

**A case study on the effects of the menstrual cycle and the oral contraceptive pill on  
variation of electrolaryngographically derived closed phase quotient**

Filipa Lã<sup>1</sup>, David Howard<sup>2</sup>, Jane Davidson<sup>1</sup>, William Ledger<sup>3</sup>, Georgina Jones<sup>4</sup>

Music Department, University of Sheffield<sup>1</sup>; Electronics Department, University of York<sup>2</sup>, Academic Unit  
of Reproductive and Developmental Medicine, University of Sheffield<sup>3</sup>, Institute of General Practice &  
Primary Care<sup>4</sup>, University of Sheffield, U.K.

**Contacts:**

Filipa Lã

Music Department

The University of Sheffield

38 Taptonville Road

Sheffield S10 5BR

U.K.

Email address: [filipasoprano@gmail.com](mailto:filipasoprano@gmail.com)

Telephone number: (+44) (0) 7752 895886

## **ABSTRACT**

This article reports the results of a case study on the effects of the menstrual cycle and the use of a third generation oral contraceptive pill (OCP) on the pattern of vibration of the vocal folds of a young classical female singer when singing a Lied by Schumann, Widmung. The electrolaryngographically derived closed phase quotient (CQ) was used as a measure of vocal control across the menstrual cycle for both OCP and placebo use. This was a double blind randomised placebo controlled trial. Neither the researchers nor the participants were aware of which arm of the study would come first. A total of six audio-recordings and six blood samples were performed at three specific stages of the menstrual cycle, for both OCP and placebo use: at menstruation, and during follicular and luteal phases of the menstrual cycle. Results indicate that the use of a third generation OCP diminishes differences between the distributions of closed quotient across the menstrual cycle by dampening fluctuations of steroid hormones. It seems that the singer was able to improve vocal control across the menstrual cycle when she was using an OCP with antimeneralocorticoid and antiandrogenic properties.

## INTRODUCTION

Previous studies have provided evidence for the connection between sex hormonal variations and voice quality. However, the degree and type of this relationship still raises some controversy, especially with regard to the singing voice.<sup>1-16</sup> Moreover, no systematic research regarding the effects of the contraceptive pill on the singing voice has been published. Therefore, further investigation in this field is justified.

The existent research concerning the effects of OCP on voice quality has reported contradictory results. On the one hand, early studies have associated the use of OCP with voice virilisation. However, these studies involved the use of earlier OCP preparations with high doses of synthetic steroid hormones (oestrogens and progesterone), which could be associated with voice virilisation.<sup>17,18</sup> On the other hand, recent studies have shown stabilization effects of OCP use on voice quality across the menstrual cycle. Women using modern OCP preparations had lower perturbation values and smaller variance, parameters mostly associated with healthier voices.<sup>19</sup> However, these previous studies only have concerned about the effects of OCP use on sustained vowels. No attention has been paid to the effects of OCP use on a much more demanding vocal mechanism, such as the one that is used during the singing of classical repertoire.

Possible explanations for the effects of steroid hormones on voice quality have been proposed. Some authors believe that vocal problems exist during the menstrual cycle because the woman's voice is difficult to control in the face of constant variations in sex hormonal concentrations.<sup>12</sup> It has been suggested that constant fluctuations on steroid hormone concentrations cause changes in the vocal folds, such as oedema and small haemorrhages. These phenomena account for modifications in the pattern of vibration of the vocal folds, with consequent difficulties in voice production and vocal control, and with negative changes in voice quality, such as hoarseness, vocal fatigue, decreased range and problems with intonation.<sup>20, 21</sup>

Taking into account the above explanations, this research aims to assess whether the dampening of fluctuations of steroid hormones across the menstrual cycle when using an OCP avoids vocal problems. To test this hypothesis, this study investigates vocal control across the menstrual cycle when using and when not using an OCP, by studying the distribution of closed quotient as derived from the

electrolaryngograph.

## **CASE STUDY**

### **Design and Procedure**

A young female classical singer (age = 22 years old), who was a post-graduate student at the Royal College of Music, in London, and who had a semi-professional singing profile volunteered to take part in this study. This was a long-term research (it lasted six months) that involved a great commitment of the singer, since she had agreed to participate in a double blind randomized placebo controlled trial. During the whole study, the singer was asked to take Yasmin for three consecutive months, and to take its matched placebo for another three consecutive months. Neither she nor the researchers knew which arm of the study would come first. Double-blind trials are thought to produce objective results since the expectations of the researcher and the participant about the experimental drug do not affect the outcome.<sup>22</sup> Ethical permission was gained from the South Sheffield Research Ethics Committee prior to the start of the study.

