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Relationship between hypertension/ blood pressure and hearing sensitivity among drivers: A correlation analysis

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Abstract:

BACKGROUND: One of the most common chronic diseases is hypertension. The majority of research has linked hearing loss to hypertension. However, the relationship between hypertension and hearing is still unknown. The primary goal of the study is to investigate the effect of hypertension on hearing and to find out the association between blood pressure levels and auditory health in auto-rickshaw drivers.

MATERIALS AND METHODS: The study utilized 121 healthy professional auto-drivers between the age range of 25 and 55 years. Pure-tone audiometry (PTA) and extended high-frequency audiometry (EHFA) were used to determine the participants' hearing thresholds from 0.25 to 16 kHz. The cochlear hair cell functioning was evaluated using distortion-product otoacoustic emission (DPOAE) testing. Blood pressure (mmHg) measurements were categorized under hypertension stage (normal (120; <80); elevated (120–129; <80); hypertension – stage 1 (130–139; 80–89); hypertension – stage 2 (≥140; ≥90)).

RESULTS: The mean age of the study participants was 42.17 ± 9.03 years. The mean systolic and diastolic BP of all the study participants were 138.24 ± 19.73 (105–216) mmHg and 87.69 ± 12.14 (60–134) mmHg, respectively. BP levels were normal for 17.4% (N = 21) of the study participants, 21.5% (N = 26) had elevated blood pressure, 21.5% (N = 26) of the population falls under stage 1 hypertension, and 39.7% (N = 48) had stage 2 hypertension. Our study discovered a significant difference between main group effects and no significant difference between group interaction effects. Hearing thresholds were significantly higher in hypertensive participants compared to non-hypertensive participants. However, there was no statistically significant relationship between the two variables hypertension and hearing loss.

CONCLUSION: Implementing health promotion initiatives and raising awareness about hearing health could improve the quality of life for a high-risk occupational group of drivers.

Keywords:

Association, health promotion, hearing loss, hypertension, occupational health

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Introduction

Professional transportation drivers are well-known for working under extremely stressful conditions, and they are considered as a high-risk group. Professional drivers have higher rates of health problems, including the risk of cardiovascular disease, when compared to the general working population.[1-3] Hypertension is one of the predominant risk factors of cardiovascular disease in the arterial walls, which is a global public health concern.[4] The World Health Organization (WHO) reports that the leading causes of death in 2015 were due to ischemic heart disease, stroke, and hypertensive heart diseases.[5] Hypertension is diagnosed when the systolic blood pressure (SBP) is consistently ≥130 mmHg and/or a diastolic blood pressure (DBP) ≥80 mmHg.[6] High blood pressure has

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been reported to lead to target organ damage (TOD) such as kidney, brain, eyes, and heart.[7-9] The American College of Cardiology Foundation/American Heart Association task force on practice guidelines (ACCF/AHA) has advised routine evaluations of hypertensive TOD symptoms.[10] The auditory system is not on the ACCF/AHA list of hypertension TODs that should be routinely assessed.[11] However, the literature provides increasing evidence demonstrating that hypertension could potentially lead to auditory deficits.[12-15] Few studies failed to observe this relationship.[16,17] However, further research is needed to determine the molecular mechanism underlying this association.[18,19] Most research studies have focused only on the effects of blood pressure level using behavioral hearing assessments or cochlear functioning testing. Furthermore, no study has simultaneously employed multiple methods of peripheral auditory system evaluation in individuals with systemic arterial hypertension at the same time. The use of other audiological procedures in addition to conventional audiometry can provide earlier and more accurate indications of possible cochlear changes resulting from hypertension.[20,21] To address some of the knowledge gaps regarding auditory evaluation, the current study included both subjective and objective measures. The specific aim of this study was to address the influence of blood pressure level on hearing in a large group of auto-driver's population by posing the questions that follow. 1) Is there a variation in the hearing-related characteristic between normal and different BP categories? 2) Is there any correlation between normal and different BP categories (systolic and diastolic) with any one of the PTA thresholds, extended high-frequency audiometry (EHFA) thresholds, and distortion-product otoacoustic emission (DPOAE) thresholds?

