Original Article

Medial Olivocochlear Functioning and Speech Perception in Noise in Individuals with Polycystic Ovary Syndrome

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Abstract

Introduction: The current study aimed to evaluate the olivocochlear bundle functioning and speech perception in the presence of noise in females with Polycystic ovary syndrome (PCOS). **Method:** Twenty participants in the age range of 18-25 years were included in the study. They were equally divided into two groups: group 1 included females diagnosed with PCOS, and group 2 included healthy adult male participants. Medial olivocochlear (MOC) functioning was evaluated using contralateral suppression of transient otoacoustic emissions (TEOAE). In addition, speech perception in noise was assessed using a quick speech perception in noise test in Malayalam. **Results:** Results showed a significant difference for the TEOAE amplitude and signal to noise ratio (SNR) of TEOAEs in quiet and in the presence of contralateral noise and the speech perception in noise between the two groups. Also, no contralateral suppression was noted in the clinical group suggesting that MOC functioning is affected in individuals with PCOS. **Conclusion:** It can be concluded that medial olivocochlear bundle functioning and speech perception in noise is affected in individuals with PCOS, which can be attributed to the abnormality in the hormonal status of PCOS.

Keywords: Contralateral suppression of otoacoustic emissions, medial olivocochlear bundle, polycystic ovary syndrome

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Introduction

Polycystic ovary syndrome (PCOS) is an endocrinological disorder commonly affecting 5%–10% of women during their reproductive age.[1] Individuals diagnosed with PCOS are more prone to get endometrial cancer, cardiovascular disease, dyslipidemia, and diabetes mellitus type 2.[2] The exact etiology of PCOS remains unknown; however, it can be due to the interaction of multiple genetic and environmental factors.[3] PCOS is diagnosed based on the criteria: the presence of clinical or biochemical hyperandrogenism, oligoovulation and/or anovulation and/or polycystic ovary, and exclusion of other entities that could cause PCOS.[4]

Epidemiologic studies have revealed that females have better thresholds in high-frequency regions than males in almost all age groups.[5] However, in females with PCOS, the auditory abilities are affected.[6] Impaired auditory abilities in the PCOS group have been attributed to the damage to the endothelial layer, cardiovascular disease, variations in biochemical activity and hormonal level, and insulin resistance. Furthermore, endothelial damage and vascular changes are observed in PCOS, mainly in the cochlea's basal part (responsible for high-frequency hearing).[6] In addition, it is reported that the possibility of hidden hearing loss in PCOS is significant in the higher frequencies (8000 Hz–20,000 Hz) compared to the lower frequencies (250 Hz–4000 Hz).[7]

Auditory abilities in the PCOS group have also been assessed using otoacoustic emissions (OAEs).[8] Results showed no difference in distortion-product OAE (DPOAE) amplitude between PCOS and the healthy female group. This could be because conventional DPOAE measures a frequency range of 500 Hz–8000 Hz. However, the PCOS group's high-frequency threshold might be impaired (between 9000 Hz and 20,000 Hz).[8]

It has also been reported that fluctuations in the ovarian hormonal level (estrogen and progesterone) can impact inner ear homeostasis and the auditory system in general.

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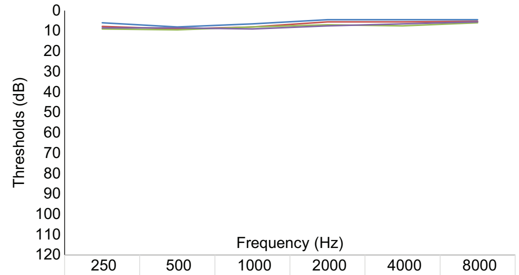
Estrogen plays a vital role in protecting the auditory system by activating the medial olivocochlear (MOC) reflex,[9] and progesterone interferes with speech perception in background noise. In the PCOS group, there is a hormonal imbalance. It is hypothesized that these individuals may have altered the MOC bundle functioning and impaired speech perception in noise (SPIN). The MOC efferent system's physiological status can be evaluated noninvasively through contralateral suppression of OAEs, which results in the alteration of cochlear micromechanics.[9] The current study aimed to investigate the MOC bundle functioning using contralateral suppression of transient-evoked otoacoustic emissions (TEOAEs) and SPIN in females diagnosed with PCOS.

