvoice.2007.05.004
5. Kuznetsova IV, Burchakov DI. Control of the menstrual cycle: a new concept of the use of combined oral contraceptives. *Obstetrics and Gynecology*. 2016;(10):132–137. doi: 10.18565/aig.2016.10.132-37 EDN: XBJGZF
6. Danilowicz K, Albiger N, Vanegas M, et al. Androgen-secreting adrenal adenomas. *Obstet Gynecol*. 2002;100(5 Pt 2):1099–1102. doi: 10.1016/s0029-7844(02)02098-7
7. Ryabova MA, Karpishchenko SA, Ermakov VN. Acoustic analysis of voice in chronic laryngeal stenosis. *Russian Otorhinolaryngology*. 2002;(1):85. (In Russ.)
8. Karpishchenko SA, Vasilyeva EV. Methods of comprehensive examination of voice function. *News of Otorhinolaryngology and Logopatologiya*. 2002;(1):72. (In Russ.)
9. Boulet MJ, Oddens BJ. Female voice changes around and after the menopause—an initial investigation. *Maturitas*. 1996;23(1):15–21. doi: 10.1016/0378-5122(95)00947-7
10. Chernobelsky SI. A study of menses-related changes to the larynx in singers with voice abuse. *Folia Phoniatri Logop*. 2002;54(1):2–7. doi: 10.1159/000048591 EDN: PGICIK
11. Ryabova MA, Ulupov MY, Stepanova VA. The role of anti-reflux therapy in preparing patients for phonosurgical intervention. *Folia Otorhinolaryngologiae et Pathologiae Respiratoriae*. 2024;30(1):77–85. doi: 10.33848/fopr626942 EDN: OCKSPV

AUTHORS INFO

*** Marina A. Ryabova**, MD, Dr. Sci. (Medicine), Professor;
address: 6–8 Lva Tolstogo St., Saint Petersburg, 197022, Russia;
ORCID: 0000-0002-6714-9454;
eLibrary SPIN: 3951-7190;
e-mail: marinaryabova@mail.ru

Maria S. Grigorieva;
ORCID: 0009-0000-8250-0372;
eLibrary SPIN: 4212-6175;
e-mail: grigorievam4sha@yandex.ru

* Corresponding author / Автор, ответственный за переписку

ОБ АВТОРАХ

*** Рябова Марина Андреевна**, д-р мед. наук, профессор;
адрес: Россия, 197022, Санкт-Петербург, ул. Льва Толстого, д. 6–8;
ORCID: 0000-0002-6714-9454;
eLibrary SPIN: 3951-7190;
e-mail: marinaryabova@mail.ru

Григорьева Мария Сергеевна;
ORCID: 0009-0000-8250-0372;
eLibrary SPIN: 4212-6175;
e-mail: grigorievam4sha@yandex.ru