Do Oral Contraceptives Improve Vocal Quality? Limited Trial on Low-Dose Formulations

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OBJECTIVE: To evaluate the effect of low-dose monophasic oral contraceptives on female vocal quality.

METHODS: Acoustic voice parameters of six women who use oral contraceptives and six women who do not were evaluated repeatedly during the menstrual cycle. Frequency and amplitude variations were measured using a computerized voice analysis program. Repeated-measures analysis of variance was performed to test differences between groups for each acoustic voice parameter.

RESULTS: Vocal stability among the women who use oral contraceptives was significantly better than among those who did not use oral contraceptives ($P < .05$). Specifically, amplitude and frequency variations between successive vocal cycles were smaller in women using oral contraceptives in comparison with the control group (.24 dB versus .37 dB and .86% versus 1.27% for amplitude and frequency variations, respectively).

CONCLUSION: Contrary to the reports of adverse effects that high-dose pills have on voice, low-dose oral contraceptives show a favorable influence on voice in young women. (Obstet Gynecol 2003;101:773–7. © 2003 by The American College of Obstetricians and Gynecologists.)

The relationship between the human larynx and ovarian hormones has been previously investigated. Studies have shown similarities between cytologic smears of the vocal fold epithelium and cervical smears during the menstrual cycle.[1] Others have discovered receptors for androgen, estrogen, and progesterone in the human vocal fold, specifically in the pharyngolaryngeal mucosa and epithelium.[2,3] The effect of these hormones on the human voice has been demonstrated in studies of endocrine dysfunction as well as in studies on the female hormonal cycles. Endocrine dysfunction of the hypophysis, thyroid, adrenal gland, testicles, and ovaries resulted in voice changes, such as vocal instability, lower pitch, and hoarseness.[1] In addition, hormonal treatment with an androgenic effect (eg, danazol) is known to potentially cause irreversible vocal changes.[4,5]

The effect of hormonal changes on the voice of healthy women was typically investigated either during menopause or during the menstrual cycle. In menopause, voice changes include lowered vocal pitch and decreased vocal control and stability.[6] These changes are explained by the decrease in serum levels of estrogen and progesterone and an increase of androgen dominance during the menopausal transition. This, in turn, causes a decrease in elasticity of the connective and mucosal tissues,[6] which increases the vibrating mass of the vocal cords,[7,8] thus lowering vocal pitch. For those women, however, who received hormone replacement therapy, vocal changes during menopause were minimized.[9]

During the menstrual cycle, women reported on changes in voice quality at the premenstrual phase[10,11] or prior to ovulation.[12] During the premenstrual phase, venous dilatation and edema increase vocal cord mass, thus lowering the vocal pitch.[1,13] In addition, fluctuations in ovarian hormones levels were found to affect laryngeal neuromotor control through afferent and efferent processes.[12] Such alterations in laryngeal neuromotor control result in increased vocal instability, which can be perceived by the listener as pitch and/or amplitude modulations.

The introduction of oral contraceptives has allowed for an additional opportunity to investigate the effect of hormones on voice. Contraceptive pills maintain constant levels of both estrogen and progesterone hormones through the menstrual cycle, thus preventing ovulation. Therefore, it is expected that women who use pills will show smaller voice changes through the menstrual cycle, compared with women who do not use the pills. Early reports, however, included occasional adverse androgenic voice changes.[14] These were explained by the high hormonal doses causing a virilization effect owing to the androgenic derivatives of progestins.[15] This has led oto-

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laryngologists and voice teachers to discourage voice performers from using birth control pills.[16–19] Today, however, low hormonal doses are commonly used in oral contraceptives. The only study that examined voice in women who use low-dose oral contraceptives reported no voice changes while using subjective evaluation.[14] It is the purpose of the present study to expand on the limited knowledge regarding the effect of modern (low hormonal dose) pills on the voice of healthy women, using objective acoustic measures.

