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Association Between Birth Control Pills and Voice Quality

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***Objectives/Hypothesis:* The objective was to extend our knowledge of the effect of birth control pills on voice quality in women based on various acoustic measures. *Study Design:* A longitudinal comparative study of 14 healthy young women over a 36- to 45-day period. *Methods:* Voices of seven women who used birth control pills and seven women who did not were recorded repeatedly approximately 20 times. Voice samples were analyzed acoustically, using an extended set of frequency perturbation parameters (jitter, relative average perturbation, pitch period perturbation quotient), amplitude perturbation parameters (shimmer, amplitude average perturbation quotient), and noise indices (noise-to-harmonics ratio, voice turbulence index). *Results:* Voice quality and stability were found to be better among the women who used birth control pills. Lower values were found for all acoustic measures with the exception of voice turbulence index. Results also provided preliminary indication for vocal changes associated with the days preceding ovulation. *Conclusion:* In contrast to the traditional view of oral contraceptives as a risk factor for voice quality, and in keeping with the authors' previous work, the data in the present study showed that not only did oral contraceptives have no adverse effect on voice quality but, in effect, most acoustic measures showed *improved* voice quality among women who used the birth control pill. The differences in the noise indices between groups may also shed light on the nature of the effect of sex hormones on vocal fold activity. It was suggested that hormonal fluctuations may have more of an effect on vocal fold regulation of vibration than on glottal adduction. *Key Words:* Voice quality, hormones, birth control pill, acoustic analysis, perturbation.**

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INTRODUCTION

Women's physiology is influenced by the two major ovarian hormones, estrogen and progesterone. The balance between these sex hormones changes in a recurring manner, which activates the menstrual cycle. Although these sex hormones target the genital tract, they were previously shown to affect other body organs, including mucosa, muscles, and bone metabolism.[1] The present study's main interest is in the effect of these hormones on the human larynx. Histological studies have previously demonstrated that estrogens have a hypertrophic effect on the laryngeal mucosa, as well as increasing secretion of the laryngeal glandular cells. On the other hand, progesterone has been shown to affect vocal fold congestion (mainly prior to menses) and to decrease glandular cell secretion while increasing its viscosity and acidity, which in turn causes tissue dryness.[2]

The effect of sex hormone changes on vocal quality was studied in women in menopause or during their menstrual cycle.[3–5] The hormonal balance in menopause is characterized by a decrease in progesterone and estrogen secretion, which causes the ovarian secretion to consist mainly of androgens. It was reported that approximately one-third of female singers in menopause complained of changes in vocal production.[6,7] Such changes include vocal fatigue, difficulties in vocal production and control, decreased intensity, narrow register, huskiness, and inability to reach high registers. These vocal changes were attributed to the decrease in elasticity of the mucosal and connective tissues[6] that increases the vibrating mass of vocal folds[8,9] and causes lowering of pitch. Further support for this association was established in studies which showed that receiving hormonal replacement therapy during menopause significantly reduced vocal changes.[10]

The hormonal changes that occur during the *menstrual cycle* are typically divided into two phases. The first phase of the menstrual cycle, the proliferative phase, is characterized by a gradual increase in estrogen levels that peak at ovulation, on the 14th day. The second (secretory) phase opens with a decline in hormonal levels; then, after seven days, estrogen and progesterone levels peak again, followed by a marked decrease in both hormone levels.[1] Studies that examined the effect of the menstrual cycle on voice production reported changes in vocal quality in each of the two phases at specific timing when significant and abrupt fluctuations in hormonal level occur: close to ovulation[4] and before menses.[7,11] Such vocal changes include vocal fatigue, decrease in vocal range, loss of vocal power, and reduction of high harmonics. These changes were explained by venous dilation and edema that were demonstrated in the vocal folds during the menstrual cycle.[12,13] In addition, hormonal alterations were shown to influence laryngeal neuromotor control through afferent and efferent processes.[4] These changes in the mass of the vocal fold combined with changes in neuromotor control can induce pitch and/or amplitude instabilities.

