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RESEARCH ARTICLE

Gender-based differences in cardiovascular autonomic function tests among deaf children

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ABSTRACT

Background: Deafness is a social stigma and also due to various reasons, studies show deaf individuals have altered autonomic functions. In our study, we tried to look for gender differences in autonomic functions in deaf population. **Aims and Objectives:** Our aim is to study the autonomic function tests among the male and female deaf children. **Materials and Methods:** After obtaining ethical clearance, we conducted a cross-sectional study among deaf children with a sample size of 60 subjects, of which 30 were male and 30 were female. Cardiovascular autonomic function tests such as systolic blood pressure (SBP) response to immediate standing, BP response to cold pressor test, heart rate (HR) response to immediate standing expressed as 30:15 ratio, and HR response to deep breathing were performed and compared among the two groups. Statistical analysis was done using the Statistical Package for the Social Sciences Software version: 22 and results are expressed in percentage and proportions. **Results:** The mean of SBP on immediate standing (108.93, $P = 0.026$) and difference of mean BP from supine to standing among male cases (5.13, $P = 0.050$) is significantly higher than female cases. The mean of 30:15 HR ratio on immediate standing from supine position among female cases (1.32) was significantly higher than male cases (1.25). **Conclusion:** Deaf individuals apart from having altered autonomic functions revealed from various studies also provide us with statistically significant results that there is a gender-based difference in the autonomic functions mostly accountable to difference in the baroreceptor sensitivity among males and females.

KEY WORDS: Deaf Children; Autonomic Function Tests; Baroreceptor Sensitivity

INTRODUCTION

Deafness is a devastating condition, wherein the individual loses the ability to communicate freely with fellow human beings. This brings a major depression in most of the deaf individuals. They feel handicapped and helpless in most of the situations due to their inability to express their views out straight. Although the individuals are able to lead quiet a normal life, a continuous state of mental stress is evident comparing to normal individuals. Since our mental well-being, activity, hormonal secretion, and bodily response to various hormones are largely dependent on the healthy functioning of the autonomic nervous system, this kind of chronic stress in deaf individuals poses a definite alteration in the autonomic nervous system function. Moreover, a congenital deaf child suffers from chronic stress which may increase or decrease autonomic discharges. These factors induce physiological alterations in the body, leading to higher rates of breathing, increased heart rate (HR), and changes in diastolic BP (DBP). These chronic conditions could, later

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on, lead to various complications such as cardiovascular diseases, hypertension, and diabetes mellitus.

Hearing impairment may have adverse effects on routine life. Multiple studies

suggest that hearing impairment is associated with psychosocial issues such as depression or loneliness or withdrawal from society. Associations between hearing impairment and increased levels of stress have been often reported. Acute stress may be evoked by physical (e.g., pain and noise exposure) or psychological provokers such as expectations or experience of failure and negative reactions from peers toward the hearing impairment.[1] Long-term stress may emerge when people are frequently exposed to stressful conditions. Stress in hearing-impaired adults might result in withdrawal from major social roles, especially occupational roles.[2-4]

On the other end, some evidence also suggests that emotional and physical stress chronically could lead to hearing problems,[1] i.e., with a reversed direction of causation. Sympathetic innervation to the inner ear is a well-documented fact. Sympathetic nervous system regulates the cochlear blood flow through the local adrenergic α-receptors. In addition, inner ear function is under the influence of sympathetic activity through the central noradrenergic pathway.[1]

In contrast, the contribution of the parasympathetic nervous branch to the cochlear innervation is relatively unknown though there is some evidence suggested by few studies about the possible parasympathetic innervation of the inner ear. Hence, this clearly indicates the relation between inner ear functioning and autonomic nervous system. Thus, evaluation of stress levels from the perspective of autonomic function may play a key role in a better comprehensive understanding of the mechanisms and consequences of hearing impairment. It may be noted that some forms of autonomic neuropathy and auditory nerve neuropathy might coexist in metabolic diseases such as diabetes mellitus without any causal association.

Thus, a complete description of the mechanisms potentially connecting autonomic nervous system and hearing impairment is unexplored, but we have tried to look for any changes in autonomic functions, especially keeping the gender differences in mind.

