Cepstral Measures of Voice in Women with Polycystic Ovarian Syndrome

Asia Pacific Journal of Multidisciplinary Research
Vol. 8 No.1, 81-85
February 2020
P-ISSN 2350-7756
E-ISSN 2350-8442
www.apjmr.com
ASEAN Citation Index

S.V. Narasimhan[1], S. Dhanya[2]
[1]Reader, Department of Speech & Language Pathology, JSS Institute of Speech & Hearing, JSS Hospital, India
[2]Dhanya Sathyan, MASLP, Samvaad Institute of Speech & Hearing, India
narasimhanslp@gmail.com[1], dhanyasathyan1@gmail.com[2]

Date Received: January 2, 2020; Date Revised: February 9, 2020

Abstract *– Human larynx is highly susceptible to hormonal fluctuations, especially in sex hormones, can be expected to cause a change in voice. Polycystic ovarian syndrome is one such frequent abnormality of the endocrinal system that affect women during their reproductive age. Therefore, the current study intended to document the cepstral measures of voice in subjects with polycystic ovarian syndrome. Thus, the study included two groups of subjects within the age range of 25-30 years. Group A included 30 female subjects having polycystic ovarian syndrome and Group B included 30 female subjects without polycystic ovarian syndrome. Voice of all the subjects was recorded, and the Smoothened Cepstral Peak Prominence and Cepstral Peak Prominence values were obtained. The obtained values were tabulated and statistically analysed. Results revealed that the subjects of group B had significantly higher Cepstral Peak Prominence and Smoothened Cepstral Peak Prominence values compared to the subjects of group A. Significant difference in both Cepstral Peak Prominence and Smoothened Cepstral Peak Prominence between the three vowels were also evidenced from the results. Supplementary researches on the relationship between the hormonal levels and the cepstral parameters could help differentiate and better quantify voice problems in subjects with the polycystic ovarian syndrome.*

Keywords *– Cepstral measures, Cepstral Analysis, Cepstral Peak Prominence, Polycystic ovarian syndrome*

INTRODUCTION

The review of the literature on the voice changes in women with Polycystic ovary syndrome (PCOS) clearly indicates that there are presences of abnormal vocal fold vibrations and the tension in the laryngeal musculature and not complemented by any symptoms related to the voice production. In this regard, cepstral analysis of voice can be used to measure and document the voice changes in women with PCOS. Even though there are studies focusing on the incidence of voice disorders in patients with PCOS, a handful of studies have focused on documenting these measures of voice in patients with PCOS. The cepstral measure indicates the degree of organization of harmonic structures in a voice signal and thus can provide valuable information on the vocal characteristics of the subjects with PCOS. However, only a handful of studies has focused on documenting the cepstral characteristics of voice among subjects with PCOS. Therefore, to address the above issues, the current investigation intended to measure the cepstral parameters of voice in women with and without PCOS.

PCOS, also termed as the Stein-Leventhal syndrome, was originally explained by Stein and Leventhal in 1935 [1]. PCOS is an abnormality of the endocrinal system that affects around nine to twenty-one percent women in their reproductive age [2,3]. PCOS is a multifaceted disorder frequently characterised by the presence of small cysts on ovaries, irregular menstruation, high androgen level, ovulatory dysfunction, hirsutism, acne, glucose intolerance, and also alopecia [4,5].

PCOS is commonly diagnosed based on Rotterdam criteria (2003). Rotterdam criteria (2003) are the most relevant and broadly utilised criteria to diagnose PCOS. PCOS is diagnosed if any two of the following conditions exist: (a) oligovulation/ anovulation, (b) hyperandrogenism, and (c) polycystic ovaries [6]. Even though the abnormality in the ovaries can be considered as the principal aetiology of the disorder, factors related to environment and obesity can significantly contribute as additional agents. Family history of PCOS is common among the patients. However, genetic factors causing PCOS to stay unfamiliar [7].

Changes in voice have been conventionally documented as one of the characteristic features of

PCOS. Many investigators have described a clear relationship linking the human voice and the endocrine system in females during various phases of their lives [8–12]. As the human laryngeal system is highly susceptible to the changes in hormonal levels, the fluctuation in sex hormones can be expected to cause a change in voice. A preliminary study on the assessment of vocal symptoms and acoustic analysis of voice among subjects with PCOS reported a higher prevalence of vocal symptoms among the subjects with PCOS [13]. However, no differences in any of the acoustic parameters except relative average perturbation (RAP), were reported between the subjects with PCOS and controls. Gugatschka et al. [14] also attempted to document the subjective and objective parameters of voice in subjects with PCOS and reported no significant differences in either objective or subjective parameters of voice between patients with and without PCOS. Later studies have also attempted to document the laryngeal examination findings and the vocal characteristics in patients with PCOS and have reported that there were no differences noted in terms of either objective vocal parameters or vocal complaints between patients with PCOS and controls subjects [15].