On the third month of Yasmin use and on the third month of placebo use, three audio-recordings and three blood tests were performed at specific stages of the menstrual cycle: during menstruation (on the second day of a regular 28 days cycle), during follicular phases (on the eleventh day of a regular 28 days cycle), and during luteal phase (on the twenty-fifth day of a regular 28 days cycle). Therefore, a total of six recordings were done during the study, all in the same room at the Royal College of Music.

The singer was asked to sing three different warming-up exercises, and then to sing a Lied of her choice - Widmung by Schumann. This she recorded whilst listening to the piano accompaniment on one channel of pair of headphone placed over that ear only.

### **Materials: the OCP**

Yasmin was the selected OCP for this study because it offers more advantages than other combined contraceptive pills available nowadays, potentially with fewer risks of vocal changes, especially for singers.<sup>23</sup> It has antimenerolocorticoid effects not found in other OCPs, so it is not expected to have effects of water retention. Additionally, it has an antiandrogenic effect, so vocal

masculinisation is also not expected when using this particular OCP.<sup>24-26</sup> Schering Health Ltd. kindly provided boxes of Yasmin<sup>®</sup> and of matched placebo, which were randomly allocated in similar boxes by the Pharmacy Department of Hallamshire Hospital.

### **Materials: the recording equipment**

A total of six audio-recordings were performed using the following equipment: a MBNM550E-L microphone; a portable microphone stand beyerdynamic; a microphone preamplifier Alice MIC•AMP•PAK 1<sup>TM</sup>; stereo digital audio tape-recorder (DAT) (Sony TCD-D7); Sony digital audio tapes PDP-125C 62m/205ft.; and a portable electrolaryngograph connected to a portable oscilloscope.

The electrolaryngograph was particularly chosen for this study because it allows aspects of vocal fold vibration to be monitored. Previous studies have suggested that changes in the vocal folds, such as oedema and haemorrhages, are associated with fluctuations in concentrations of steroid hormones (oestradiol and progesterone) during a natural menstrual cycle.<sup>20, 21</sup> Therefore, changes in the pattern of vibration of the vocal folds are also expected. The electrolaryngograph generates a signal does not have components of supra-glottal influence, thus it provides accurate information about vocal phenomena.<sup>27</sup> In the present study this is the focus of attention, bearing in mind that the explanations presented to date for vocal changes during the premenstrual and menstrual phases of the menstrual cycle refer mostly to alterations in the voice source. Additionally, it is a non-invasive means of assessing aspects of vocal fold vibration which does not interfere with voice production. Thus the singer's voice can be monitored mean while she is performing classical repertoire.<sup>28</sup> It also allows: i) the analysis of large amounts of data, which is important when analysing the singing repertoire;<sup>29</sup> ii) the study of a high range of notes and loudness levels, also important when analyzing the operatic singing repertoire;<sup>30</sup> iii) the analysis of every vocal fold vibratory cycle, which is extremely important given that sometimes pitch and vocal clarity can be affected over a longer time than one phonatory cycle;<sup>31</sup> iv) the study of the myoelastic properties of the vocal folds by measuring the contact of the vocal folds, glottal area variations during the vocal fold cycle, glottal area and vocal fold vibratory cycle; therefore, it indicates the presence of any voice pathology exists<sup>32</sup> (abnormalities in the closed phase of the vibratory cycle correspond to changes in the quality of the voice, since the closed phase corresponds to maximum excitation of the

vocal tract, when it is isolated from the subglottal cavities<sup>29-33</sup>); v) the assessment of whether there is an oedematous conditions of the vocal folds, pathology most associated with premenstrual and menstrual vocal side effects mentioned to date.<sup>34</sup>

For each recording session, the electrolaryngograph electrodes were positioned at the level of the larynx of the participant, and its position checked out with reference to the output waveform (Lx) on an oscilloscope, potentially important for trained singers who tend to keep the larynx low when singing.<sup>35</sup>

A Sharp® minidisk portable recorder MD-MT80, TDK 80 recordable Mini Discs and Vivanco Airspace DX400 head phones were used to play back the piano accompaniment of the chosen Lied, recorded previous to the beginning of the experiment.