Materials and Methods

Study design and setting

A cross-sectional study was conducted between February 2021 to March 2022. Professional autorickshaw drivers working in urban areas were approached to take part in the study. This study was carried out in accordance with the Institutional Ethics Committee and with the participants' informed consent. (Ethics Ref. Code: IEC-NI/19/DEC/72/121).

Study participants and sampling

A total of 121 healthy auto-drivers from urban areas of Chennai were enrolled in this study. The sample size was calculated considering the prevalence of hearing loss in autorickshaw drivers from the previous literature that gave a prevalence of 76.7%, with the relative precision of 10% and confidence level of 95%. This study employed simple random sampling with participants between the ages of 25 and 55 and have worked as an auto-driver for at least five years to meet the inclusion criteria. Elderly auto-drivers above the age of 55 were excluded from the study considering the onset of presbycusis (age-related hearing loss). A history of ototoxic drug exposure-related hearing loss, drivers with any obvious ear disease/ear/head injury in the past, and middle ear function disorders who underwent otoscopic examination were all excluded from the study. General physical examination and otoscopy were done for all the participants before continuing with other aspects of the study.

Demographic information, blood pressure measurements, and classification of hypertension

SBP and DBP were measured by a trained nurse using automated sphygmomanometer device (HBP-9021J, Omron, Japan). Blood pressure was measured twice in the upper left arm of the participant in a seated position after the subject had rested for 15 minutes. Each measurement had a 15-minute interval and was taken between 8 and 10 a.m. The average of these two measurements was used for analysis.

According to the practice guidelines ACC/AHA published in 2017, adult blood pressure is classified as normal if the SBP is less than 120 mmHg and the DPB is less than 80 mmHg; prehypertension or elevated blood pressure if the SBP is between 120 and 129 mmHg and the DBP is less than 80 mmHg; hypertension stage 1, if the SBP is between 130 and 139 mmHg and the DBP is less than 80–89 mmHg; hypertension stage 2, if the SBP exceeds more than 140 mmHg and DBP exceeds more than 90 mmHg.[6]

Hearing evaluation by audiological measurements

The study participant's auditory status was evaluated and reported. The most common method for the assessment of hearing loss is conventional pure-tone audiometry (PTA). All participants underwent audiometric evaluation by a qualified clinical audiologist. The Piano Inventis clinical audiometer was used for audiometric testing in a sound-treated audiological booth. For conventional PTA testing, TDH 39 headphones were used. The ambient noise level in the room was maintained within the permissible limits in accordance with the recommendations of ANSI S3.1-1999 (R2013). Participants were individually tested in a free field acoustical chamber for both right and left ears. Audiometric hearing thresholds for air conduction (AC) stimuli were established for frequencies of 250–8000 Hz. EHFA is the testing of hearing threshold levels above 8 KHz frequencies. The same clinical audiometer was used for EHFA (Piano Inventis). Pure tones were presented using Sennheiser HAD 300 headphones at frequencies of 9 kHz, 10 kHz, 11.2 kHz, 12.5 kHz, 14 kHz, and 16 kHz. Both PTA and EHFA sessions took approximately 20–25 minutes for each participant.

DPOAE testing

An otoscopic examination was performed prior to the DPOAE procedure to ensure that the ear canal was cleaned. DPOAE was recorded using ILO V6 version v6.41.27.33 in a quiet room. All the participants were seated in sedentary positions during the test. It was ensured that the probe tip doesn't slip out of the ear canal. An acoustically treated room was used to carry out the test procedures and recordings. The f2/f1 was set as 1.22, and the levels of the signals were L1 = 65 dB and L2 = 55 dB SPL, respectively. In this study, the SNR of 2f1-f2 was considered and evaluated as a response to DPOAEs in the subject's right and left ears separately at 1001, 1257, 1587, 2002, 2515, 3174, 4004, 5042, 6348, 7996, and 10083 Hz frequencies. The researchers chose this frequency range because ears are prone to hearing loss within this frequency range. The SNR of 6 dB or greater was considered as the pass criteria. The relationship between hypertension and hearing ability was the focus of this study. Three hearing evaluations were used to determine the relationship between hypertension and hearing ability.