Even though there is a high prevalence of PCOS and it is also a well-known fact that vocal changes are associated with hormonal imbalances among women affected with PCOS, only a handful of investigations have assessed vocal changes in PCOS. Most of these investigations have assessed the vocal characteristics using acoustic analysis of voice and have reported no differences between the patients with PCOS. Although cepstral measures of voice have been considered to be more reliable, none of the studies has attempted the use of cepstral analysis of voice among the patients with PCOS.

Even though acoustic analysis has been regarded as a necessary tool for the investigation of dysphonic voices, cepstral measures are considered more reliable. Traditional acoustic voice measurements are based on the accurate determination of measurement of the cycle to cycle variations in voice and the fundamental frequency (Fo). Advantage of cepstral measures of voice is that the cepstral measurements are not carried out based on the cycle to cycle measurements; rather cepstral measures are acquired by averaging the vocal signal throughout its complete length, and therefore decreasing the errors during analysis [16]. Acoustic measurements related to frequency and perturbation mainly rely on the accuracy in the calculation of the fundamental frequency, whereas the cepstral measures of voice primarily rely upon the peak to average calculation and thus the cepstral measurements are considered to be more reliable [17].

Cepstrum is the Fourier transformation of a spectrum [18]. It is defined as a discrete Fourier transform of the logarithm power spectrum [17,19]. The cepstral measure indicates the degree of organisation in the harmonic structure of a signal, i.e., a prominent cepstral peak reflects a spectrum having a clear harmonic structure [20]. Cepstral peak prominence (CPP) measures the difference in amplitude between the fundamental period and the cepstral peak after the overall amplitude of the signal is normalised [17]. Similarly, smoothened CPP (CPPs) is the averaged values of individual cepstra over a specific number of frames before extracting the cepstral peak [19].

Thus, the cepstral measures of voice provide a quantifiable tool for determining the degree of glottal closure and thus helps in distinguishing the dysphonic voices from normal voices better than the traditional acoustic analysis. Even though earlier researches have suggested that cepstral analysis can be used as a quantifiable acoustic index and is a powerful marker of voice disorders, only a few studies have been attempted on documenting the cepstral measures of voice particularly in subjects with PCOS

OBJECTIVES OF THE STUDY

The present study's objective was to document and compare the cepstral measures of voice (CPP and CPPs) between the subjects with and without PCOS.

MATERIALS AND METHODS

The present study used the standard group comparison research to compare the cepstral measures of voice between the subjects with and without PCOS. Thus, two groups of subjects in the age range of 25-30 years were recruited for the present study using purposive sampling.

Group A included 30 female subjects diagnosed as having PCOS and Group B included 30 female subjects without PCOS. The subjects of group A were chosen from the Private Hospitals at Wayanad, Kerala, India. These subjects were diagnosed as having PCOS based on Rotterdam criteria (2003) by a qualified gynaecologist, i.e., anovulation or oligovulation, clinical polycystic ovaries identified through Ultrasonography or biochemical hyperandrogenism. All the subjects of Group A had PCOS for the past 5 years and were on medications for the same. Patients identified with any symptoms of the gastro-oesophageal reflux disease such as frequent heartburn, chest pain, regurgitation of food,

the sensation of a lump in the throat and any other causes for anovulation/ oligovulation or hyperandrogenism such as thyroid dysfunction, hyperprolactinemia, Cushing's syndrome were eliminated from the present study.

Group B consisted of 30 age match control subjects with no symptoms of PCOS. All the subjects of Group B had a clinically normal voice, and none of the subjects reported a history of voice disorders. Group B subjects were formally evaluated by an experienced Speech Language Pathologist, a qualified otolaryngologist and a Gynecologist. All the subjects of Group 2 had structurally and functionally normal vocal folds on laryngoscopic examination and had a normal ovarian function on gynaecological examination. Convenience sampling was used to employ all the subjects for the study. Further, all the subjects were explained the purpose of the voice recording and the informed written consents were obtained.