Materials and Methods

Participants

In the current study, a standard group comparison research design was used to evaluate the MOC functioning in individuals with PCOS. A total of twenty participants in the age range of 18–25 years (mean age: 21.5 years) were taken for the study, and they were equally divided into two groups. The clinical group included ten female participants diagnosed with PCOS, and the control group included ten healthy adult male volunteers. Healthy male volunteers were considered to avoid the effect of subtle changes in auditory functioning during the menstrual cycle in female participants. The participants were selected using the purposive sampling technique, and informed consent was obtained from all the participants before the experiment. The clinical group participants were selected based on infrequent or irregular ovulation, hyperandrogenism, and polycystic ovaries on ultrasound examination. Participants of both the groups had normal otoscopic findings and normal hearing sensitivity for frequencies between 250 Hz and 8000 Hz (thresholds within 15 dBHL for air conduction and bone conduction bilaterally). The mean pure-tone thresholds of both groups are depicted in Figure 1.

Further, participants in both groups did not report any other otological, neurological problems and speech and language impairments. None of the participants had endocrine diseases,



	250	500	1000	2000	4000	8000
Control group Right	6	8	6.5	4.5	4.5	4.5
Control group Left	7.8	9	8	5.5	5.5	5.3
Clinical group Right	9	9.5	8	7	7.5	6
Clinical group Left	8.5	8.5	9	7.5	6.5	5.5

Figure 1: Mean pure-tone thresholds of the right and left ears among control and clinical groups

including diabetes mellitus, androgen-secreting tumors, thyroid hormone abnormalities, hypertension, usage of ototoxic drugs, autoimmune diseases, and taking medications for hormonal imbalance, which can affect the sex hormonal level. All the participants were native speakers of Malayalam.

Procedure

All the participants underwent routine audiological evaluation in a sound-attenuated room with a noise level within the permissible level (ANSI S3.1-1991). Before the testing, an otoscopic examination was done to investigate the status of the external ear and tympanic membrane. Pure-tone audiometry was performed for frequencies between 250 Hz and 8000 Hz. A dual-channel diagnostic audiometer with TDH 39 headphone and B71 bone vibrator was used for air conduction threshold and bone conduction threshold measurement, respectively. Middle ear functioning was assessed using tympanometry with 226 Hz probe tone, and acoustic reflex testing was done at 500 Hz, 1000 Hz, and 2000 Hz for ipsilateral and contralateral stimuli. Later, MOC bundle functioning was assessed using contralateral suppression of TEOAEs, and SPIN was done in females diagnosed with PCOS.

Transient-evoked otoacoustic emission recording

TEOAE recording was done, and MOC bundle functioning was evaluated using contralateral suppression of TEOAEs using ILO v6 (Otodynamics Ltd., Hatfield, UK), OAE equipment. Participants were asked to sit comfortably and were instructed to relax and minimize extraneous movements during the test. An appropriate probe tip was inserted gently into the ear canal. Once the probe tip was inserted, it was adjusted to give a flat frequency spectrum. TEOAEs were recorded using clicks of 80 µs duration at 65 dB peSPL. The response was acquired using a standard nonlinear click with 260 sweeps. TEOAE amplitude and signal-to-noise ratio (SNR) at each frequency band were noted down (1000 Hz, 1414 Hz, 2000 Hz, 2828 Hz, and 4000 Hz). This was also considered as a baseline for the recording of contralateral suppression of OAEs.

Contralateral suppression of TEOAEs was recorded in the presence of white noise presented contralaterally at 60 dBHL. For this purpose, an insert receiver from the audiometer was placed contralateral to the probe ear. TEOAE amplitude and SNR were recorded at each frequency band in the presence of continuous white noise. The difference between the baseline TEOAE amplitude and TEOAE amplitude in the presence of contralateral noise at different frequencies was considered as the amount of contralateral suppression. If this value was positive, it was considered as the presence of suppression, and if it was negative or zero, it was considered as no suppression.[10] TEOAE recording was done for each ear separately. For all the participants, the TEOAE recording was first done in quiet, followed by recording in the presence of contralateral noise testing.