Statistical analysis

All statistical analysis was done using SPSS 16 version. The descriptive statistics were used to summarize mean, standard deviation (SD), and frequency percentages. Kolmogorov–Smirnov test and Mauchly's test were employed to check for normality and sphericity, respectively. Levene's test was used to test the homogeneity of variances. Since the assumption of sphericity was not met, the significance of F-ratios was adjusted according to the Greenhouse–Geisser correction. Mixed method ANOVA was employed to verify the effect of blood pressure on hearing sensitivity. The statistical analysis considered the data of all subjects. Analysis of variance (mixed method ANOVA) with repeated measures was performed for eight frequencies in PTA evaluation using groups as between-subject factors (four levels) and groups as between-subject factors (two levels: right and left ears) using SPSS (V16.0). Analyses of variance with repeated measurements were also performed for the EHFA and DPOAE thresholds. Pearson correlation analysis was used to test the relationship between hearing test results and SBP and DBP. The P value of < 0.05 was taken as a level of statistical significance.

Results

Characteristics of study population

The data was analyzed for 121 participants ranging in age from 25 to 55 years. The mean age of the study participants was 42.17 ± 9.03 years. The mean SBP and DBP of all the study participants were 138.24 ± 19.73 (105–216) mmHg and 87.69 ± 12.14 (60–134) mmHg, respectively. Blood pressure levels were normal for 17.4% (N = 21) of the study participants, 21.5% (N = 26) had elevated blood pressure, 21.5% (N = 26) of the population falls under stage 1 hypertension and 39.7% (N = 48) had stage 2 hypertension. The distribution of BP level categories with PTA, EHFA, and DPOAE thresholds characteristics of participants with different BP categories is summarized in Table 1.

I) Blood pressure categories and hearing evaluation

A mixed method ANOVA was used to see if there is a difference in hearing-related characteristics between different BP categories, as well as how it differs between groups using PTA, EHFA, and DPOAE testing. (4 × 2 × 8) way ANOVA was performed on four levels of groups, two levels of subjects (within level subjects, i.e. right and left ears), and eight frequencies (0.250-8) kHz.

A) The effect of hypertension on PTA thresholds

All PTA data were analyzed to see if there was a statistical difference between the mean scores for each group (four hypertension categories) and hearing sensitivity. ANOVA with repeated measures showed no statistical significant difference among group (right and left ears), F (1,120) =0.013, P = 0.909, η^2 = 0.000, and with interaction among bp levels and PTA intervention, F (7,120) =72.11, P = 0.639, η^2 = 0.38. The main effect of group on PTA intervention was statistically significant.

Table 1: Characteristics of subjects according to blood pressure criteria

BP classifications	Normal level	Elevated level	Stage 1 hypertension	Stage 2 hypertension
n	21	26	26	48
Age (years)	41.2±9.0 (25-55)	40.3±9.57 (25-55)	41.7±8.6 (27-55)	43.9±8.9 (25-55)
Distribution of PTA hearing threshold among hypertensive and non-hypertensive drivers				
RE_LF_PTA	25.7±12.2 (13.8-60.0)	29.4±12.8 (10.0-60.0)	28.8±12.8 (16.3-75.0)	28. 5±9.1 (17.5-53.8)
LE_LF_PTA	28.3±15.8 (13.8-75.0)	30.3±15.12 (15.0-83.80)	27.7±9.3 (17.5-50.0)	29.1±11.1 (17.5-83.8)
RE_SF_PTA	28.1±12.3 (13.8-62.5)	33.9±14.8 (12.5-71.3)	32.9±12.6 (17.5-76.3)	32.8±10.0 (16.3-66.3)
LE_SF_PTA	31.6±16.8 (12.5-76.3)	34.8±16.5 (13.8-86.3)	30.9±10.6 (15.0-53.8)	34.3±12.5 (17.5-92.5)
RE_HF_PTA	36.4±17.2 (11.7-75.0)	44.6±20.5 (15.0-93.3)	40.7±17.5 (15.0-76.7)	43.7±17.4 (6.7-86.7)
LE_HF_PTA	40.4±22.0 (11.7-100.0)	44.1±19.4 (13.3-95.0)	38.4±14.8 (18.3-66.7)	45.0±17.6 (13.3-106.7)