There are a few reports on gender-related differences in cardiac autonomic tone. In a population of normal subjects, using short-term and long-term observations, it was found that parasympathetic tone is predominant over sympathetic tone in women and vice versa in men. This indicates that males are more prone for acute stress compared to females with a sympathetic dominance. The internal mental state shows wide variation among males and females. The method of handling different situations and reaction to acute stress also shows huge variation among the genders. On a whole since the autonomic nervous system comprising the neurotransmitters which are released during acute stressful situations and the bodily reflex mechanisms which are tightly regulated by the sympathetic and parasympathetic control altogether play a role in how an individual responds to various situations. Furthermore, studies provide data that baroreceptor sensitivity is more among females compared to males. It was also demonstrated that the gender-related difference in parasympathetic regulation diminishes after the age of 50, while sympathetic dominance in men disappears significantly in a later age.[5] To study this pattern of variation, we have employed the autonomic function tests to test both the sympathetic and parasympathetic parameters and to derive a relation between the differences of autonomic functions among the genders. Talking about stress compared to the normal population deaf individuals do not have way of expressing their feelings like normal human beings and hence are more prone to psychological effects.

Hence, we designed our study such that our subjects belong to the congenital deaf population. Furthermore, we chose the subjects of school-going age considering that they are in the peak period of handling stress along with studies. In this population, we tried to look for gender differences in autonomic nervous system functioning by employing battery of tests to check both sympathetic and parasympathetic parameters.

MATERIALS AND METHODS

Study Design

This was a cross-sectional study.

Sample Size

60 deaf children.
Male - 30.
Female - 30.
Age group: 6–18 years.

Study Period

The study duration was January 2016–December 2016.

The Institutional Ethical Clearance was obtained.

Subjects included 60 deaf children from the Government Deaf School for Girls and Ajay Deaf School for boys in Belagavi city.

The details such as purpose of the study, nature of the study, and methods used were explained to the parents/guardians in their own understandable language. Informed written

consents were duly signed by the parents/guardians and the authorities of the respective schools of both genders. The children were tested in the premises of their respective schools in Belagavi. The time chosen for the data collection was from 11 am to 1 pm and 3–to 5 pm.

Inclusion Criteria

Healthy deaf children with sensorineural hearing loss of either sex aged between 6 and 18 years were included in the study.

Exclusion Criteria

Children with a history of hypertension, diabetes mellitus, asthma, known cardiovascular disease, conductive deafness, and who are uncooperative were excluded from the study.

Instruments

The following instruments were used to record the parameters:

- Sphygmomanometer: Mercury sphygmomanometer of diamond make was used to record the BP.
- Stethoscope: Pulse stethoscope Mark IV type was used.
- Thermometer: Thermometer with graduations from 0 to 50 degree centigrade was used to record and regulate the temperature of cold water for cold pressor test (CPT).
- Electrocardiography (ECG) machine: Cardiart 6108T of BPL health care was used. This is a portable 12-lead electrocardiograph with a single-channel printing system, capable of processing all ECG leads simultaneously.

Methods

In the present study, four simple, non-invasive cardiovascular reflex tests have been used to assess autonomic function since one test alone does not distinguish the degree or severity of autonomic damage. These tests provide a useful framework to assess autonomic neuropathy simply, quickly, and non-invasively.[6]

The tests include:

1. BP response to standing
2. CPT[7]
3. HR response to standing
4. HR response to deep breathing.

Procedure

BP response to standing

BP was recorded when the subject is lying down quietly for 5–10 min. Two basal readings were taken. The subject stood up suddenly, taking <5 s; then, blood pressure (BP) was recorded immediately, then at 30 s, 60 s, and 90 s after standing. The difference in systolic BP (SBP) was noted.

CPT

After the subject had rested supine for 15–20 min, BP was measured in the right upper arm. The left hand was then immersed to just above the wrist in cold water (3–5°C) for 1 min, BP was measured at 30 s, 60 s, and 120 s after immersion. Maximum increase in SBP and DBP was noted.

Immediate HR response to standing

The test was done with the subject lying quietly while HR was recorded continuously for 30 s, on ECG. The subject then stood suddenly and the point at starting to stand was marked on ECG. ECG was recorded for 30 s after standing. The shortest RR interval at the 15th beat and the longest RR interval at around the 30th beat were measured. HR response was expressed by 30:15 ratio.

The ratio was expressed as follows:

- Longest R-R interval at around the 30th beat
- Shortest R-R interval at around the 15th beat.

