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The Effect of Oral Contraceptives on Voice: Preliminary Observations

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Summary: Most studies investigating the effect of sex hormones on the larynx and vocal folds focused on the voice quality of women either around menopause or during the menstrual cycle. To our knowledge, however, there have been no studies that investigated the effect of oral contraceptives on the female voice. In the present study five women who ingest oral contraceptives (pill group) and five women who do not (natural group) were recorded producing the vowels /i/ and /a/ repeatedly over a period of 40 days. Acoustic analyses were performed on these recordings including F_0, amplitude, jitter, shimmer, and harmonic-to-noise ratio (HNR). Results indicated that jitter and shimmer values of the pill group were significantly lower than those of the natural group. No group differences were found for F_0, amplitude, or HNR. In addition, the pill group demonstrated significantly smaller variance for all variables tested. The results suggest that oral contraceptives might increase voice stability associated with smaller hormonal changes. Thus the present study provides preliminary evidence of the effect of oral contraceptives on the female voice. **Key Words:** Voice—Women—Oral contraceptives—Hormones.

INTRODUCTION

Women are subjected to the influence of two major sex hormones, estrogens and progesterone. These sex hormones target mainly the genital tract. However, they have also been found to affect mucosa, muscles, bone, and other body organs, including the larynx.[1] Estrogens influence bone metabolism, calcium absorption, and mucus proliferation. In addition, they promote the maturation of fat cells, and cause hypertrophy of the mammary glands. Progesterone, on the other hand, has an antiproliferative effect on mucus and causes dehydration of the mucous membranes with a reduction in secretions of the glandular epithelium. It decreases capillary permeability, and by this causes tissue congestion. Through its influence on the hypothalamus and the cerebrum, progesterone also raises body basal temperature by approximately half a degree (^{0}C). The progesterone has a major role in preparing the endometrium for implantation of the inseminated egg. Combined with estrogen, it activates the menstrual cycle. The balance between the two hormones, however, varies during the menstrual cycle.

Histological studies show that estrogens have a hypertrophic effect on laryngeal mucus and increase the secretion of the glandular cells in the vicinity of the vocal folds. In contrast, progesterone causes tissue congestion of the vocal folds, which typically appears prior to the menses. It also decreases the

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amount of glandular cell secretions while increasing the viscosity and acidity of the secretions resulting in tissue dryness.[2]

The question of whether physiological changes in the vocal folds and larynx that result from hormonal changes also affect voice quality has been the focus of many studies.[3–10] Such information may be relevant to singers, teachers, and other female voice professionals. Two types of studies have dealt with the relationship between voice quality and sex hormones. One group of studies investigated the voice quality of women at menopause and the other investigated it during the menstrual cycle. At menopause the secretion of progesterone is stopped, estrogen secretion is decreased, and the ovarian secretion consists mainly of androgens. The absence of estrogens and progesterone causes gradual atrophy of mucosa. The reduction in the activity of the glandular cells around the vocal folds causes dryness, which in turn may result in vocal fatigue and dysphonia. Boulet and Oddens[11] reported that 29% of the female singers in their study experienced vocal changes around menopause. The specific changes include huskiness, as well as problems with voice emission, voice control, and the inability to reach high registers. Abitbol and Abitbol[12] also reported similar findings of decreased intensity, vocal fatigue, and narrow register in professional voice performers.

In younger women, during the reproductive years, voice quality has been investigated in relation to the menstrual cycle. The changes in the hormonal balance between estrogen and progesterone during the menstrual cycle have been documented extensively.[1] During the first phase of the menstrual cycle (the proliferative phase) there is a gradual increase in estrogen levels which peak on the fourteenth day, at ovulation, followed by a decline in hormonal levels. Toward the twenty-first day, estrogen and progesterone levels peak again, after which an abrupt decline in both hormones occurs.[1] These changes in the hormonal balances through menstruation result in morphological and histological changes that are of a cyclical nature. It is assumed that similar changes occur in the vocal folds, which may result in vocal changes as well.