Most studies to date have examined professional voice performers who are known to be more sensitive and more aware of voice quality changes than nonprofessionals. Although studies that observe voice performers bear the potential benefit of revealing subtle voice changes, it is not clear how these results can be generalized to all women. Furthermore, subject selection may become a problematic issue in reviewing the results of studies that evaluated voice quality by self-reporting, especially in a population of voice performers who are highly motivated and aware of their voices. In addition, most of these studies were conducted in women who do *not* use oral contraceptives[3,4] because they change the natural hormonal balance and are thought to negatively affect vocal quality (primarily virilization). It should be noted that these results are based on sparse literature, which studied the effect of oral contraceptives on voice in the 1960s and 1970s. However, modern birth control pills consist of lower doses of estrogen and progesterone with less androgenic derivatives than those used at that time, suggesting possibly less negative effect on voice quality. Nonetheless, although an increasing number of women at reproductive age use the pill,[14] voice professionals and otolaryngologists still advocate the traditional approach toward oral contraceptives and regard it as a potential risk factor for voice.

In light of the fact that most previous studies included voice performers, used subjective measures of voice quality, and excluded women who use oral contraceptives, we initiated a series of studies that examined the effect of oral contraceptives on voice in nonprofessional speakers.[15,16] We chose to evaluate voice quality using *acoustic analysis* because of its potential to reliably reveal and quantify subtle vocal changes. Results of the preliminary studies did *not* reveal an adverse effect for pills.[15] Furthermore, and in contrast to the traditional thinking, these studies suggested that women who used the pill produced more stable, better-quality voice (in terms of frequency and amplitude perturbation) than those who did not use the pill.[15,16] Our previous studies used the classic *jitter* and *shimmer* parameters. However, recent literature has suggested that different calculations of these acoustic measurements could be more sensitive and indicative of voice quality.[17,18]

The purposes of the present study were to continue the investigation of the effect of birth control pills on voice using a more comprehensive set of acoustic parameters and to learn whether these additional acoustic parameters would reveal additional information on the effect of sex hormones on voice.

PATIENTS AND METHODS

An initial group of 30 young, healthy female students at Tel-Aviv University (Tel-Aviv, Israel) volunteered to serve as participants in the present study. After obtaining approval from the Institutional Review Board and written consent from all participants, an initial screening was conducted. Based on an anamnesis interview and questionnaire, women were included only if they reported *no* history of 1) formal voice or singing training, 2) smoking or substance abuse, 3) pregnancies, 4) hormonal imbalances, and 5) neurological problems. In addition, all women who eventually participated in the study reported regular menses and menstrual cycle of 28 to 32 days. Also, the women who were chosen for participation were assessed by an experienced speech-language pathologist to rule out any speech or voice disorder. Following this procedure, seven women who used birth control pills (the pill group) and seven women who did not (the control group) were selected. The pill group had a mean age of 23.96 years (age range, 22–26 y), a mean weight of 58.29 kg (range, 53–70 kg) and a mean height of 166.8 cm (range, 159–173 cm). Three of the seven women in the pill group used the oral contraceptive Meliane, with 0.075 mg gestodene and 0.02 ethinylestradiol, and two women used Harmonet, which has identical formulation to Meliane. One women used Gynera, with 0.075 mg gestodene and 0.03 mg ethinylestradiol, and one used Microdiol, with 0.15 mg desogestrel and 0.03 mg ethinylestradiol. Because the four preparations were all low-dose monophasic formulations, they were regarded as one group. All women in this group reported no omission in pill-taking during the time of the study and the 3 preceding months. The control group consisted of seven women who did not use any oral or other hormonal contraceptive before or at the time of the study. Mean age for this group was 22.00 years (age range, 20.3–24.5 y), mean weight was 54.57 kg (range, 45–65), and mean height was 165.6 cm (range, 155–174 cm).