Procedure

A sound-treated room used for audiometry which met the American National Standards Institute (ANSI) specifications prescribed for hearing evaluation was used for data collection. The room was free from distraction and had a comfortable temperature and well lit. Participants were instructed to phonate the vowels /a/, /i/ and /u/ at their habitual pitch and comfortable loudness levels. A unidirectional dynamic microphone (Sony F-V120 Dynamic, Unidirectional Microphone with a frequency response of 60-12,000Hz) was used to record the data onto the Praat software (version 6.0.56). The distance between the microphone and the participant's mouth was 15 cm. All the phonations were recorded with a sampling frequency of 44.1 kHz and quantised at a rate of 16 bits/ sample. Each participant was instructed to phonate each vowel three times and all the three repetitions were recorded. Most stable recording out of the three repetitions was chosen, and the five-second segment from the middle of the recording of each vowel was considered for further analysis. Further, each sample was displayed as a waveform using the software (Speech Tool) and CPP and CPPs values were obtained using the Hillenbrand algorithm for all the phonation samples. The values obtained were analysed using SPSS software, version 24.0 (SPSS Inc, Chicago, IL).

RESULTS AND DISCUSSION

The CPP and CPPs values were tabulated and statistically analysed. As a part of descriptive statistics, mean and standard deviation values of CPP and CPPs were obtained for the subjects of both the groups. To determine the individual effect of each independent variables (Groups and vowel) on both the dependent variables (CPP and CPPs), Univariate analysis of variance (ANOVA) was performed with 95% confidence interval (at a significance level of 0.05).

Table 1. Mean values of CPP and CPPs for subjects of Group A and Group B

Parameters	Groups	/a/	/i/	/u/
CPP	Group A	11.8	11.8	10.4
	Group B	13.8	13.2	12.0
CPPs	Group A	4.8	4.0	3.7
	Group B	5.0	4.9	4.4

It is evident from Table 1 that the mean values of both CPP and CPPs were higher for subjects of group B compared to the subjects of group A. It is also evident that the standard deviation values of both CPP and CPPs were higher for subjects of Group A. The results of ANOVA revealed that there was a significant effect of group on both CPP and CPPs. Subjects of group B had significantly higher CPP ($F= 12.7$, $p< 0.05$) and CPPs ($F= 6.4$, $p< 0.05$) compared to that of group A subjects. Results also showed significant effects of vowels on CPP ($F= 4.4$, $p< 0.05$) and CPPs ($F= 4.3$, $p< 0.05$). As ANOVA showed that there was a significant difference in both CPP and CPPs between the three vowels, Scheffe's Post Hoc test was carried out to note the significant differences in CPP and CPPs between the three vowels. The results of the Scheffe's Post Hoc test showed that vowel /a/ and /i/ had significantly high CPP and CPPs values compared to the vowel /u/.

Thus, the present study results showed that CPP and CPPs were lower among the subjects with PCOS compared to that of control subjects. According to Heman-Ackah, Michael and George[21], strong cepstral peaks can be evidenced in voices with a well-defined harmonic structure, whereas voices with flat harmonic structure demonstrate lower cepstral peaks. Further, earlier studies on dysphonic subjects have concluded that subjects with dysphonia show significantly lower CPP values than control subjects. As the cepstral peak represents the most harmonic part of the signal that stands out above the background noise, the reduced cepstral peak can be attributed to the increase in noise and poor harmonic structure during voice production [22],[23].

Human larynx is often considered as a hormonal target. As the laryngeal system is highly susceptible to the changes in the level of hormones, the fluctuation in sex hormones can be expected to cause a change in

laryngeal physiology. Thus, the changes in cepstral parameters of voice in the present study ought to be inferred together with the hormonal variations evidenced among the subjects with PCOS. It is well known that these hormonal changes, especially the changes in estrogen levels can cause hypertrophic effects on laryngeal mucosa, increase in capillary permeability and increased secretion of glandular cells on top and below the vocal folds [13]. On the contrary, Progesterone can cause a decrease in the secretion of mucosal, dehydration of the mucosal layer, and tissue congestion [13]. Commonly, as the progesterone level is elevated, the estrogen level is diminished, and vice versa and these fluctuations in the levels of progesterone and estrogen can significantly alter the vocal folds' vibratory characteristics [8] and thus could be the possible contributory factor for poor harmonic structure and increase in glottal noise in patients with PCOS. These results can be further substantiated by the findings of the study attempted to document the stroboscopic and fiberoptic laryngeal alterations in subjects with PCOS [15]. The current study results exposed the evidence of hour-glass closure pattern of the vocal folds, posterior glottic chink, irregular vocal fold edges and abnormal mucosal wave patterns during phonation in subjects with PCOS. Therefore, the lower values of CPPs and CPP observed in subjects with PCOS in the current investigation could be suggestive of the presence of higher noise levels during voice production indicative of possible phonatory gap during phonation.