HR variation during deep breathing

The subject sits quietly and is instructed to start deep breathing on verbal command as trained earlier (5 s deep inspiration and 5 s deep expiration) for 30 s and ECG was recorded throughout the period of deep breathing. The maximum and minimum RR interval during each breathing cycle was measured.

The ratio was expressed as follows:

- E/I ratio - maximum R-R interval minimum R-R interval.

Statistical Application

Analysis of the obtained data from autonomic functions tests was done using the Statistical Package for the Social Sciences Software version 22. Unpaired Student's *t*-test was used when data followed normal distribution and Mann–Whitney U-test when data did not follow normal distribution. $P < 0.05$ was a statistically significant difference.

RESULTS

The comparison was done among the 60 deaf children, of which 30 were male and 30 were female. The values are given as mean ± standard deviation.

The autonomic function tests such as BP response to standing, BP response to CPT, HR response to standing expressed as 30:15 ratio, and HR response to deep breathing expressed as E: I ratio were compared.

The mean of supine SBP among male (105.73) and female cases (103.26) shows insignificant difference. The mean of SBP on immediate standing among male cases (108.93, $P = 0.026$) is statistically significantly higher than female cases (104.66).

The mean difference in SBP from supine to standing in male cases (5.13, $P = 0.050$) is significantly higher than female cases (4.33) and is shown in Table 1.

The mean baseline SBP among male cases (107.73) and female cases (106.00) shows no significant difference between the two groups. The mean of maximum SBP reached as a response to CPT among male cases (121.66) and female cases (120.60) shows no significant difference. The mean of maximum rise in SBP achieved as response to CPT among male cases (13.93) shows no significant difference against female cases (14.60) and is shown in Table 2.

The mean of baseline DBP among male cases (75.66) and female cases (75.33) shows no significant difference. The mean of maximum DBP reached as a response to CPT among male cases (90.80) and female cases (89.33) shows insignificant difference. The mean of maximum rise in DBP from baseline as response to CPT among male cases (15.13) and female cases (13.80) shows no significant difference and is shown in Table 3.

The mean of 30:15 HR ratio on immediate standing from supine position among female cases (1.32) was significantly higher than male cases (1.25) and is shown in Table 4.

The mean of HR response to deep breathing expressed as E: I ratio in male cases (1.32) and female cases (1.36) shows insignificant difference and is shown in Table 5.

DISCUSSION

In our study which aimed at finding the variations in cardiovascular autonomic function tests taking gender aspect into consideration between male and female deaf children. The mean of SBP on immediate standing (108.93, $P = 0.026$) and difference of mean BP from supine to standing among male cases (5.13, $P = 0.050$) is significantly higher than female cases. The mean of 30:15 HR ratio on immediate standing from supine position among female cases (1.32) was significantly higher than male cases (1.25).

Table 1: Comparison of BP response to standing among male cases and female cases

Category	*n*	Parameters	SBP values (mean±SD)	IQR	CI for mean	Significance	*P* value
Cases male	30	Supine SBP	105.73±6.74	10.50	103.21–108.25	*t*=1.301	*P*=0.199
Cases female	30		103.26±7.90	12.50	100.31–106.21		
Cases male	30	SBP on standing	108.93±6.90	8.50	106.35–111.51	Mann–Whitney U-test - 300.50	*P*=0.026
Cases female	30		104.66±7.32	16	101.93–107.40		
Cases male	30	Supine minus	5.13±2.08	2	4.35–5.91	Mann–Whitney U-test - 321.50	*P*=0.050
Cases female	30	Standing	4.33±3.26	4	3.07–5.59		

BP: Blood pressure, SBP: Systolic blood pressure, SD: Standard deviation, IQR: Interquartile range, CI: Confidence interval

Table 2: Comparison of SBP response to CPT among male cases and female cases

Category	*n*	Parameters	SBP values (mean±SD)	IQR	CI for mean	Significance	*P* value
Cases male	30	Baseline SBP	107.73±5.67	8.50	105.61–109.85	*t*=0.981	*P*=0.331
Cases female	30		106.00±7.84	10.50	103.07–108.92		
Cases male	30	Max. SBP reached	121.66±7.66	11	118.80–124.52	*t*=0.456	*P*=0.650
Cases female	30		120.60±10.25	12	116.77–124.42		
Cases male	30	Max. rise SBP	13.93±7.34	14	11.19–16.67	Mann–Whitney U-test - 425.50	*P*=0.715
Cases female	30		14.60±7.33	14	11.86–17.33		