All women had their voices recorded repeatedly over a 36- to 45-day period. Although our preliminary studies did not indicate significant differences among the menstruation cycle phases,[15,16] we still decided to consider it as a possible confounding factor, based on previous reports in the literature.[4,5,12] Thus, each woman's menstruation cycle was divided into six consecutive, equal intervals. Interval 1 included the days of the menses, and interval 6 included the days preceding the following menses. The remaining days of the menstrual cycle were divided into four equal intervals (intervals 2 to 5). Each woman had her voice recorded at least twice during each interval, yielding approximately 18 recording sessions for each participant.

The recording sessions were performed individually in a quiet room at approximately the same time of day (between 9:00 A.M. and noon). In each session the subject's voice was recorded while producing, twice, the Hebrew vowel /*i*/ (similar to the vowel in the word "h*ee*d") and the vowel /*a*/ (similar to the vowel in the word "f*a*ther") in isolation. Each vowel was sustained for 3 to 5 seconds in a random order that was changed between subjects and sessions. In all, 1004 sustained vowels were recorded throughout the study.

Signal was recorded through a Sony ECM-T150 (Tokyo, Japan) headset microphone onto TDK (Tokyo, Japan) data cartridges using a Sony TCD-D100 digital audio tape recorder. Sampling rate for the recording was set at 48 kHz. Each recorded vowel was fed to a computer at a sampling rate of 50 kHz using the same tape recorder on which recordings were performed. Acoustic analyses were conducted using a voice analysis computer program (Multi Dimensional Voice Profile, MDVP model 5105, version 2) (Kay Elemetrics Corporation, Lincoln Park, NJ).

Eight acoustic parameters were measured from each vowel production. First measured was the *mean fundamental frequency* (F0), which quantifies the number of complete cycles produced by the vocal folds per second. Second, three *frequency perturbation* parameters were measured: *jitter,* which presents a relative evaluation of the period-to-period variability of the pitch within the analyzed voice sample; *relative average perturbation* (RAP), which presents a relative evaluation of the period-to-period pitch variability with a smoothing factor of three periods; and *pitch period perturbation quotient* (PPQ), which presents a relative evaluation of the period-to-period pitch variability with a smoothing factor of five cycles. Third, two *amplitude perturbation* parameters were measured: *shimmer*, which presents a relative evaluation of the period-to-period variability of the peak-to-peak amplitude, and *amplitude average perturbation quotient* (APQ), which presents a relative evaluation of the period-to-period variability of the peak-to-peak amplitude at smoothing of 11 periods. Fourth, two noise indices were measured: *noise-to-harmonics ratio* (NHR), which calculates an average ratio of the inharmonic spectral energy in the frequency range of 1500 to 4500 Hz to the harmonic spectral energy in the frequency range of 70 to 4500 Hz, and *voice turbulence index* (VTI), which calculates an average ratio of the inharmonic high-frequency energy in the frequency range of 2800 to 5800 Hz to the spectral harmonic energy in the frequency range of 70 to 4500 Hz. For all parameters included in the analysis (with the exception of *F0*), lower values typically represent a healthier voice, whereas higher values are generally associated with less stable, lower-quality voice.[13,19]

Statistical analyses were performed using eight separate repeated-measure analyses of variance, one for each acoustic parameter. In each analysis, the two vowels (/*a*/ and /*i*/) and the six menstrual cycle intervals were treated as repeated factors, whereas the group (pill vs. control group) was regarded as the between-subject factor.

RESULTS

After obtaining the individual acoustic parameter measurements for each vowel, initial data reduction was performed by calculating a mean value for the two recordings made in each session and then for each interval. Based on these individual values, group means were calculated for each acoustic parameter at all intervals and vowels. These data are presented in Table I for the vowel /*a*/ and in Table II for the vowel /*i*/.