Most studies reported on changes in vocal quality either before menses or close to ovulation where hormone levels change rapidly. The extent of these vocal changes, however, varied among studies. Several studies reported on changes in voice quality prior to menstruation only in professional voice performers.[2,6,12–14] Approximately one-third of these performers complained of voice fatigue, decreased vocal range (especially on the high tones), loss of vocal power, and loss of specific high harmonics prior to menses. These symptoms are generally regarded as vocal premenstrual syndrome (VPMS). Among nonprofessional speakers, awareness of voice quality[15] and the prevalence of VPMS were estimated to be low.[4] Others, however, reported vocal changes, such as increased jitter, to occur at ovulation but not prior to menses among this nonprofessional group.[5]

The introduction of contraceptive pills has allowed for an additional experimental paradigm to explore the effect of hormones on voice quality. Most contraceptive pills are a combination of synthetic estrogen and progesterone hormones that are aimed at maintaining constant levels of both hormones through the menstrual cycle and ultimately to prevent ovulation. Thus, in women ingesting contraceptive pills we do not expect to see the abrupt hormonal declines present during the physiological menstrual cycle prior to ovulation and prior to menses. It should be noted here that several reports dated in the 1960s and 1970s indicated some virilization effect in women who used oral contraceptives (for review, see Wendler et al[16]). It is argued, however, that the modern composition of contraceptive pills reduces these effects.[16] As of yet, it is not clear whether the modified hormonal balance in women who ingest oral contraception affects vocal quality differently from the physiological menstrual cycle. This question is of interest because of the increase in the use of oral contraception. In the United States, for example, it is estimated that approximately 30% of women of reproductive age use contraceptive pills.[17] In Europe, oral contraception is one of the most common birth-control methods, especially in western and northern Europe.[18] In spite of the above, the majority of the female voice studies have been performed with women who were not ingesting contraceptive pills.[4–6] A Medline search from 1981 to the present showed no studies comparing the voices of women with and without oral contraceptives. The present study is an initial attempt to compare voice quality in women

with and without oral contraception using objective acoustic measures of voice parameters. These measures include fundamental frequency, jitter, shimmer, and harmonic-to-noise ratio.

METHOD

Subjects

Ten young women participated in this study, five who ingest birth control pills (pill group) and five who do not (natural group). Of the five women in the pill group, two were ingesting the commercial oral contraceptive Gynera®, with 21 coated tablets, each containing 0.075 mg gestodene and 0.03 mg ethinyl estradiol. The other three women in this group were ingesting Meliane®, also with 21 coated tablets, each containing 0.075 mg gestodene and 0.02 mg ethinyl estradiol. The two groups were 23.8 and 22.2 years of age, respectively. Additional background information of height, weight, and age of first menstruation are shown in Table 1. All were native speakers of Hebrew, born in Israel, and have lived there since birth. Voice, language, and speech disorders were ruled out by self-reporting, as well as by assessments performed by two experienced speech-language pathologists. Additional criteria for inclusion of subjects were no formal singing or voice training, no smoking history, no known hormonal imbalances, no history of pregnancies, and no history of neurological problems.

TABLE 1. *Mean Age (Years), Height (cm), Weight (kg), Age of First Menstruation (Years), in Group P (Pill) and Group N (Natural)*

Subjects' Variables		Group P	Group N
Age	Mean	23.83	22.17
	(SD)	(1.22)	(1.65)
Height	Mean	166.83	164.20
	(SD)	(4.92)	(5.81)
Weight	Mean	58.67	53.80
	(SD)	(6.80)	(1.92)
Age of first menstruation	Mean	13.42	13.20
	(SD)	(0.80)	(1.30)

Abbreviation: SD, standard deviation.

Recording procedure

Subjects were recorded over a period of approximately 40 days (typically 1 to 2 menstrual cycles). The rationale for repeating the measurements over time was to account for possible variability in vocal quality that could arise as a result of the menstruation cycle.[5,13] Specifically, studies have shown that vocal changes related to hormonal changes are more likely to appear several days prior to menses[2,6] or close to ovulation.[5] We, therefore, divided each subject's menstrual cycle into six consecutive equal intervals (approximately 4 days long) according to the subjects' reports. Interval 1 was defined as beginning on the first day of the menses whereas interval 6 was defined as the last days prior to the beginning of the menses of the following menstrual cycle. Intervals 2 through 5 were equally divided between the days that elapsed from interval 1 to interval 6. For each subject, 2 to 4 recordings were obtained at each interval, totaling approximately 20 recordings per subject.