CPT: Cold pressor test, SBP: Systolic blood pressure, SD: Standard deviation, IQR: Interquartile range, CI: Confidence interval

Table 3: Comparison of DBP response to CPT among male cases and female cases

Category	*n*	Parameters	DBP values (mean±SD)	IQR	CI for mean	Significance	*P* value
Cases male	30	Baseline DBP	75.66±4.90	8	73.83–77.49	*t*=0.089	*P*=0.929
Cases female	30		75.53±6.57	10.5	73.07–77.98		
Cases male	30	Max. DBP reached	90.80±6.65	10	88.31–93.28	*t*=0.787	*P*=0.435
Cases female	30		89.33±7.74	10.5	86.44–92.22		
Cases male	30	Max. rise DBP	15.13±5.86	12	12.94–17.32	Mann–Whitney U-test - 403.00	*P*=0.484
Cases female	30		13.80±6.48	12	11.37–16.22		

CPT: Cold pressor test, DBP: Diastolic blood pressure, SD: Standard deviation, IQR: Interquartile range, CI: Confidence interval

Table 4: Comparison of HR response to standing 30:15 ratio among male cases and female cases

Category	*n*	Parameters	HR 30:15ratio (mean±SD)	IQR	CI for mean	Significance	*P* value
Cases male	30	HR 30:15 ratio	1.25±0.090	0.008	1.21–1.28	*t*=2.793	*P*=0.007
Cases female	30		1.32±0.102	0.14	1.28–1.35		

HR: Heart rate, SD: Standard deviation, IQR: Interquartile range, CI: Confidence interval

Table 5: Comparison of HR response to deep breathing E: I ratio among male cases and female cases

Category	*n*	Parameters	HR E: I ratio (mean±SD)	IQR	CI for mean	Significance	*P* value
Cases male	30	HR E: I ratio	1.32±0.103	0.14	1.28–1.36	*t*=6.81	*P*=0.098
Cases female	30		1.36±0.081	0.10	1.33–1.39		

HR: Heart rate, SD: Standard deviation, IQR: Interquartile range, CI: Confidence interval

Sympathetic Parameters

In our study [Table 1], the mean of SBP on immediate standing among males (108.93, $P = 0.026$) is statistically significantly higher than females (104.66). The mean of difference in SBP from supine to standing in males (5.13, $P = 0.050$) is significantly higher than female cases (4.33). This finding is supported by another study which concludes that gender differences are there in arterial baroreflex sensitivity and they observed that females may have a greater baroreflex sensitivity, in such a way that alterations in BP are more efficiently controlled compared to males.[8] Since females can regulate the immediate change in BP more effectively due to the probable above-mentioned reason change in posture caused a significant rise in BP in males.

In our study, the mean baseline SBP among male cases (107.73) and female cases (106.00), maximum SBP attained, and maximum rise in SBP reached as a response to CPT shows no significant difference between the two groups [Table 2]. The mean of baseline DBP among male cases (75.66) and female cases (75.33), maximum DBP attained, and maximum rise in DBP reached a response to CPT shows no significant difference [Table 3]. However, in contrary, another study conducted among 24 healthy volunteers using cardiovascular magnetic resonance suggested a difference in CPT response among males and females possible based on the extent of endothelial-dependent vasodilation.[9] Furthermore, females tend to have a low threshold for pain perception[10] suggested by another study which could cause a difference in the maximum SBP attained in females as a response to CPT. However, in our study, we did not get any such specific difference among males and females possibly because the subjects included were deaf, they were more calm and composed and lack of apprehension of the procedure and proper study conductance technique and environment could have been a reason for not getting a significant difference. Further, detailed approach has to be done to substantiate the subjective reason with evidence. Also high cardiovascular reactivity to the CPT, a known sympathoexcitatory stimulus,[11] predicts the future development of hypertension[12] and may represent a preclinical manifestation before actual elevations in peripheral arterial BP is detected says a study**.** Hence, CPT can be a very useful study to understand the pattern of autonomic regulatory activity in the body.