Group Differences

The data presented in Tables I and II indicated that, with the exception of the F0 parameter, the values for all acoustic measurements were lower in the pill group than in the control group. Statistical analysis confirmed a significant (overall) group difference for shimmer ($F_{1,12}$ = 7.32, P = .019), APQ ($F_{1,12}$ = 7.39, P = .019), jitter ($F_{1,12}$ = 6.30, P = .027), RAP ($F_{1,12}$ = 6.15, P = .029), PPQ ($F_{1,12}$ = 6.08, P = .030), and NHR ($F_{1,12}$ = 5.47, P = .037). However, group differences for the VTI and F0 parameters were not statistically significant ($P > .05$). Grand mean group differences for the voice quality parameter (i.e., excluding the F0 parameter) are shown in Figure 1. In addition, a Levene test of equality of variance demonstrated greater variability among the natural group ($P <$ .05) for the shimmer and APQ parameters when producing the vowel /*i*/.

Menstruation Cycle Interval Differences

The effect of the menstrual cycle interval was tested across all six intervals separately for each acoustic parameter. Contrast analyses indicated that a significant change occurred between the second and third intervals for jitter, RAP, and PPQ ($F_{1,12}$ = 6.11, P = .029; $F_{1,12}$ = 6.27, P = .028; and $F_{1,12}$ = 6.87, P = .022, respectively). No significant differences were found between all other consecutive intervals and for all other parameters ($P > .05$).

Vowel Differences

The statistical analyses revealed significant differences between the two vowels (/*a*/ and /*i*/) for F0, all frequency perturbation measures, and for NHR. Specifically, F0 values were overall significantly *higher* for the vowel /*i*/ than for the vowel /*a*/ (223.17 and 214.51 Hz, respectively [$F_{1,12}$ = 15.00, P = .002]). The overall mean values of the three frequency perturbation parameters were significantly *lower* for the vowel /*a*/ than for the vowel /*i*/ (1.11% versus 1.53%, respectively, for jitter [$F_{1,12}$ = 20.56, P = .001]; 0.67% vs. 0.92%, respectively, for RAP [$F_{1,12}$ = 20.34, P = .001]; and 0.63% vs. 0.89%, respectively, for PPQ [$F_{1,12}$ = 23.72, $P < .001$]). Values for NHR were *higher* for the vowel /*a*/ than for the vowel /*i*/ (0.130 vs. 0.122, respectively [$F_{1,12}$ = 20.96, P = .001]).

Although the overall mean values of the two amplitude perturbation parameters were, as expected, higher for the vowel /*a*/ than for the vowel /*i*/ (3.42% vs. 3.07% and 2.39% vs. 2.10% for shimmer and APQ, respectively), these differences were nonsignificant ($P > .05$). Similarly, VTI values did not show a statistically significant vowel difference ($P > .05$). No significant vowel interactions with either group or interval were found ($P > .05$).

DISCUSSION

The literature on the effect of oral contraceptives on voice is limited, mostly outdated, and based mainly on subjective evaluation. The main goal of the present study was to deepen our knowledge of this issue using acoustic measures. To that end, we compared the voice of women who used the birth control pill with that of women who did not. The primary finding of the present study was that no adverse effect was found on voice quality of women who used the pill when tested by a selected set of acoustic parameters. In fact, and in keeping with our previous studies, voice quality of the pill group was found to be better than that of the control group as demonstrated by the pill group's lower frequency and amplitude perturbation values, as well as lower NHR values.

Frequency and Amplitude Perturbation Parameters

The finding of lower frequency and amplitude perturbation in the voice of women who use the pill is in keeping with the notion that low-dose monophasic oral contraceptives reduces substantially the "natural" hormonal fluctuations along the menstrual cycle, thus improving vocal quality and stability. Our results are also in keeping with those of Higgins and Saxman,[4] who found higher frequency perturbation measurements around the time of ovulation, a time period that is associated with rapid, pronounced hormonal fluctuations. They suggested three possible explanations for this reduced frequency stability

TABLE I.
Mean (SD) Values for All Eight Acoustic Parameters Recorded From Two Study Groups for Vowel /a/ at Each of Six Menstruation Cycle Intervals.