Earlier studies on the acoustic analysis of voice among subjects with PCOS had reported an increase in RAP. However, the differences between the subjects with PCOS and controls for any of the acoustic parameters except for RAP were reported to be not statistically significant [13] and the trend towards lower fundamental frequency in the subjects with PCOS. The present study has documented significantly lower values of CPPs and CPP among the subjects with PCOS compared to that of control subjects. Many previous studies on the cepstral analysis of voice [24-27] have claimed that cepstral parameters are reliable and robust tools in predicting overall dysphonia. As the present study also documented the differences in cepstral parameters between subjects with and without PCOS, the investigation substantiated the findings of all the previous studies reporting that cepstral parameters of voice are reliable in predicting overall dysphonia in various types of laryngeal pathologies including PCOS. Therefore, the study strongly recommends the deployment of cepstral parameters of voice as a quantifiable acoustic index to measure dysphonia.

CONCLUSION AND RECOMMENDATION

The present study evaluated the cepstral parameters of voice between the subjects with and without PCOS. Cepstral measures of voice, namely CPP and CPPs, were analysed for both the groups. The results revealed that CPPs and CPP were significantly reduced in the phonation of the subjects with PCOS compared to that of control subjects. However, the present study also had a few limitations. Primarily, the investigation of the cepstral measures of voice in phonation of the three vowels was carried out in the present study and the study did not focus on the investigation of these parameters during the speaking task. Secondly, the subjects with PCOS were not classified based on the severity of voice disorder or voice problems. The study was also restricted to the investigation of the cepstral voice characteristics among the subjects with PCOS who reported no presence or history of voice problems and had not considered the subjects with PCOS with the complaint of vocal symptoms. Thirdly, the present study had included the subjects having PCOS for the past 5 years and all the subjects were on medications for the same, but the duration and type of treatment or medication received by these subjects were not uniform. Lastly, the study also failed to locate grounds to elaborate on the exact relationship between the hormonal levels and cepstral parameters.

As the present study was a preliminary attempt to investigate the cepstral parameters among the subjects with PCOS, future research could also throw more light on correlating the cepstral parameters of voice and other traditional acoustic parameters in subjects with PCOS. It would be interesting to document the effect of duration of onset of PCOS, the effects of different treatment types and duration of treatment on the cepstral characteristics of voice in subjects with PCOS. Research on the cepstral parameters of voice in the PCOS subjects with and without voice disorders would also help in better understanding of voice problems in these subjects. Supplementary studies on the relationship between the hormonal levels and the cepstral parameters could help differentiate and better quantify voice problems in patients with PCOS in a more efficacious manner.

ACKNOWLEDGMENTS

The author expresses his sincerest gratitude to Professors Helen Watt and Paul Richardson, for allowing use of their FIT-Choice scale in this study.

REFERENCES

[1] Bednarska, S., & Siejka, A. (2017). The pathogenesis and treatment of polycystic ovary syndrome: What's new? Advances in Clinical and Experimental Medicine, 26(2), 359–367.

[2] March, W. A., Moore, V. M., Willson, K. J., Phillips, D. I. W., Norman, R. J., & Davies, M. J. (2010). The prevalence of polycystic ovary syndrome in a community sample assessed under contrasting diagnostic criteria. Human Reproduction.

[3] Yildiz, B. O., Bozdag, G., Yapici, Z., Esinler, I., & Yarali, H. (2012). Prevalence, phenotype and cardiometabolic risk of polycystic ovary syndrome under different diagnostic criteria. Human Reproduction.

[4] Lin, L. H., Baracat, M. C. P., MacIel, G. A. R., Soares, J. M., & Baracat, E. C. (2013). Androgen receptor gene polymorphism and polycystic ovary syndrome. International Journal of Gynecology and Obstetrics.

[5] Goodarzi, M. O., Dumesic, D. A., Chazenbalk, G., & Azziz, R. (2011). Polycystic ovary syndrome: Etiology, pathogenesis and diagnosis. Nature Reviews Endocrinology.

[6] Rotterdam ESHRE/ASRM-Sponsored PCOS Consensus Workshop Group. (2004). Revised 2003 consensus on diagnostic criteria and long-term health risks related to polycystic ovary syndrome. Fertility and Sterility.