The interaction between the two factors was insignificant in terms of group comparison, F (3, 120) =0.648, P = 0.586, η^2 = 0.016. The results revealed that there were no statistically significant differences in PTA results (hearing thresholds at 0.25, 0.5, 1, 2, 3, 4,6, and 8 kHz) between BP levels [Figure 1]

B) The effect of hypertension on EHFA thresholds

All EHFA data were analyzed using mixed method ANOVA to evaluate whether the mean scores for each group (four BP categories) differed statistically from the EHFA thresholds. ANOVA with repeated measures revealed no significant differences between groups (right and left ears), F (1,120) =3.83, P = 0.053, η^2 = 0.032, or interactions between BP levels and EHFA intervention, F (5,120) = 87.61, P = 0.496, η^2 = 0.38. However, there was a significant difference in the main effect of the group on EHFA intervention. The interaction between the two factors between-group comparison was also not significant, F (3, 120) =0.890, P = 0.448, η^2 = 0.022. ANOVA analysis revealed no significant relationships between EHFA variables (hearing thresholds at 9, 10, 11.2, 12.5, 14, 16 kHz) and BP levels. The findings revealed that there is no interaction between blood pressure levels and EHFA intervention [Figure 2].

C) The effect of hypertension on DPOAE functioning

The mean signal-to-noise ratio (SNR) values for 1000, 1257, 1587, 2002, 2515, 3174, 4004, 5042, 6348, 7669, and 10083 Hz were analyzed to examine whether the mean scores have any variation for each group among four BP categories. ANOVA with repeated measures showed no significant interaction effect among groups (right and left ears), F (1,120) =2.401, P = 0.124, η^2 = 0.020, and with interaction among BP levels and DPOAE thresholds, F (10,120) =15.56, P = 0.993, η^2 = 0.117. However, there was a significant difference in the group's main effect on DPOAE intervention. The interaction between the two factors between subjects was also not significant, F (3,120) =2.25, P = 0.087, η^2 = 0.087.

ANOVA analysis revealed no significant relationships between DPOAE variables and BP levels. The results revealed that there is no interaction between BP levels and DPOAE intervention [Figure 3].

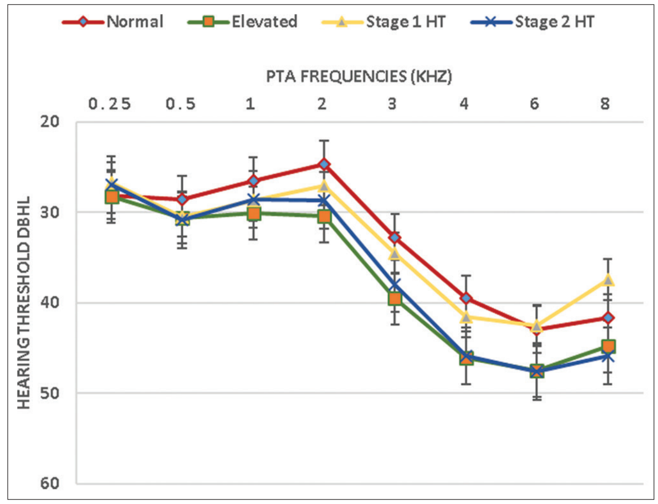

Figure 1: Mean PTA thresholds and hearing loss distribution for different blood pressure level categories