Parameter	Group	Menstruation Cycle Interval 1	2	3	4	5	6	Mean Value
F0 (Hz)	P	214.92	216.81	217.32	218.59	212.57	211.95	215.36
		(17.29)	(19.98)	(23.31)	(23.55)	(15.52)	(21.15)	(19.23)
	C	211.63	214.93	213.17	212.20	215.97	214.02	213.65
		(29.37)	(26.49)	(29.23)	(28.68)	(.97)	(30.85)	(27.75)
Jitter (%)	P	1.00	.76	.81	.89	.83	.89	.86
		(.52)	(.35)	(.37)	(.29)	(.24)	(.29)	(.34)
	C	1.34	1.51	1.26	1.25	1.43	1.39	1.36
		(.35)	(.38)	(.35)	(.22)	(.32)	(.36)	(.33)
RAP (%)	P	.61	.45	.49	.53	.49	.53	.52
		(.34)	(.22)	(.23)	(.17)	(.15)	(.18)	(.22)
	C	.81	.91	.76	.75	.87	.84	.82
		(.21)	(.23)	(.22)	(.14)	(.21)	(.22)	(.20)
PPQ (%)	P	.54	.43	.45	.50	.46	.51	.48
		(.25)	(.20)	(.21)	(.16)	(.14)	(.17)	(.18)
	C	.77	.85	.71	.71	.79	.78	.77
		(.18)	(.21)	(.20)	(.13)	(.17)	(.20)	(.18)
Shimmer (%)	P	3.33	2.37	2.66	2.70	3.10	2.77	2.82
		(1.13)	(.50)	(.46)	(.24)	(1.18)	(.44)	(.77)
	C	4.09	3.99	3.96	3.93	4.10	4.01	4.01
		(1.44)	(1.26)	(.95)	(1.13)	(1.03)	(1.23)	(1.11)
APQ (%)	P	2.24	1.76	1.86	1.92	2.12	2.04	1.99
		(.60)	(.37)	(.29)	(.21)	(.70)	(.32)	(.45)
	C	2.87	2.75	2.72	2.74	2.84	2.82	2.79
		(.97)	(.83)	(.63)	(.71)	(.67)	(.75)	(.72)
NHR	P	.127	.118	.122	.122	.133	.130	.125
		(.013)	(.012)	(.013)	(.019)	(.018)	(.019)	(.016)
	C	.133	.129	.135	.136	.140	.134	.135
		(.010)	(.010)	(.013)	(.012)	(.014)	(.008)	(.012)
VTI	P	.044	.039	.045	.045	.045	.046	.044
		(.002)	(.008)	(.005)	(.008)	(.008)	(.013)	(.004)
	C	.054	.052	.048	.051	.052	.054	.052
		(.020)	(.013)	(.010)	(.014)	(.009)	(.010)	(.011)

F0 = mean fundamental frequency; P = women who used the birth control pill; C = women who did not use the birth control pill (control group); RAP = relative average perturbation; PPQ = pitch period perturbation quotient; APQ = amplitude average perturbation quotient; NHR = noise-to-harmonics ratio; VTI = voice turbulence index.

among women during times of rapid hormonal fluctuations: 1) a reduction in neural inhibition of the extrapyramidal motor neurons, 2) a change in the speed of neural transmission, and 3) altered sensitivity of the laryngeal mechanoreceptors. The model of Higgins and Saxman[4] was based on perturbation measurements in the frequency domain, whereas our results extend to perturbation measurements in the amplitude domain as well.