Speech perception in noise testing

SPIN was measured using a quick speech perception in a noise test in Malayalam.[11] The test contains seven equivalent lists, and each list consists of seven sentences, and each of them has five keywords. The SNR in each list varies from +8 dB to − 10 dB in 2.5 dB steps in each successive sentence in a list. Lists 1 and 2 were used in the present study. Every stimulus was presented monaurally through a laptop connected with a calibrated headphone. The participants were instructed to listen and repeat the target sentences. For scoring, every correct keyword identification was given a score of 1, and the incorrect response was assigned a score of 0. Thus, the maximum possible score for each list was 35. SPIN was measured for each ear separately.

The data were analyzed statistically using Statistical Package for Social Sciences (SPSS) version 20 (IBM Corp., Armonk, NY, USA). Shapiro–Wilk tests of normality indicated normally distributed data ($P > 0.05$). Hence, parametric statistics were done to analyze the data. Descriptive statistics were done to estimate the mean and standard deviation (SD) of SPIN and TEOAEs in quiet and in the presence of noise for all the participants, separately for the right and left ears. A paired *t*-test was done to assess the significant difference between the right ear and the left ear of TEOAE amplitude, SNR in quiet and in the presence of contralateral noise, and SPIN for both groups. A mixed analysis of variance (ANOVA) was carried out to compare the difference between the clinical and control groups for SPIN and TEOAEs.

Results

The present study aimed to compare the MOC functioning and SPIN between females diagnosed with PCOS and healthy male participants. Pure-tone thresholds were within the normal limits in both clinical and control participants. A paired *t*-test was done to compare the thresholds of the right and left ears. Results showed no significant difference in thresholds between the ears ($P > 0.05$). Thus, to compare the thresholds between the control and clinical groups, the thresholds of the right and left ears were combined (40 ears). An independent sample *t*-test was done to assess the significant difference in pure-tone thresholds between the two groups. Results showed no significant statistical difference in pure-tone thresholds between the two groups at 250 Hz ($t[38] = -1.791$, $P = 0.081$), 500 Hz ($t[38] = -0.403$, $P = 0.689$), 1000 Hz ($t[38] = -0.990$, $P = 0.329$), 2000 Hz ($t[38] = -1.690$, $P = 0.099$), 4000 Hz ($t[38] = -1.798$, $P = 0.080$), and 8000 Hz (t[38= −0.831, $P = 0.255$).

Further, to fulfill the aim, TEOAE was recorded in quiet (as baseline) and in the presence of contralateral noise for both the clinical group and the control group. A paired *t*-test was done to assess the significant difference in TEOAE amplitude and SNR between the right and left ears. Results showed no difference between the scores of the right and left ears ($P > 0.05$). Thus, for further statistics, the right and left ear results were combined (40 ears). The mean and SD of TEOAE amplitude and SNR in the

Table 1: Mean and standard deviation of transient-evoked otoacoustic emissions with and without contralateral noise for the control group

Frequency (Hz)	Control group							
	Quiet				Noise			
	TE amp (dB)		SNR (dB)		TE amp (dB)		SNR (dB)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1000	−3.4	6.19	6.32	14.45	−5.19	6.07	4.54	13.45
1414	1.17	5.43	12.18	6.86	−0.19	4.18	10.18	10.03
2000	2.49	5.21	13.06	5.05	1.24	5.66	11.6	5.58
2828	−0.34	4.37	9.75	4.54	−0.36	7.21	8.87	4.45
4000	−2.39	5.68	8.65	4.31	−3.49	5.53	6.36	6.55

SD: Standard deviation, SNR: Signal-to-noise ratio, TE: Transient-Evoked

Table 2: Mean and standard deviation of transient-evoked otoacoustic emissions with and without contralateral noise for clinical group