[7] Ndefo, U. A., Eaton, A., & Green, M. R. (2013). Polycystic ovary syndrome: a review of treatment options with a focus on pharmacological approaches. P & T: A Peer-Reviewed Journal for Formulary Management, 38(6), 336–355.

[8] Abitbol, J., Abitbol, P., & Abitbol, B. (1999). Sex hormones and the female voice. Journal of Voice, 13(3), 424–446.

[9] Çelik, Ö., Çelik, A., Ateşpare, A., Boyaci, Z., Çelebi, Ş., Gündüz, T., … Yelken, K. (2013). Voice and speech changes in various phases of menstrual cycle. Journal of Voice.

[10] Hamdan, A. L., Mahfoud, L., Sibai, A., & Seoud, M. (2009). Effect of Pregnancy on the Speaking Voice. Journal of Voice.

[11] Pipitone, R. N., & Gallup, G. G. (2008). Women's voice attractiveness varies across the menstrual cycle. Evolution and Human Behavior.

[12] Sovani, P. V., & Mukundan, D. G. (2017). Comparison of post menopausal voice changes across professional and non-professional users of the voice. South African Journal of Communication Disorders.

[13] Hannoun, A., Zreik, T., Husseini, S. T., Mahfoud, L., Sibai, A., & Hamdan, A. (2011). Vocal Changes in Patients with Polycystic Ovary Syndrome. Journal of Voice, 25(4), 501–504.

[14] Gugatschka, M., Lichtenwagner, S., Schwetz, V., Lerchbaum, E., Graupp, M., Gerstenberger, C., … Friedrich, G. (2013). Subjective and objective vocal parameters in women with polycystic ovary syndrome. Journal of Voice, 27(1), 98–100.

[15] Aydin, K., Akbulut, S., Demir, M. G., Demir, S., Ozderya, A., Temizkan, S., & Sargin, M. (2016). Voice characteristics associated with polycystic ovary syndrome. Laryngoscope.

[16] Jannetts, S., & Lowit, A. (2014). Cepstral Analysis of Hypokinetic and Ataxic Voices: Correlations with Perceptual and Other Acoustic Measures. Journal of Voice, 28(6), 1–8.

[17] Hillenbrand. (1994). Acoustic Analysis of Voice: A Tutorial. 2–27.

[18] Hillenbrand, J; Cleveland, R; Erickson, R. (1994). Acoustic Correlates of Breathy Vocal Quality. Journal of Speech and Hearing Research, 37(August), 298–306.

[19] Hillenbrand, J., & Houde, R. A. (1996). Acoustic correlates of breathy vocal quality: dysphonic voices and continuous speech. Journal of Speech and Hearing Research, 39(2), 311–321.

[20] Balasubramanium, R. K., Shastry, A., Singh, M., & Bhat, J. S. (2015). Cepstral Characteristics of Voice in Indian Female Classical Carnatic Singers. Journal of Voice, 29(6), 693–695.

[21] Heman-Ackah, Y. D., Michael, D. D., & George, G. S. (2002). The Relationship Between Cepstral Peak Prominence and Selected Parameters of Dysphonia. Journal of Voice, 16(1), 20–27.

[22] Balasubramanium, R. K., Bhat, J. S., Fahim, S., & Raju, R. (2011). Cepstral analysis of voice in unilateral adductor vocal fold palsy. Journal of Voice, 25(3), 326–329.

[23] Balasubramanium, R. K., Bhat, J. S., & Prasad, N. (2010). Cepstral Analysis of Voice in Persons with Vocal Nodules. Journal of Voice, 24(6), 651–653.

[24] Eadie, T. L., & Baylor, C. R. (2006). The Effect of Perceptual Training on Inexperienced Listeners' Judgments of Dysphonic Voice. Journal of Voice, 20(4), 527–544.

[25] Hasanvand, A., Salehi, A., & Ebrahimipour, M. (2017). A Cepstral Analysis of Normal and Pathologic Voice Qualities in Iranian Adults: A Comparative Study. Journal of Voice, 31(4), 508.

[26] Virginia, W., & Martina, D. (1997). Acoustic correlates of dysphonia: type and severity. Journal of Communication Disorders, 30(5), 403–416.

[27] Wolfe, V., & Martin, D. (1997). Acoustic correlates of dysphonia: Type and severity. Journal of Communication Disorders, 30(5), 403–416.

COPYRIGHTS