Recording instrumentation

During every individual recording session each subject was instructed to produce two sustained /i/ vowels and two sustained /a/ vowels. Each production was sustained for 5 seconds. The two vowels, /i/ and /a/, were selected because they are commonly used for clinical evaluation of vocal quality. In addition, these two vowels represent two distinct articulatory gestures in many languages[19] as well as in Hebrew.[20] Finally, typical jitter and shimmer values that were previously reported for these vowels were found to differ significantly.[19,21–24]

Each session was audio recorded while the subject was seated in a quiet room. A Sony ECM-T150 microphone (Sony, Tokyo, Japan) was attached to a headset located approximately 5 cm from the subject's mouth. The signal was directed to a Sony TCD-D100 digital audio tape recorder and was recorded onto TDK DC4-90R digital data cartridges (TDK Corp., Tokyo, Japan). The sampling rate for the recording was set for 44.1 kHz. This tape has a dynamic range of 87 dB and a flat frequency response (20–20,000 Hz). Total harmonic distortion is reported to be less than 0.008%, and wow and flutter are below the measurable limit.

Analysis of recordings

Each sustained vowel was fed to a Kay Elemetrics Computerized Speech Lab (CSL) model 4300B (Kay

Elemetrics, Lincoln Park, NJ), via the same tape recorder on which the data was acquired. The acoustic parameters that were measured for each vowel were fundamental frequency (F_0), jitter, amplitude (amp), shimmer, and harmonic-to-noise ratio (HNR). These measurements were obtained via the voicing analysis function of the CSL after determining each glottal pulse initiation, with sampling rate for analysis set at 44.1 kHz.

RESULTS

For each vowel (/i/ and /a/) and recording interval (1 through 6) the group mean was obtained as follows. First, for each subject the two recordings of the sustained vowel within an individual recording session were averaged. Next, for each subject, all recordings within each interval were averaged. Finally, group means for the various voice parameters (F_0, jitter, amp, shimmer, HNR) were calculated for each interval and are presented separately for vowels /i/ and /a/ in Tables 2 and 3, respectively.

A series of separate analyses of variance (ANOVA) with repeated measures were conducted to test the main effects of group (with and without contraceptive pills), interval (1 through 6), vowel (/i/ and /a/), and the interactions between them for each of the five voice parameters. Results revealed that the two groups (with and without pills) differed significantly in the shimmer [$F(1, 8) = 7.84$, $p = 0.023$] and in the jitter values [$F(1, 8) = 5.31$, $p = 0.050$]. Specifically, the natural group had consistently higher shimmer and jitter values than the pill group as illustrated in Figure 1. No significant group differences were found for the remaining voice parameters (F_0, amp, and HNR), although F_0 values were typically higher for the natural group.

TABLE 2. *Mean Values and Standard Deviations (in Parentheses) of F_0, Jitter, Amplitude (Amp), Shimmer, and HNR of the Pill Group (P) and the Natural Group (N) for the Vowel /i/ across the Six Recording Intervals in the Menstruation Cycle*

		Menstruation Cycle Interval						
Variable	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**Mean**
F_0	P	217.48	217.54	215.13	219.38	213.78	215.78	217.42
(Hz)		(8.18)	(12.00)	(7.40)	(10.97)	(6.13)	(11.94)	(12.51)
	N	222.60	224.12	224.25	222.93	224.27	223.99	223.13
		(22.80)	(22.05)	(23.39)	(25.20)	(27.85)	(28.81)	(22.96)
Jitter	P	0.83	0.85	0.77	0.93	0.80	0.68	0.81
(%)		(0.23)	(0.28)	(0.20)	(0.33)	(0.13)	(0.18)	(0.36)
	N	1.01	1.08	0.94	1.11	1.17	1.19	1.09
		(0.47)	(0.75)	(0.31)	(0.66)	(0.62)	(0.75)	(0.67)
Amp	P	72.68	73.07	73.52	72.39	73.61	73.50	73.36
(dB)		(1.34)	(1.64)	(2.19)	(2.10)	(1.83)	(1.39)	(2.16)
	N	71.62	73.34	72.78	72.73	72.02	72.32	72.51
		(4.24)	(3.35)	(4.11)	(3.37)	(1.94)	(3.83)	(3.90)
Shimmer	P	0.23	0.22	0.22	0.21	0.23	0.23	0.22
(dB)		(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.05)
	N	0.37	0.37	0.34	0.36	0.38	0.35	0.35
		(0.13)	(0.22)	(0.11)	(0.12)	(0.17)	(0.15)	(0.14)
HNR	P	6.94	7.21	7.71	7.47	7.00	7.57	7.31
(dB)		(0.74)	(0.84)	(0.32)	(1.36)	(2.24)	(1.40)	(2.10)
	N	6.70	7.49	7.01	6.96	6.87	7.58	6.92
		(2.11)	(3.18)	(2.48)	(1.93)	(1.71)	(1.81)	(2.33)