Parasympathetic Parameters

From results of our study, among male and female comparison of HR 30:15 ratio showed significant difference with females having higher HR range. Similarly, in a study conducted among healthy males and females aged 6–55 years, HR variability analysis was done and the high frequency/low frequency ratio was significantly higher in the adolescent and adult females compared to male of same age groups. Hence, this suggests that gender differences exist in age-related changes in HRV. This finding in this study limited to adolescent and adult age groups may indicate a role for female sex hormones in cardiac autonomic modulation.[13]

The mean of HR response to deep breathing expressed as E:I ratio in male cases (1.32) and female cases (1.36) shows insignificant difference. Overall, sympathetic overactivity and withdrawal of parasympathetic activity result in stress.[14] A study conducted in 2017 exhibits the gender differences in autonomic function by eliciting HR response to deep breathing test and concludes that females have a parasympathetic dominance over males.[15] In our study, we aimed at finding the differences in autonomic functions as an initiative to find out gender-related differences. Furthermore, we selected the deaf children as our study group as there is evidence of altered autonomic function in them adding on to it we wanted to make out gender differences in the same group.

Assessing autonomic functions between male and female deaf children as in our study are one of its kinds in this region which gives a lot of insight about the gender differences and stress associated. The limitations of the study include small sample size and manual tests to study autonomic function. Performing the study in a proper autonomic laboratory will produce better substantial and reproducible results.

CONCLUSION

Our study has revealed the existence of differences in autonomic nervous system functioning evident through battery of tests performed among male and female groups comprising deaf children. From our study results, females seem to exhibit parasympathetic dominance compared to males.

REFERENCES

1. Horner KC. The emotional ear in stress. Neurosci Biobehav Rev 2003;27:437-46.
2. Nachtegaal J, Smit JH, Smits C, Bezemer PD, van Beek JH, Festen JM, *et al.* The association between hearing status and psychosocial health before the age of 70 years: Results from an internet-based national survey on hearing. Ear Hear 2009;30:302-12.
3. Kramer SE, Kapteyn TS, Houtgast T. Occupational performance: Comparing normally-hearing and hearing-impaired employees using the Amsterdam checklist for hearing and work. Int J Audiol 2006;45:503-12.
4. Terluin B, van Marwijk HW, Adèr HJ, de Vet HC, Penninx BW, Hermens ML, *et al.* The four-dimensional symptom questionnaire (4DSQ): A validation study of a multidimensional self-report questionnaire to assess distress, depression, anxiety and somatization. BMC Psychiatry 2006;6:34.
5. Kuo TB, Lin T, Yang CC, Li CL, Chen CF, Chou P, *et al.* Effect of aging on gender differences in neural control of heart rate. Am J Physiol 1999;277:H2233-9.
6. Chinagudi S, Patted SM, Herur A. A study of cardiovascular autonomic functions in congenitally deaf children with a long QTC interval. J Clin Diagn Res 2011;5:804-7.
7. Krantz DS, Manuck SB. Acute psychophysiologic reactivity and risk of cardiovascular disease: A review and methodologic critique. Psychol Bull 1984;96:435-64.
8. Hinojosa-Laborde C, Chapa I, Lange D, Haywood JR. Gender differences in sympathetic nervous system regulation. Clin Exp Pharmacol Physiol 1999;26:122-6.
9. Moro PJ, Flavian A, Jacquier A, Kober F, Quilici J, Gaborit B, *et al.* Gender differences in response to cold pressor test assessed with velocity-encoded cardiovascular magnetic resonance of the coronary sinus. J Cardiovasc Magn Reson 2011;13:54.
10. Rokyta R, Yamamotova A. Sex differences in pain perception and interpretation. Act Nerv Super Rediviva 2013;55:125-34.
11. Victor RG, Leimbach WN Jr., Seals DR, Wallin BG, Mark AL. Effects of the cold pressor test on muscle sympathetic nerve activity in humans. Hypertension 1987;9:429-36.
12. Treiber FA, Kamarck T, Schneiderman N, Sheffield D, Kapuku G, Taylor T, *et al.* Cardiovascular reactivity and development of preclinical and clinical disease states. Psychosom Med 2003;65:46-62.
13. Moodithaya S, Avadhany ST. Gender differences in age-related changes in cardiac autonomic nervous function. J Aging Res 2012;2012:679345.
14. Dutt A, Kumar S, Ramaswamy C, Bhat R, Murthy N. A comparative study of blood pressure, heart rate variability and metabolic risk factors in software professionals. Natl J Physiol Pharm Pharmacol 2011;1:51-6.
15. Jha RK, Acharya A, Nepal O. Autonomic influence on heart rate for deep breathing and valsalva maneuver in healthy subjects. JNMA J Nepal Med Assoc 2018;56:670-3.

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