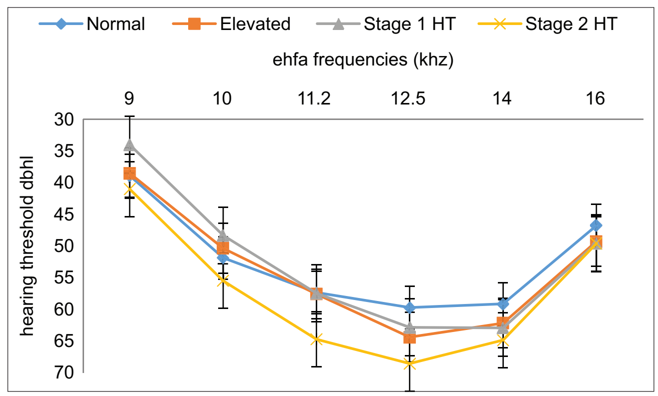

Figure 2: Mean EHFA thresholds for different blood pressure level categories

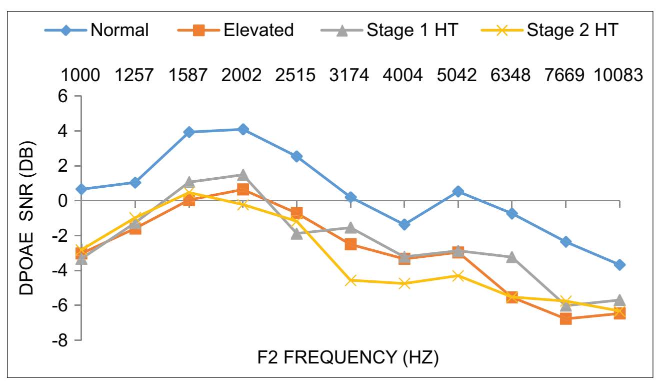

Figure 3: Mean DPOAE levels and SNR values plotted as a function of frequency for different blood pressure categories

II) Correlation between BP categories and hearing assessments

Pearson's product moment correlation analysis was used to investigate the possible association of blood pressure values (systolic and diastolic) with PTA, EHFA, and DPOAE thresholds. Hearing thresholds at 0.25, 0.5, 1, 2, 3, 4, 6, and 8 kHz frequencies did not correlate with BP categories, and hearing sensitivity did not show any significant relationships with BP levels.

The correlation between BP level and EHFA threshold was investigated to gain a better understanding of the effects of BP level on EHFA. Between SBP levels, statistically significant associations were observed between hypertension and EHFA thresholds at 11.2, 12.5, 14, and 16 kHz frequencies in right ear similarly, 12.5 and 16 kHz frequencies in the left ear. {$EHFA_{11.2k\ (RE)}$ [r = 0.21; P = 0.023; r^2 = 0.043]; $EHFA_{12.5k\ (RE)}$ [r = 0.254; P = 0.005;

r^2 = 0.065]; $EHFA_{14k\ (RE)}$ [r = 0.213; P = 0.019; r^2 = 0.045]; $EHFA_{16k\ (RE)}$ [r = 0.198; P = 0.029; r^2 = 0.039]; $EHFA_{12.5\ k\ (LE)}$ [R = 0.197; P = 0.030; r^2 = 0.039]; $EHFA_{16k\ (LE)}$ [R = 0.197; P = 0.030; r^2 = 0.039]}. However, there is only a weak correlation between these associations. There is no association between the systolic variables because a correlation coefficient (r) of 0.1 or 0.2 indicates very weak correlation. Figure 4 shows correlation plots for EHFAs as a function of systolic (right and left) blood pressure levels. There was no significant difference or correlation between DBP levels and any of the EHFA thresholds.

The DPOAE procedure was used to examine another audiological measure of cochlear functioning. Patterns of DPOAE (SNR values) were examined, and it was discovered that only a few DPOAE amplitudes have statistical significance with SBP and DBP levels. The P values below show that there is a statistically significant association between hypertension and DPOAE thresholds at frequencies 6348 and 10083 Hz in the right ear and 1001, 1587, 2002, 6348 Hz in the left ear between SBP levels. {$DPOAE_{6348k\ (RE)}$ [r = -0.25; P = 0.005; r^2 = 0.065]; $DPOAE_{10083k\ (RE)}$ [r = -0.20; P = 0.026; r^2 = 0.041]; $DPOAE_{1001(LE)}$ [r = - 0.218; P = 0.016; r^2 = 0.047]; $DPOAE_{1587k\ (LE)}$ [r =- 0.208; P = 0.022; r^2 = 0.043]; $DPOAE_{2002k\ (LE)}$ [r = -0.209; P = 0.021; r^2 = 0.044]; $DPOAE_{6348\ k\ (LE)}$ [r = -0.183; P = 0.045; r^2 = 0.033]; A similar significant relationship was found between hypertension and DBP levels, $DPOAE_{3174k\ (RE)}$ [r = -0.182; P = 0.046; r^2 = 0.033]; $DPOAE_{7669k\ (RE)}$ [r =- 0.186; P = 0.041; r^2 = 0.035]}. The correlation factor (r) indicates a very weak relationship between DPOAE thresholds and SBP and DBP. It is clear that there is no correlation between DPOAE thresholds and blood pressure variables [Figure 5].