### **Materials: collection of hormonal samples**

A total of six blood samples were collected using: medi swab IPA cleaning pad; cotton wool balls; Sharps bin; micro-pore tape; vacutainer barrels; 22G vacutainer needles; vacutainer bottles containing an activator and separator gel; disposable needles; tourniquet; request form containing the hormones to analyze; and a small pillow.

### **Data**

For all six blood samples, concentrations of steroid hormones (oestradiol and progesterone) were analyzed in the Department of Clinical Chemistry, at the Royal Hallamshire Hospital. These hormones were chosen according to the fact that they have different concentrations for the different phases of the menstrual cycle, and because OCPs contain synthetic preparations of these hormones.<sup>36</sup>

Distribution of closed phase quotient ( $DQ_x$ ) was measured for each recording session using the automated Lx-based analysis technique described elsewhere.<sup>35</sup> Distribution of closed quotient (CQ) has been described as an important tool to assess the control of the voice of trained classical singers, since higher CQ in a cycle has been associated with more sound energy reaching the listener, since the glottis is open for a shorter length of time each cycle when sub glottal clamping can occur.<sup>37</sup>

## **RESULTS**

Concentrations of steroid hormones were compared for both placebo and Yasmin cycles and for the three phases of the menstrual cycle. Table 1 shows the means and standard deviations for concentrations of steroid hormones.

(insert Table 1 about here)

The results suggested that: placebo use showed great fluctuations in hormonal concentrations across the menstrual cycle (Figure 1); OCP use showed a dampening in the fluctuations of hormonal concentrations across the menstrual cycle, as expected (Figure 2).

(insert Figures 1 and 2 about here)

Distributions of closed quotient were also compared for both Yasmin and placebo cycles, and for the three phases of the menstrual cycle. Table 2 shows the means and standard deviations for closed phase quotient (expressed in percentage). The results suggested that the use of OCP generally showed higher CQ values. Both menstruation and follicular phase of the menstrual cycle showed higher mean values of CQ; OCP use showed lower mean value of CQ only during the luteal phase of the menstrual cycle.

(insert Table 2 about here)

Additionally, OCP use showed less variation in the distribution of CQ across the menstrual cycle when compared with placebo use (Figure 3).

(insert Figure 3 about here)

## **CONCLUSIONS**

Generally, the results obtained from the case study confirmed the initial expectations. Lower mean values of CQ during menstruation might indicate less vocal control during placebo use. The results support therefore previous results, in which evidence that during menstruation oedema of the vocal folds and swollen microvarices might exist, accounting for less voice quality during this phase of the menstrual cycle.

Lower mean values of CQ during the luteal phase of the menstrual cycle when using OCP were not expected; however, this could be related to the fact that at this stage of the menstrual cycle, there is a sudden stop in the supply of synthetic steroids. An OCP is taken during twenty-one days, following which there is a period of seven days rest until a next box of OCP is initiated. The last recording and blood test were performed during this period of seven days rest for the cycle using OCP. Therefore, a sudden stop in the supply of steroid hormones could be related to less vocal control and higher vocal effort, thus with lower CQ mean values.

Finally, the hypothesis that the use of OCP might improve vocal control across the menstrual cycle by dampening of steroid hormonal fluctuations across the menstrual cycle it seems to be also supported by the findings of this case study. During placebo use, fluctuations of oestradiol and progesterone exist and differences between the distribution of CQ for the three phases of the menstrual cycle seem to be more evident. During OCP use, the fluctuations of steroid hormones are dampened, and differences between the distributions of CQ between the three phases of the menstrual cycle seem to be less evident. Thus, it is possible that OCP use increases vocal control across the menstrual cycle and consequently decreases vocal effort. Yasmin intake might have benefits on the control of the vocal mechanism across the menstrual cycle and stabilize vocal quality across the menstrual cycle because hormonal fluctuations are dampened.

Further investigation in this field should be done to compare several types of oral contraceptive pills, and assess whether the same results would be obtained when using other kinds of OCP preparations. It is the researchers' opinion that non-invasive devices that could display a visual feedback of the vocal folds should be developed and used in further investigations, so that additional information in this field could disclose the extremely complex relationship between hormonal background and voice quality in female voices.