The finding that results were consistent across all tested perturbation parameters indicates that, within the context of the present study, no additional information was supplemented by analyzing three frequency perturbation parameters (jitter, RAP, and PPQ) and two amplitude perturbation parameters (shimmer and APQ) instead of using the classic parameters of *jitter* and *shimmer* alone. One reason for this can be attributed to the nature of these additional parameters. The RAP, PPQ, and APQ all use smoothing factors based on the traditional calculations of *jitter* and *shimmer*. Although these modified parameters describe short-term perturbation accurately, they are less sensitive to period-to-period variations. The advantage of these parameters over the "traditional" jitter and shimmer is more clearly evident in conditions in which pitch or amplitude (or both) varies significantly along the analyzed voice sample. However, in the present study, the participants were recorded while producing sustained vowels, when pitch and amplitude contours remained practically unchanged; hence, the additional perturbation parameters did not have an advantage over the traditional parameters.

TABLE II.
Mean (SD) Values for All Eight Acoustic Parameters Recorded From Two Study Groups for Vowel /i/ at Each of Six Menstruation Cycle Intervals.

Parameter	Group	Menstruation Cycle Interval 1	2	3	4	5	6	Mean Value
F0 (Hz)	P	223.19	227.07	228.60	228.39	222.40	218.89	224.76
		(26.15)	(25.99)	(27.66)	(28.33)	(20.81)	(26.96)	(24.72)
	C	220.06	222.54	221.21	221.18	224.70	219.81	221.58
		(25.67)	(20.86)	(25.09)	(21.99)	(27.03)	(30.61)	(23.87)
Jitter (%)	P	1.39	1.46	1.23	1.25	1.37	1.27	1.33
		(.43)	(.41)	(.53)	(.35)	(.52)	(.67)	(.47)
	C	1.87	1.54	1.69	1.77	1.62	1.89	1.73
		(.40)	(.70)	(.37)	(.70)	(.53)	(.91)	(.60)
RAP (%)	P	.84	.88	.74	.75	.82	.76	.80
		(.26)	(.24)	(.31)	(.21)	(.31)	(.40)	(.28)
	C	1.13	.92	1.02	1.06	.97	1.14	1.04
		(.24)	(.41)	(.23)	(.42)	(.33)	(.56)	(.37)
PPQ (%)	P	.87	.85	.71	.72	.80	.74	.78
		(.19)	(.24)	(.30)	(.19)	(.30)	(.40)	(.27)
	C	1.07	.89	.95	1.01	.93	1.09	.99
		(.25)	(.43)	(.20)	(.41)	(.29)	(.52)	(.35)
Shimmer (%)	P	2.80	2.50	2.68	2.39	2.44	2.42	2.54
		(.62)	(.41)	(.76)	(.32)	(.26)	(.51)	(.50)
	C	3.88	3.44	3.78	3.38	3.52	3.59	3.60
		(1.56)	(1.53)	(1.57)	(1.22)	(1.68)	(1.46)	(1.43)
APQ (%)	P	1.89	1.70	1.83	1.68	1.76	1.71	1.76
		(.40)	(.24)	(.46)	(.17)	(.26)	(.27)	(.30)
	C	2.71	2.34	2.54	2.28	2.43	2.39	2.45
		(.98)	(1.07)	(1.08)	(.86)	(1.16)	(.92)	(.96)
NHR	P	.128	.117	.109	.117	.125	.109	.117
		(.024)	(.019)	(.015)	(.027)	(.013)	(.017)	(.020)
	C	.129	.123	.124	.123	.125	.135	.127
		(.026)	(.015)	(.009)	(.018)	(.017)	(.028)	(.019)
VTI	P	.045	.042	.048	.042	.048	.038	.044
		(.009)	(.009)	(.018)	(.012)	(.080)	(.012)	(.009)
	C	.056	.055	.053	.053	.054	.061	.055
		(.019)	(.017)	(.015)	(.014)	(.017)	(.028)	(.017)

F0 = mean fundamental frequency; P = women who used the birth control pill; C = women who did not use the birth control pill (control group); RAP = relative average perturbation; PPQ = pitch period perturbation quotient; APQ = amplitude average perturbation quotient; NHR = noise-to-harmonics ratio; VTI = voice turbulence index.