TABLE 3. *Mean Values and Standard Deviations (in Parentheses) of F_0, Jitter, Amplitude (Amp), Shimmer, and HNR of the Pill Group (P) and the Natural Group (N) for the Vowel /a/ across the Six Recording Intervals in the Menstruation Cycle*

		Menstruation Cycle Interval						
Variable	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**Mean**
F_0	P	213.11	209.86	205.05	213.87	205.75	209.93	209.90
(Hz)		(5.82)	(8.56)	(7.38)	(6.83)	(4.29)	(8.98)	(10.54)
	N	214.22	211.93	215.30	211.99	217.75	219.09	214.28
		(29.97)	(29.03)	(30.08)	(31.54)	(33.82)	(32.08)	(28.74)
Jitter	P	1.01	0.93	0.90	1.03	0.90	0.86	0.93
(%)		(0.19)	(0.10)	(0.12)	(0.16)	(0.11)	(0.19)	(0.22)
	N	1.28	1.28	1.29	1.31	1.42	1.15	1.27
		(0.40)	(0.37)	(0.42)	(0.24)	(0.19)	(0.28)	(0.42)
Amp	P	70.56	69.99	70.80	70.67	70.41	70.74	70.64
(dB)		(2.19)	(2.66)	(2.16)	(2.27)	(1.62)	(1.98)	(2.76)
	N	72.31	71.03	69.42	71.72	70.77	71.34	70.90
		(2.47)	(3.32)	(4.38)	(3.07)	(3.47)	(3.88)	(4.98)
Shimmer	P	0.30	0.26	0.27	0.25	0.27	0.26	0.26
(dB)		(0.05)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.06)
	N	0.36	0.36	0.37	0.36	0.40	0.35	0.35
		(0.13)	(0.10)	(0.07)	(0.08)	(0.10)	(0.10)	(0.11)
HNR	P	1.53	2.22	2.45	1.56	2.58	0.56	1.92
(dB)		(2.38)	(2.71)	(1.85)	(1.38)	(2.52)	(2.44)	(2.99)
	N	2.76	2.72	1.95	2.65	2.22	3.05	2.42
		(1.92)	(2.11)	(2.28)	(1.90)	(2.03)	(1.99)	(2.67)

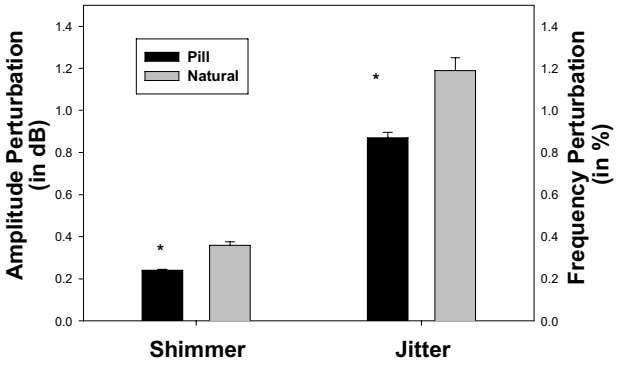

FIGURE 1. Group mean values (± 1 standard error bars) for shimmer and jitter voice parameters for the pill group and the natural group. Each mean is the average of 60 measurements (5 subjects × 2 vowels × 6 recording intervals). Asterisks indicate level of significance between the two groups of women (* $p < 0.05$).

No significant main effect of interval was found for all the acoustic variables ($p > 0.05$). However, for F_0, a significant group X interval interaction was found [$F(5, 40) = 2.62$, $p = 0.038$]. Analyses of contrasts revealed that the two groups differed significantly in their change of F_0 from interval 3 to 4 and from 4 to 5. It can be seen that while F_0 in interval 4 decreased for the natural group, it increased for the pill group.