## **ACKNOWLEDGEMENTS**

The authors would like to thank the participant, for her enormous commitment during this study;



the Head of Vocal studies at Royal College of Music; Dr. George Nicholson for the recording of the piano accompaniment of the repertoire analyzed; the Pharmacy Services Directorate at Royal Hallamshire Hospital, for the randomization of the OCP and matched placebo; the Department of Clinical Chemistry at Royal Hallamshire Hospital, for providing the equipment for the collection and analysis of blood samples; Schering Health Care Ltd. U.K. for the support given to the experimental stage of the study; and Fundação para a Ciência e a Tecnologia (FCT), Ministério da Ciência e da Tecnologia, Portugal, for financial support.

## REFERENCES

1. Frable, M.A. S. Hoarseness, a Symptom of Premenstrual Tension. *Archives of Otolaryngology*. 1961, 75: 66-68.
2. Lacina, V. Der einfluss der menstruation auf die stimme der sangerinnen. *Folia Phoniatica*. 1968, 20: 13-24.
3. Flach, M., Schwickardi, H. and Simon, R. Welchen einfluss haben menstruation und schwangerschaft auf die ausgebildete gesangsstimme? *Folia Phoniatica*. 1968: 21; 199-210.
4. Brodnitz, F. S. Hormones and the Human Voice. *Bulletin of the New York Academy of Medicine*. 1971, 47: 183-191.
5. Brodnitz, F. S. Hormones and the Human Voice. *Bulletin of the New York of Academy Medicine*. 1971: 47; 183-91.
6. Leo van Gelder, M. D. Psychosomatic Aspects of Endocrine Disorders of the Voice. *Journal of Communication Disorders*. 1974, 7: 257-262.
7. Whitehead, R. L., Kohler, R., Schlueter, S. The Effect of the Menstrual Cycle on Female Vowel Spectra. *Presented at the Annual Meeting of the American Speech and Hearing Association*, Houston, Texas. 1974.
8. Wilson, F. and Purvis, J. A Study of Selected Vocal Behaviours during the Menstrual Cycle of Trained Singers. *Journal Research Singing*. 1980: 10; 16-23

9. Brown, W. S. and Hollien, H. Effect of Menstruation on Fundamental Frequency on Female Voices. In V. Lawrence (ed.) *Transcripts of the tenth symposium for the care of the professional voice*. New York: *The Voice Foundation*. 1981: Part I; 94-101.
10. Brown, W. S. and Hollien, H. Effects of Menstruation on the Singing Voice. In V. Lawrence (ed.) *Transcriptions of the eleventh symposium for the care of the professional voice*. New York. *The Voice Foundation*. 1982: Part I; 140-7.
11. Brown, W. S. and Hollien, H. Effects of Menstruation on the Singing Voice. Part I: History and Current Status. In V. Lawrence (ed.) *Transcripts of the twelfth symposium for the care of the professional voice*. New York: *The Voice Foundation*. 1983: Part I; 112-6.
12. Isenberg, H., Brown, W. S. and Rothman, H. B. Effects of Menstruation in the Singing Voice; Part II: Further developments in research. In V. Lawrence (ed.) *Transcriptions of the twelfth symposium for the care of the professional voice*. The voice foundation. New York. 1983, Part I: 117-123.
13. Brown, W. S., Howard, B. and Rothman, H. The menstrual cycle and its relationship to the highly female voice. In V. Lawrence (ed.) *Transcripts of the fourteenth symposium for the care of the professional voice*. New York: *The Voice Foundation*. 1985: Part I; 114-23.
14. Wicklund, K. et al. Fundamental Frequency Changes in Singers and Non-Singers Related to Menstruation. *Medical Problems of Performing Arts*. 1988: 13; 100-103.
15. Davis, C. B. & Davis, M. L. The Effects of Premenstrual Syndrome (PMS) on the Female Singer. *Journal of Voice*. 1993: 4; 337-353.
16. Chae, S. W., Choi, G., Kang, H. J., Choi, J. O. and Jin, S. M. Clinical Analysis of Voice Change as a Parameter of Premenstrual Syndrome. *Journal of Voice*. 2001: 15; 278-283.
17. Damsté, P. Voice changes in adult women caused by virilizing agents. *Journal of Speech and Hearing Disorders*. 1967, 32: 126-132.
18. Dordain, M. Etude statistique de l'influence des contraceptives hormonaux sur la voix. *Folia Phoniatica*. 1972, 24: 86-96.
19. Amir, O., Kishon-Rabin, L. and Muchnik, C. The Effect of Oral Contraceptives on Voice:

Preliminary Observations. *Journal of Voice*. 2002, 16: 267-273.