Frequency (Hz)	Clinical group							
	Quiet				Noise			
	TE amp (dB)		SNR (dB)		TE amp (dB)		SNR (dB)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1000	0.5	3.91	13.26	5.13	1.29	4.61	12.19	5.91
1414	2.57	5.04	16.74	5.27	3.38	4.18	16.67	5.85
2000	1.04	6.79	14.21	6.33	1.89	6.43	15.72	8.31
2828	0.15	6.95	14.21	6.33	−0.36	7.21	13.26	7.23
4000	−0.34	5.45	13.4	4.81	−0.69	5.27	13	4.47

SD: Standard deviation, SNR: Signal-to-noise ratio, TE: Transient-Evoked control group and clinical group for the quiet condition and the presence of contralateral noise conditions obtained at different frequencies are shown in Tables 1, respectively. Tables 1 show that the TEOAE amplitude and SNR were better in the clinical group than in the control group.

Further, ANOVA was done to compare the difference between the clinical and control groups for TEOAEs. Results showed a significant difference in SNR of TEOAEs in quiet at 1000 Hz ($F[1, 38] = 4.038$, $P = 0.05$), 1414 Hz ($F[1, 38] = 5.570$, $P < 0.05$), 2828 Hz ($F[1, 38] = 6.504$, $P < 0.05$), and 4000 Hz ($F[1, 38] = 11.378$, $P < 0.01$) and in the presence of contralateral noise between the two groups at 1000 Hz ($F[1, 38] = 5.179$, $P < 0.05$), 1414 Hz ($F[1, 38] = 6.014$, $P < 0.05$), 2828 Hz ($F[1, 38] = 5.353$, $P < 0.05$), and 4000 Hz ($F[1, 38] = 14.186$, $P < 0.01$). There was also a significant difference in TEAOE amplitude noted in quiet at 1000 Hz ($F[1, 38] = 5.679$, $P < 0.05$) and in the presence of contralateral noise at 1000 Hz ($F[1, 38] = 14.498$, $P < 0.01$) and 1414 Hz ($F[1, 38] = 4.925$, $P < 0.033$) between the two groups.

Figure 2 shows the mean value of contralateral suppression of TEOAE among the clinical and control groups along with 1 SD, respectively. In healthy controls, suppression of the TEOAE response amplitude at 1000 Hz (mean suppression amplitude: 1.91 dB) and 2000 Hz frequencies (mean suppression amplitude: 1.245) was seen. However, in the clinical group, there was no marked suppression found in all the frequencies. It can also be noted from Table 2 that there was an enhancement in TEOAE amplitude in the presence of contralateral noise at 1000 Hz, 1414 Hz, and 2000 Hz in the clinical group.

A comparison of SPIN scores among both the groups was also made. A paired *t*-test was done to assess the significant difference in SPIN between the right and left ears. Results showed no difference between the scores of the right and left ears ($P > 0.05$). Thus, for further statistics, the right and left ear results were combined (40 ears). Figure 3 shows the mean and SD of SPIN scores for both groups. From Figure 3, it can be seen that the clinical group has a lower mean score compared to the control group. Further, an independent *t*-test was done to assess the significant difference in SPIN across the two groups. Results showed a significant difference ($t[38] = 6.966$, $P < 0.01$) in SPIN scores between the clinical and control groups. This indicates that the clinical group with PCOS participants had significantly poorer SPIN scores than the control group.

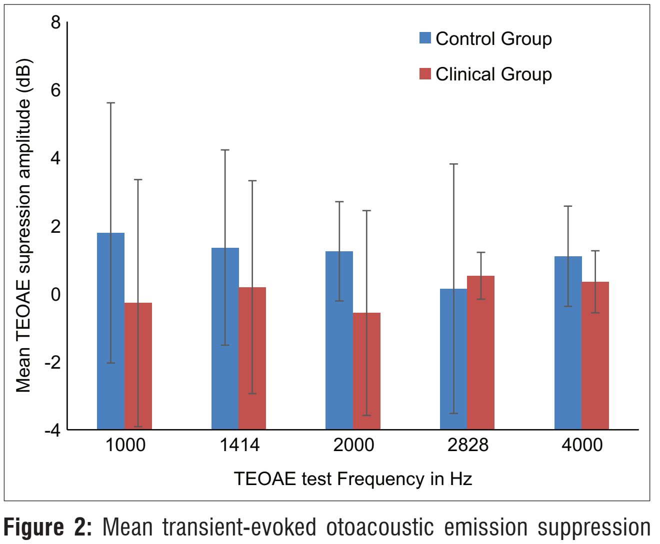


Figure 2: Mean transient-evoked otoacoustic emission suppression amplitude among control and clinical groups