MATERIALS AND METHODS

Thirty-four young women, students at Tel-Aviv University, volunteered to serve as participants in this study. After obtaining the approval from our institutional review board and verbal and written consent from all participants, an initial screening was conducted. The first consecutive six women who used birth control pills and the first six women who did not, and who also fulfilled the inclusion criteria described below, were chosen for participation in the study and were regarded as the two groups. The first group (Pill) consisted of six women who used birth control pills, had a mean age of 23.8 years (range: 22–25), a mean weight of 57.3 kg (range: 52–66), and a mean height of 166.3 cm (range: 160–173). Of the six women in this group, four were using the oral contraceptive Meliane (Schering AG, Berlin, Germany), with 0.075 mg gestodene and 0.02 mg ethinylestradiol; the other two women were using Gynera (Schering), with 0.075 mg gestodene and 0.03 mg ethinylestradiol. Because these two preparations are so similar in composition, it was assumed that they would not have different effects, and they were therefore regarded as one group. All women in this group were aware of the content of their pills, and all reported no omission in pill taking during the time of the study. The second group (Natural) consisted of six women who did not use any oral or other hormonal contraceptives before or during the time of the study. This group had a mean age of 21.6 years (range: 21–23), a mean weight of 54.2 kg (range: 43–70), and a mean height of 160.6 cm (range: 153–170).

Speakers' physical characteristics (height, weight, body mass) are not considered to affect voice quality.[20] Nevertheless, to rule out the possibility that physical characteristics biased the results, an independent-sample *t* test was used to evaluate weight, height, and age differences between the two groups. No significant differences were found between the two groups for weight and height ($P > .05$). The age difference between the two groups was statistically significant ($P < .05$) but was small in magnitude (approximately 2 years). Such small age difference is considered negligible for voice evaluation in that age group.

Speech and voice disorders were ruled out by assessments performed by two experienced speech and language pathologists as well as by self-report. In addition, all participants had no history of formal singing or voice training, smoking or substance abuse, reported hormonal imbalances, pregnancies, and neurologic problems. All women were healthy, with no remarkable medical history, and with regular menses and menstrual cycles of 28–32 days.

All women were recorded repeatedly over a period of 40 days (typically 1–2 menstrual cycles). Although our primary research question focused on the effect of oral contraceptives on voice, we still wanted to consider the possible confounding factor of menstruation-cycle-effect on our measurements. To obtain data from the days preceding menses in comparison with the remaining days of the menstrual cycle, each participant reported the onset of menses. Based on these reports, the 4 days before menses were regarded as one interval. The remaining days of the menstrual cycle were divided into five additional equal intervals to enable statistical analysis. Each participant was recorded at least twice during each interval (typically three to four times), totaling approximately 20 recordings per subject.

During the individual recording sessions, participants were instructed to sustain the Hebrew vowels /i/ (as in "heed") and /a/ (as in "father") in isolation, twice for 3–5 seconds. These vowels were selected as representing two distinct articulatory gestures in many languages,[21] as well as in Hebrew,[22] and because they are clinically utilized for evaluation of vocal quality. For each recording session, the participant was seated in a quiet room; with a Sony (Tokyo, Japan) ECM-T150 headset–microphone attached approximately 5 cm from her mouth. The signal was stored onto TDK (Tokyo, Japan) DC4-90R digital data cartridges using a Sony TCD-D100 digital audio tape recorder, with a sampling rate of 44.1 kHz. Following the recordings, each vowel was fed independently to a voice analysis computer program (Kay Elemetrics [Lincoln Park, NJ] Computerized Speech Lab, Model 4300B). A more detailed description of the recording procedure can be found in a preliminary study.[23]

Figure 1 illustrates a sample segment of a voice signal. This visualization method is typically regarded as a "time–wave" display. Each vocal cycle within this sample segment is marked with a two-sided numbered arrow.

Three acoustic parameters were measured for each vowel. The first parameter was mean fundamental frequency. *Mean fundamental frequency* is defined as the number

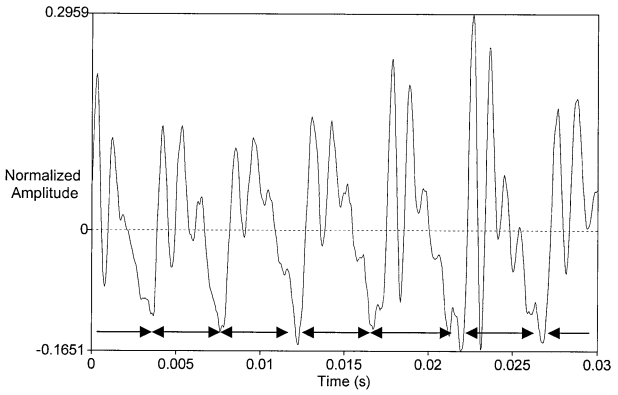

Figure 1. Sample of a voice signal during the production of the vowel /a/. Each voicing cycle within this sample is marked by a two-sided arrow. Note that the durations of the cycles are not equal in length, suggesting variability in frequency (jitter). Similarly, amplitude is not constant throughout this sample wave-form, suggesting variability in amplitude (shimmer).