20. Abitbol, J., Brux, J., Millot, G., Masson, M., Minoun, O. L., Pau, H. and Abitbol, B. Does a Hormonal Vocal Cord Cycle Exist in Women? Study of Vocal Premenstrual Syndrome in voice Performers by Videostroboscopy-Glottography and Cytology on 38 Women. *Journal of Voice*. 1989; 3: 2157-162.

21. Abitbol, J., Abitbol, P. and Abitbol, B. Sex Hormones and Female Voice. *Journal of Voice*. 1999, 13: 424-446.

22. Martin, E. A. *Concise Colour Medical Dictionary*. 2<sup>nd</sup> edn. Oxford: Oxford University Press, 1998.

23. Boschitsch, E., Skarabis, H., Wuttke, W. and Heithecker, R. The Acceptability of a Novel Oral Contraceptive Containing Drospirenone and its Effect on Well-Being. *The European Journal of Contraception and Reproductive Health Care*. 2000, 5: 34-40.

24. Oelkers, W., Foidart, J. M. Dombrovicz, N. Weter, A. and Heithecker, R. Effects of a New Oral Contraceptive Containing an Antimineralocorticoid Progestogen, Drospirenone, on the Renin-Aldosterone System, Body Weight, Blood Pressure, Glucose Tolerance and Lipid Metabolism. *Journal of Clinical Endocrinology and Metabolism*. 1995, 80: 1816-1820.

25. Wendler, J. Siegert, C., Schelhorn, P., Klinger, G., Gurr, S., Kaufmann, J. Aydinlik, S. and Braunschweig, T. The Influence of Microgynon® and Diane-35®, Two Sub-Fifty Ovulation Inhibitors on Voice Function in Women. *Contraception*. 1995, 52: 343-348.

26. Foidart, J. M. The contraceptive profile of a new contraceptive with antimineralocorticoid and antiandrogenic effects. *The European Journal of Contraception and Reproductive Health Care*. 2000, 3: 25-33.

27. Baken, R. J. Electrolottography. *Journal of Voice*. 1992, 6: 98-110.

28 Carlson, E. and Miller, D. Aspects of Voice Quality: Display, Measurement and Therapy. *International Journal of Language and Communication Disorders*. 1998, 33: 304-309.

29. Abberton, E. and Fourcin, A. Ellectrolaryngography. In C. Code and M. Ball, (eds.)

*Experimental Clinical Phonetics*. San Diego: Croom Helm Ltd. 1984.

30. Abberton, A. F., Abberton, E., Miller, D. and Howells, D. Laryngography. *European Journal of Disorders of Communication*. 1995, 30: 101-115.

31. Fourcin, A. Electrolaryngographic assessment of vocal fold function. *Journal of Phonetics*. 1986, 14: 435-442.

32. Abberton, E. R. M., Howard, D. M. and Fourcin, A. J. Laryngographic assessment of normal voice: a tutorial. *Clinical Linguistics & Phonetics*. 1989, 3: 281-296.

33. Fourcin, A., McGlashan, J. and Blowes, R. Measuring voice in clinic – Laryngograph Speech studio Analyses. *6<sup>th</sup> Symposium of Australia*. 2002.

34. Rubin, J. S., Sataloff, R. T., Korovin, G. S. and Gould, W. J. *Diagnosis and Treatment of Voice Disorders*. New York: IGAKU-SHOIN Medical Publishers, Inc. 1995.

35. Howard, D. M. Variation of Electrolaryngographically Derived Closed Quotient for Trained and Untrained Adult Female Singers. *Journal of Voice*. 1995, 9: 163-172.

36. Larsen, P. R., Kronenberg, H. M., Melmed, S. and Polonsky, K. *William Textbook of Endocrinology*. Philadelphia: Saunders. Tenth Edition. 2003.

37. Howard, D. M., Lindsey, G. A. & Allen, B. Toward the Quantification of Vocal Efficiency. *Journal of Voice*. 1990, 4: 205-212.