Discussion

The current study evaluated the MOC functioning in females diagnosed with PCOS and compared it with healthy male volunteers. The present study showed that the pure-tone thresholds were normal in both PCOS and control participants. It has also been reported in the literature that the probability of hearing loss (hidden type) was significant in the higher frequencies (8000 Hz–20,000 Hz), and thresholds were in the normal limits in lower frequencies (250 Hz–4000 Hz) in PCOS participants.[7]

In the present study, a significant difference in TEOAE SNR and amplitude among both the groups was noted both in quiet and in the presence of contralateral noise. It was noted that the TE amplitude and SNR were better in the clinical group compared to the control group. This could be because studies have shown that OAEs are better in females than males.[12,13] In the present study, the clinical group included females diagnosed with PCOS, and the control group included male participants. Further, suppression values of TEOAE suggested an evident suppression of the TEOAE response amplitude in healthy controls at 1000 Hz (mean suppression amplitude: 1.91) and 2000 Hz frequencies (mean suppression amplitude: 1.245). However, no suppression in the clinical group suggests that MOC functioning is affected in individuals with PCOS. This indicates that the efferent functioning is affected in individuals with PCOS as contralateral suppression was not seen, which could be attributed to the hormonal changes in individuals with PCOS. In our study, participants in the PCOS group had abnormal estrogen levels and

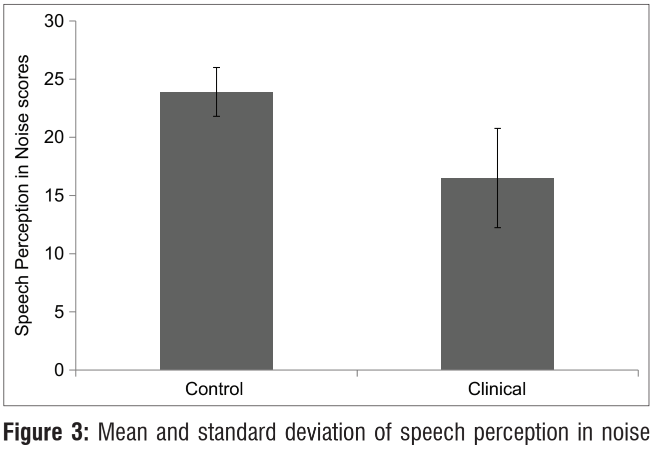


Figure 3: Mean and standard deviation of speech perception in noise scores among the control and clinical groups

estrogen seems to protect hearing through the MOC efferent system.[14] However, studies in the literature have shown an equally functioning MOC system with TEOAE in PCOS and healthy adult females.[8,15] The difference seen in the present study could be because the control group included male participants.

Further, SPIN was significantly poorer in the PCOS group compared to the control group. Studies have identified a correlation between SPIN and hormonal variation, and it can be concluded that progesterone can interfere with SPIN, and a higher level of estrogen can improve perception.[16] In our study, participants in the PCOS group had abnormal estrogen levels, leading to poor SPIN scores. The MOC functioning was also affected in the clinical group as evident from no suppression. Moreover, MOC plays an important role in sound discrimination from background noise.[17] Hence, it can be concluded that abnormality in the hormonal status of PCOS would impact MOC functioning and SPIN abilities.

There were a few limitations of the current study. Firstly, as this study utilized conventional audiometry (250 Hz–8000 Hz), we could not quantify the higher frequency hidden hearing losses in PCOS subjects. Another limitation is that relatively, a smaller number of participants were enrolled in the study. Future studies can include more participants with high-frequency audiometry as part of the procedure for better generalizations. Future research can also be done with one more control group of female participants for better generalization.

Conclusion

It can be concluded that due to the abnormality in the hormonal status of PCOS, there is an impact on the medial olivocochlear bundle functioning and speech perception in noise.

Informed consent

Informed consent was obtained from all participants.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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