Noise Index Parameters

Our findings of lower NHR values in the pill group can be explained by improved vocal quality and stability associated with more stable hormonal balance. In general, the NHR parameter measures noise in the signal globally and is influenced by subharmonic components, voice breaks, turbulent noise, and frequency and amplitude variations. These acoustic features are commonly influenced by irregularities in the vibration pattern of the vocal folds.[19] Therefore, an increase in NHR is naturally linked to instability of vocal fold activity. Surprisingly, the two noise indices used in the present study did not demonstrate similar results. The NHR parameter revealed a significant group difference, whereas the VTI parameter did not. The VTI parameter is targeted to identify high-frequency components as an acoustic correlate to breathiness. As such, it was suggested that VTI correlates mostly with turbulence caused by incomplete or loose adduction of the vocal folds.[19] The fact that group differences were observed in the NHR parameter but not in the VTI parameter can be interpreted to suggest that the improved hormonal stability among women who use the pill influences mainly vocal fold regulation of vibration and has less influence on the magnitude or efficiency of adduction. Whether this result suggests that the hormonal fluctuations during the menstrual cycle affect mainly the vibration pattern of the vocal fold mucosa or affect both the mucosa and muscle layers remains unanswered. A more definite answer to that question would probably require a study that combines acoustic and stroboscopic examination of the larynx.

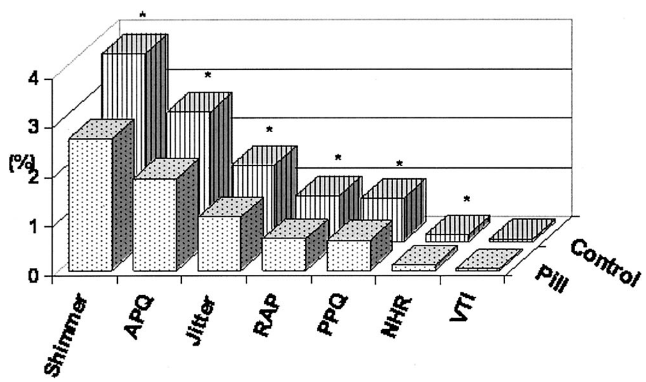

Fig. 1. Grand group mean values for the voice quality acoustic parameters (i.e., excluding the mean fundamental frequency parameter) for the group of women who used birth control pills and the group of women who did not (control group). Asterisk indicates level of significance between the two groups (*$P < .05$). APQ, amplitude average perturbation quotient; RAP, relative average perturbation; PPQ, pitch period perturbation quotient; NHR, noise-to-harmonics ratio; VTI, voice turbulence index.

Menstrual Cycle Effect

Our results revealed significant changes in frequency perturbation parameters (jitter, RAP, and PPQ) between the second and third intervals along the menstrual cycle. The second and third intervals in the present study can be viewed as representing the days before ovulation. To our knowledge, only one study directly investigated voice production before ovulation.[4] In that study, a significant change was reported in voice quality before ovulation, using a frequency perturbation parameter (jitter factor), similar to the result reported in the present study. Although the present results are not sufficient to readily support the existence of menstrual cycle effect on voice quality, our findings may provide preliminary support for such a conclusion using an acoustic analysis paradigm.

CONCLUSION

The present study has provided three major findings. First, women who used oral contraceptives had higher quality of voice in keeping with the effect of hormonal balance on voice stability. This was demonstrated by lower values of all related frequency and amplitude perturbation parameters, as well as lower values for NHR but not for VTI, suggesting that hormonal fluctuations may have a greater effect on vocal fold regulation of vibration than on adduction effectiveness. Second, differences in frequency perturbation were observed at periods that are assumed to precede ovulation, thus providing preliminary support for the existence of menstrual cycle effect on voice quality. Third, the current findings could have important implications for female singers who often complain about vocal changes associated with the menstrual cycle.[11,12] However, the possibility that vocal quality may be improved by use of oral contraceptives should be examined further. Future studies should also explore the effect of a wider variety of commercial oral contraceptives on vocal quality to better understand the relation between hormonal fluctuations and vocal production.

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