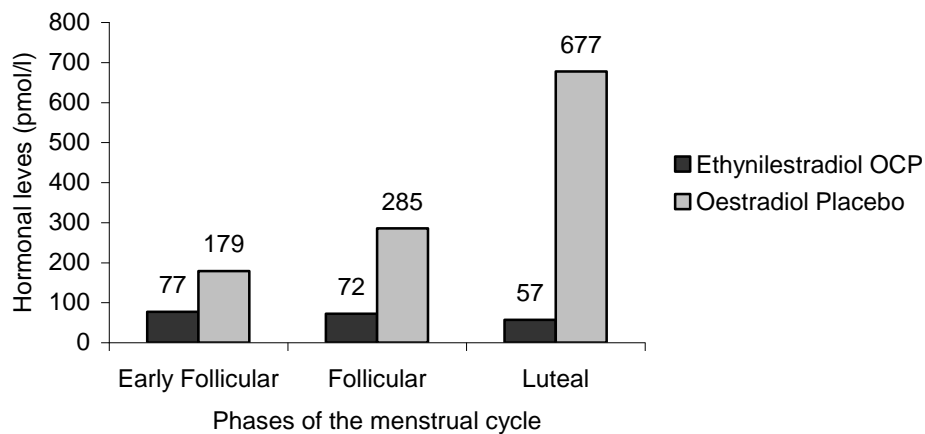
**Table 1:** Concentrations of steroid hormones during OCP and placebo use, and for the three stages of the menstrual cycle (menstruation or menses, follicular and luteal phases; E = oestradiol; P = progesterone).

<b>Hormones</b>	<b>OCP</b>			<b>Placebo</b>		
	<b>Menses</b>	<b>Follicular</b>	<b>Luteal</b>	<b>Menses</b>	<b>Follicular</b>	<b>Luteal</b>
<b>E (pmol/l)</b>	77.0	72.0	<57.0	179.0	285.0	677.0
<b>P (nmol/l)</b>	1.6	4.8	2.3	5.6	4.2	47.2

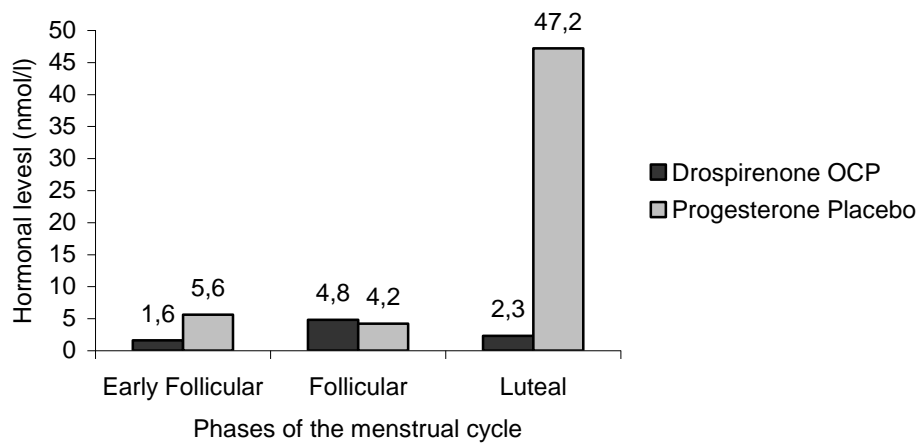
**Table 2:** Summary statistics for means and standard deviations (SD) for the distribution of closed phase quotient (DQ<sub>x</sub>), for the Lied “Widmung” by Schumann, during OCP and placebo use, and for the three phases of the menstrual cycle (menstruation or menses, follicular and luteal phases).

Vocal Parameter	OCP						Placebo					
	Menses		Follicular		Luteal		Menses		Follicular		Luteal	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
QF <sub>x</sub> (%)	40.50	5.26	40.50	8.99	37.50	5.78	35.50	4.28	36.50	2.88	42.50	7.64

**Figure 1:** Concentrations of ethynylestradiol and oestradiol during OCP and placebo use, respectively, for the three phases of the menstrual cycle (earlier follicular, i.e. menstruation, follicular and luteal phases of the menstrual cycle).



**Figure 2:** Concentrations of drospirenone and progesterone during OCP and placebo use, respectively, for the three phases of the menstrual cycle (earlier follicular, i.e. menstruation, follicular and luteal phases of the menstrual cycle).





**Figure 3:** Closed phase quotient distribution histogram ( $DQ_x$ ) derived electrolyngographically during the performance of the Lied “Widmung” by Schumann, during OCP and placebo use, and for the three phases of the menstrual cycle (menstruation- black line; follicular phase – red line; and luteal phase – green line).