Discussion

Hypertension has long been regarded as one of the essential risk factors underlying pathophysiological processes of the cochlea from early in the twentieth century. The findings of published studies on the relationship between hypertension and hearing loss remain unclear and conflicting.[17] This study aimed

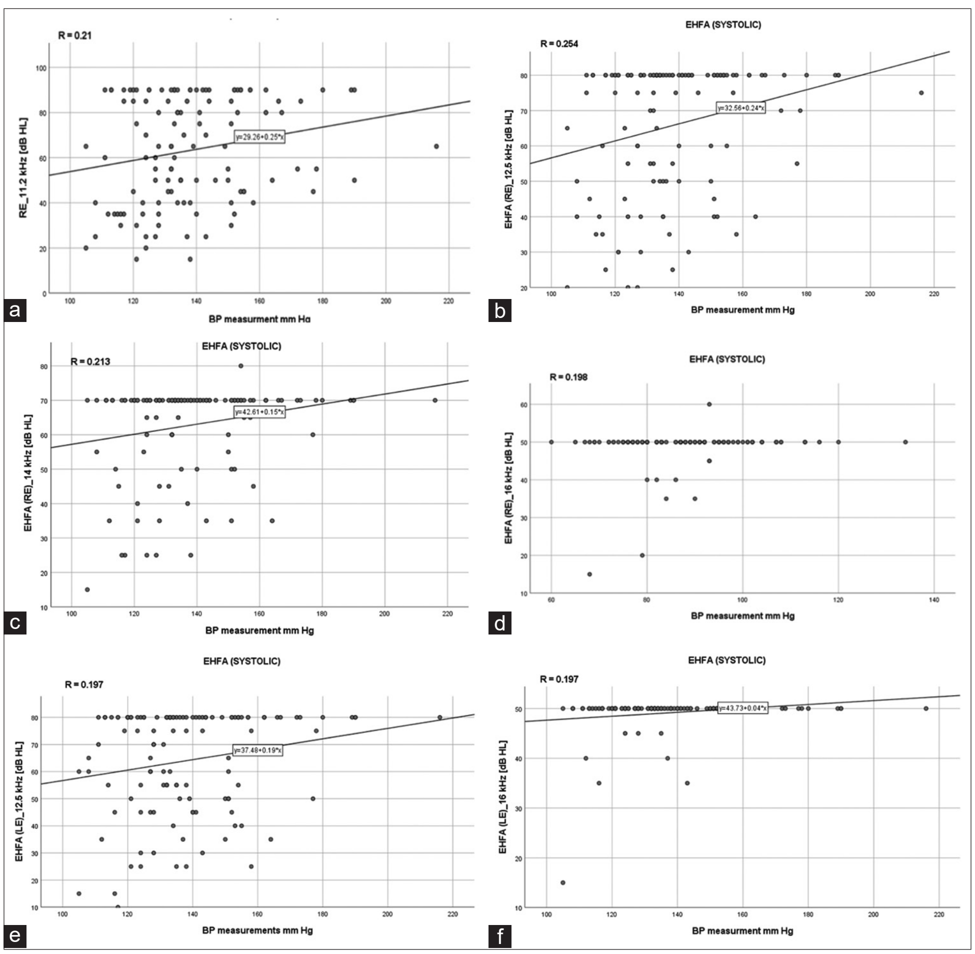

Figure 4: Correlation plots for EHFA vs systolic (right and left ears) blood pressure. Statistical significance was obtained for these frequencies ($EHFA_{(RE)\ 11.2,\ 12.5,\ 14,\ and\ 16\ kHz}$ and $EHFA_{(LE)\ 12.5\ and\ 16\ kHz}$) with very weak correlation. Diastolic blood pressure (DBP) levels for EHFA frequencies did not achieve statistical significance. (a) SBP vs 11.2 kHz(RE); (b) SBP vs 12.5 kHz (RE); (c) SBP vs 14 kHz (RE); (d) SBP vs 16 kHz (RE); (e) SBP vs 12.5 kHz (LE); (f) SBP vs 16 kHz (LE)