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of vocal cycles (as shown in Figure 1) produced per second (in Hz). This parameter determines the pitch perceived by the listeners. The second parameter was frequency stability, which was evaluated using the jitter measurement. *Jitter* is defined as the amount of frequency variation (in %) between successive vocal cycles, derived by comparing the duration of the different cycles (in Figure 1, for example, comparing cycle 1 with cycle 2, cycle 2 with cycle 3, etc). The third parameter was amplitude stability, which was evaluated using the shimmer measurement. *Shimmer* is defined as the amount of amplitude variation (in dB) between successive vocal cycles. Note that small variation of jitter and shimmer measurements are typically associated with more stable and healthier voice, whereas higher values are associated with disordered voice.[21] Specifically, data were statistically analyzed using separate repeated-measures analyses of variance for each acoustic variable. In these analyses, Vowel (/i/ and /a/) and Interval (1 through 6) were treated as repeated factors and Group (Pill and Natural) as the between-subjects factor. All statistical analyses were performed with SPSS for Windows 9.0.1 (SPSS Inc., Chicago, IL).

RESULTS

Group means were obtained for each acoustic parameter, at each interval and vowel. These are presented in Table 1.

Table 1. Values of Mean Fundamental Frequency, Jitter, and Shimmer of the Pill and Natural Groups for the Vowels /i/ and /a/ at Each of the Six Recording Intervals in the Menstruation Cycle

			Interval					
Vowel	Parameter	Group	1	2	3	4	5	6
/i/	F0 (Hz)	P	224.15	225.43	223.34	227.66	220.26	222.52
			(17.90)	(22.12)	(21.17)	(22.54)	(16.80)	(19.67)
		N	219.12	222.88	221.68	221.86	221.34	221.76
			(22.09)	(19.95)	(21.85)	(22.70)	(25.92)	(26.34)
	Jitter (%)	P	.81	.86	.85	.89	.77	.69
			(.21)	(.25)	(.27)	(.31)	(.14)	(.16)
		N	1.11	1.17	1.10	1.21	1.25	1.27
			(.48)	(.70)	(.50)	(.63)	(.59)	(.70)
	Shimmer (dB)	P	.23	.23	.24	.21	.23	.23
			(.02)	(.03)	(.04)	(.02)	(.03)	(.03)
		N	.37	.36	.35	.36	.37	.35
			(.11)	(.20)	(.10)	(.11)	(.15)	(.14)
/a/	F0 (Hz)	P	216.35	213.89	209.71	217.83	209.63	213.18
			(9.50)	(12.50)	(13.18)	(11.46)	(10.26)	(11.31)
		N	211.62	212.21	213.91	211.54	214.47	217.33
			(27.55)	(25.97)	(27.12)	(28.23)	(31.30)	(29.01)
	Jitter (%)	P	.95	.88	.87	.96	.93	.85
			(.23)	(.15)	(.13)	(.23)	(.14)	(.17)
		N	1.36	1.35	1.35	1.35	1.46	1.25
			(.38)	(.37)	(.41)	(.23)	(.21)	(.35)
	Shimmer (dB)	P	.29	.25	.27	.24	.27	.26
			(.05)	(.04)	(.03)	(.03)	(.02)	(.02)
		N	.38	.37	.39	.36	.42	.37
			(.12)	(.09)	(.07)	(.07)	(.10)	(.09)

F0 = mean fundamental frequency; P = Pill group; N = Natural group.
Values are presented as mean (standard deviation).

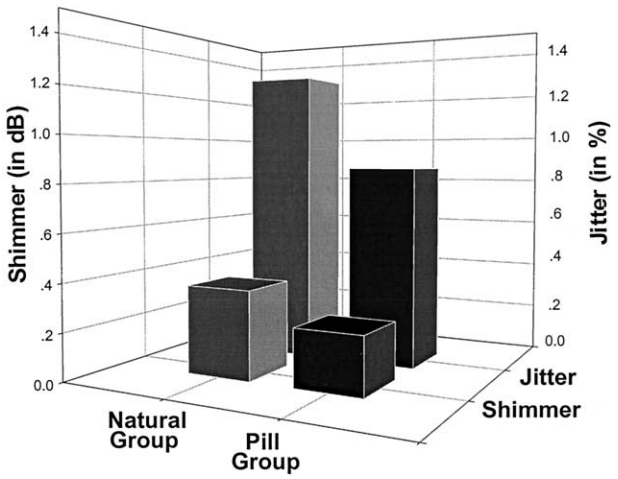

Figure 2. Means for jitter and shimmer across all six intervals of the menstruation cycle for the Pill and Natural groups.