The fundamental frequency, HNR, and amplitude voice parameters were found to be significantly higher for the vowel /i/ than for /a/ [$F(1, 8) = 13.11$, $p = 0.007$, $F(1, 8) = 62.57$, $p < 0.001$, and $F(1, 8) = 23.34$, $p = 0.001$, respectively]. Also note significant interval X vowel interactions for F_0 and amplitude [$F(5, 40) = 3.16$, $p = 0.017$ and $F(5, 40) = 3.68$, $p = 0.039$, respectively]. Contrast analyses revealed that

for both voice parameters, the difference between the vowels occurred between intervals 1 and 2. A test of equal variances revealed that the natural group had significantly greater variability than the pill group for all voice parameters and vowels, with one exception: HNR measured for the vowel /a/.

DISCUSSION

The effect of sex hormones on voice quality in women is controversial. In the present study, a different paradigm than that used thus far was utilized: comparison of voice parameters of women with and without contraceptive pills. Two major findings were observed. First, the natural group showed significantly higher jitter and shimmer values compared to the pill group. The second finding was a significantly smaller variance within the pill group compared to the natural group.

Lower perturbation values and smaller variance, as found in the pill group, are typically associated with a healthier voice.[19] This can be explained by the stable and more unified hormonal balance in women who ingest contraceptive pills. As described previously, the balance between a female's two major sex hormones, estrogen and progesterone, varies during the menstrual cycle. Changes in the amount of hormonal secretion cause, among other things, histological changes in the muscles, mucus, and glandular cells in the larynx. This, in turn, may cause changes and instability in voice quality. In women who ingest oral contraceptives, sex hormones are kept at a relatively constant level, thus reducing vocal fluctuation. Our findings are, therefore, in keeping with the assumption that hormonal changes associated with the menstrual cycle can affect voice quality.

An unexpected finding was the moderate, but significant interaction between the tested groups and menstrual intervals for F_0. The data suggest that at the middle of the menstrual cycle, probably close to ovulation, the pill group shows F_0 changes that are not evident in the natural group. These findings are in contrast to our hypothesis that larger changes in voice parameters would occur in the group of women who experience greater hormonal changes. On the other hand, previous data suggest that hormonal changes during the menstrual cycle were not found to affect F_0.[4] Thus it is possible that the F_0 changes observed here are unrelated to hormonal differences between the groups. We are currently investigating this issue in a larger sample of women.

Comparison of the present findings with previously published data is difficult due to several reasons. First, the majority of the relevant studies used self-evaluating questionnaires or judgment rating scales whereas only a few of them were conducted using acoustic measurements. Secondly, while many studies evaluated the effect of menstruation on voice, we did not find any published study that investigated the effect of oral contraception on voice. And finally, although we have repeated recordings during the menstrual cycle, the present study was not designed to identify the exact menstrual phases, specifically ovulation. Nonetheless, the present data are in keeping with Higgins and Saxman's study[5] suggesting that jitter is a sensitive measure of hormonal effect on voice. The present study further suggests that shimmer may be a sensitive measure as well. The finding that HNR is not a sensitive measure by which to differentiate between the two tested groups may imply that if any physiological changes in the larynx may occur due to hormonal changes, they do not affect the closure of the vocal folds during phonation.

The present data suggest that the relation of voice quality and oral contraceptives is not dependent on the vowel. In other words, both vowels appear to be equally susceptible to the effects of hormonal changes. Comparison between the two vowels show generally higher F_0 values for the /i/ than /a/. This result follows the expected relation between vowel height and F_0[25] and is in keeping with published data in English[26] and in Hebrew.[20] The finding that the amplitude of the vowel /i/ was consistently higher than the vowel /a/ was unexpected. Published data show that when vowels are produced in connected speech the /i/ is weaker than /a/.[19] In our study, however, the vowels were produced in isolation and not in sequence. In addition, the vowel /i/ was always produced before the /a/. Thus it is possible that the differences in amplitude between the two vowels are the result of this specific design.

CONCLUSIONS

In summary, the present preliminary study provides supporting evidence of the effect of oral con-

traceptives on the female voice. The group that ingests oral contraceptives showed smaller jitter and shimmer values, as well as smaller group variance, both associated with smaller hormonal changes. In addition to the theoretical relevance, these data also have clinical implications. Most clinical voice evaluation tools that are presently in use view women as a unified group. The present data suggest that the use of oral contraceptives should be considered when evaluating the female voice. We suggest that further investigation of the effect of oral contraceptives on voice should include perceptual tests (as well as acoustic measurements), an otolaryngology examination of the subjects prior to participation in the study, inclusion of different commercial brands of oral contraceptives, and accurate measurements of hormonal status in a larger sample of women.

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