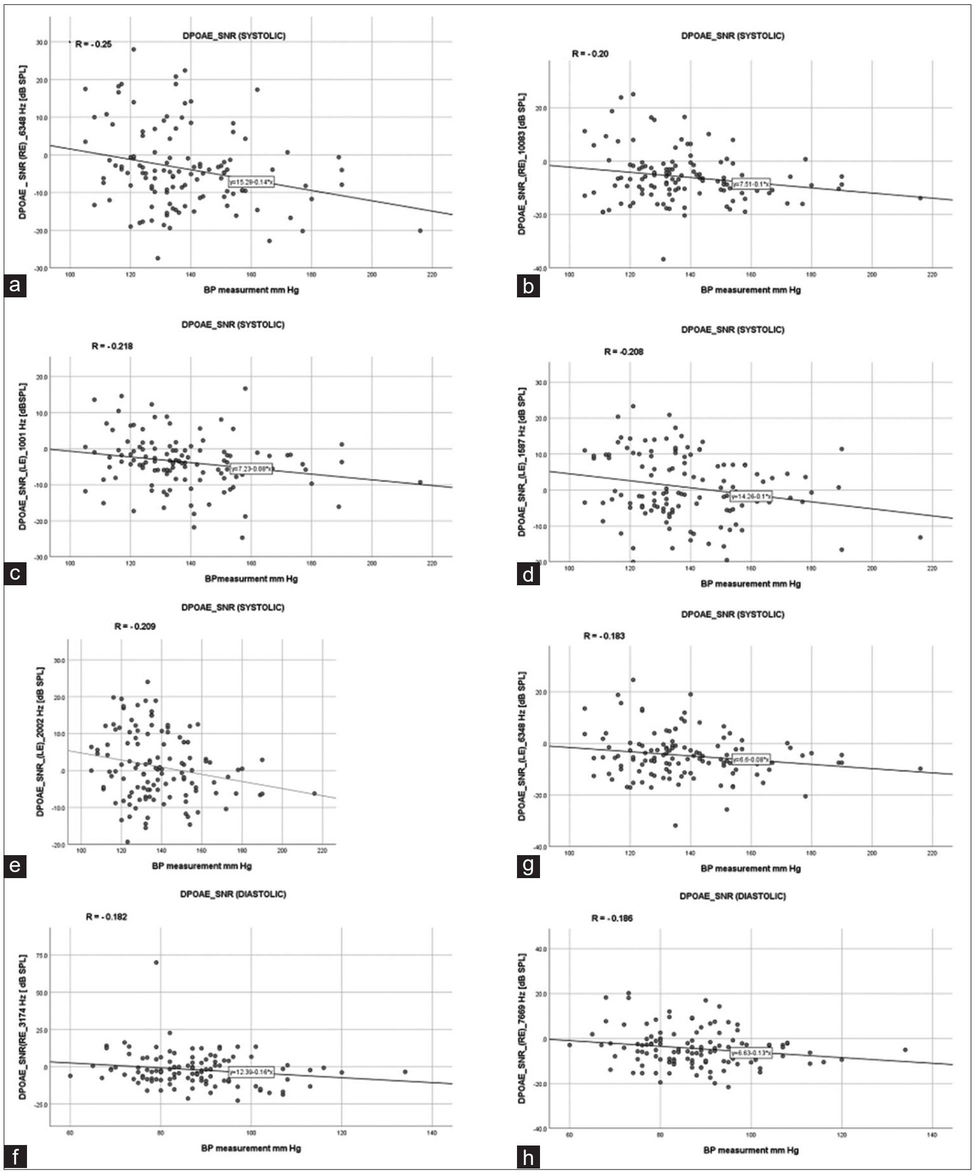

Figure 5: Correlations between DPOAE and BP levels. Statistical significance was obtained for six systolic frequencies (DPOAE $_{(RE)\ 6348\ and\ 10083\ Hz}$ and DPOAE $_{(LE)\ 1001,\ 1587,\ 2002,\ and\ 6348\ Hz}$) with very weak correlation. Significant correlations were obtained for two diastolic frequencies (DPOAE $_{(RE)\ 3174\ and\ 7669\ Hz}$). (a) SBP vs DPOAE_SNR 6348 Hz(RE); (b) SBP vs DPOAE_SNR 10083 Hz(RE); (c) SBP vs DPOAE_SNR 1001 Hz(LE); (d) SBP vs DPOAE_SNR 1587 Hz(LE); (e) SBP vs DPOAE_SNR 2002 Hz(LE); (f) SBP vs DPOAE_SNR 6348 Hz(LE); (g) SBP vs DPOAE_SNR 3174 Hz(RE); (h) SBP vs DPOAE_SNR 7669 Hz(RE)