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Statistical analyses revealed that women in the Pill group had significantly more stable voices in comparison with those in the Natural group. Specifically, mean jitter of the Pill group, across all vowels and intervals, was significantly lower than the mean of the Natural group (.86% versus 1.27%, respectively, $F_{1,10} = 8.68$, $P = .015$). Similarly, mean shimmer of the Pill group, across all vowels and intervals, was significantly lower than that of the Natural group (.24 versus .37 dB, respectively, $F_{1,10} = 12.72$, $P = .005$). These grand mean group differences are illustrated in Figure 2.

Furthermore, a Levene test of equality of error variances demonstrated greater variability within the Natural group in comparison with the Pill group for all voice parameters ($P < .05$). As expected, mean fundamental frequency was found to be significantly higher for the vowel /i/ compared with /a/ ($F_{1,10} = 13.32$, $P = .004$), whereas no group differences were demonstrated using this parameter. The difference in mean fundamental frequency between vowels is in keeping with published literature on Hebrew[22] and other languages[21] and helps to validate the current results. No significant differences or interactions among the intervals were found ($P > .05$).

To approximate the follicular and secretory phases, data were rearranged, clustering the three early intervals as one phase and the three subsequent intervals as another. This analysis resulted in identical results; that is, the Pill group had more stable voice (lower jitter and shimmer values) in comparison with the Natural group.

DISCUSSION

Our results support the assumption that hormonal changes associated with the menstrual cycle affect voice quality. This was demonstrated through two major findings. First, women who use contraceptive pills showed reduced frequency variation (jitter) and amplitude variation (shimmer) among successive voice cycles, compared with women who did not use any oral or other hormonal contraceptives. The second finding was that women in the Pill group were more homogeneous in their voice characteristics than those in the Natural group, as reflected by smaller within-group variance. These lower jitter and shimmer values (representing more stable voice quality), as well as the smaller variances, are typically associated with a more stable, healthier voice.[21] We assume that women who use contraceptive pills have a relatively unified hormonal balance, thus minimizing the effect of hormonal changes on voice quality. On the other hand, women who do not use pills are affected by changes in the serum levels of estrogen and progesterone during the menstrual cycle. These changes are assumed to be related to histologic changes in the muscles, mucus, and glandular cells in the larynx,[1,7,8] which in turn may cause instability in voice quality.

Traditionally, otolaryngologists and speech-language pathologists consider oral contraceptives to have an adverse effect on the female voice.[16–19] This position is based mainly on the concern regarding the androgenic effect of the progesterone derivatives on voice. Modern oral contraceptives, however, contain modified estrogen–progesterone balance and new progestins, which have less potent androgenic derivatives and therefore induce fewer androgenic side effects.[15] The current results demonstrate that not only did oral contraceptives have no adverse effect on voice, but rather they improved specific acoustic voice parameters. It should be noted here that the present study employed monophasic formulations, which are widely used. It is possible that multiphasic formulation of low-dose oral contraceptives could yield different results.

The results of the present study are in keeping with the Wendler et al study[14] that reported no voice changes associated with using low-dose oral contraceptives. It should be noted, however, that Wendler et al evaluated voice quality using perceptual judgments that are known to be influenced by many factors, such as human ear sensitivity and intra- and interjudge reliability. The present study used objective acoustic measurements that on the one hand are not prone to the influence of these factors and, on the other hand, are sensitive to small physical changes that may be missed by the human

listener. These changes may contribute to the basic knowledge of the physiologic effects of low-dose oral contraceptives. However, before the information obtained in the present study can be used as a reliable reference to the relationship between sex hormones and voice, there is clearly a need for a follow-up study with a larger sample size.

Although the present study provides evidence that oral contraceptives may improve vocal stability in young women, these results cannot be readily applied to professional singers. Previous studies have shown that female voice performers tend to report vocal changes associated with the menstrual cycle more frequently than women with no vocal training.[1,11] It would be interesting, thus, to extend the present study to voice performers and evaluate these acoustic parameters in the same group of women, with and without oral contraceptives.

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