to investigate the relationship between grades of hypertension and auditory characteristics using both objective and subjective measures of auditory function with an emphasis on cochlear health in both hypertensive and non-hypertensive drivers. When examining the association of hypertension with one or other outcomes, the co-occurrence of hearing loss and hypertension presents a challenge. The study found that hypertensive drivers had higher hearing threshold levels than non-hypertensive drivers. The results of audiometric testing at frequencies 0.25–8000 kHz and hearing thresholds were worse in hypertensive participants than in non-hypertensive participants [Table 2]. However, we discovered no prospective statistical link between PTA thresholds and hypertension. Our findings at frequencies ranging from 0.250 to 8 kHz are consistent with previous research that found no significant differences in conventional thresholds.[19,21] According to the findings of the Reed et al. study, there is a lack of statistical evidence to support the correlation between sustained blood pressure levels and the occurrence of hearing impairment.[22] Results from research findings reported that the relationship between continuous blood pressure and hearing loss is not consistent.[17,23]

In the present study, we looked at the relationship between hypertension severity and hearing thresholds in EHFA thresholds (8–16 kHz). The link between the degree of hypertension and the EHFA hearing thresholds is depicted in Figure 2. The average

Table 2: Distribution of mean EHFA hearing threshold among hypertensive and non-hypertensive drivers

BP classifications	Normal Level	Elevated level	Stage 1 hypertension	Stage 2 hypertension
RE_9 kHz_EHFA	38.3±27.0 (5-90)	41.7±25.9 (5-90)	37.1±22.4 (5-90)	43.3±22.6 (15-90)
LE_9 kHz_EHFA	39.5±26.5 (5-90)	35.38±24.3 (5-90)	30.9±21.1 (0-80)	38.8±23.3 (10-85)
RE_10 kHz_EHFA	49.8±30.1 (10-90)	50.9±25.1 (15-90)	50.7±23.5 (15-90)	56.4±22.2 (20-90)
LE_10 kHz_EHFA	54.1±28.4 (10-90)	49.8±19.7 (15-90)	45.9±22.1 (15-90)	54.58±22.9 (20-90)
RE_11.2 kHz_EHFA	57.1±27.2 (20-90)	61.5±25.1 (15-90)	62.1±22.6 (15-90)	67.5±21.1 (25-90)
LE_11.2 kHz_EHFA	57.6±28.6 (15-90)	53.6±22.8 (20-90)	52.9±22.3 (15-90)	61.9±22.3 (25-90)
RE_12.5 kHz_EHFA	58.8±22.1 (20-80)	65.8±20.5 (20-80)	63.1±18.6 (25-80)	70.4±15.1 (30-80)
LE_12.5 kHz_EHFA	60.7±23.9 (10-80)	63.1±19.7 (25-80)	62.7±17.7 (25-80)	66.7±17.8 (25-80)
RE_14 kHz_EHFA	57.1±18.7 (15-70)	62.9±14.1 (25-70)	62.7±12.8 (25-70)	65.3±10.3 (35-80)
LE_14 kHz_EHFA	61.2±17.8 (10-70)	61.5±13.8 (20-70)	63.3±12.8 (25-70)	64.5±11.6 (25-70)
RE_16 kHz_EHFA	46.4±9.9 (15-50)	49.0±3.5 (35-50)	49.8±0.9 (45-50)	49.6±3.1 (35-60)
LE_16 kHz_EHFA	47.1±8.3 (15-50)	49.6±1.4 (45-50)	49.4±2.2 (40-50)	49.7±2.2 (35-50)

thresholds of hypertension group 2 revealed that EHFA's hearing ability had deteriorated. Many study findings remarkably confirmed the concept that EHFA hearing thresholds may be more sensitive for early detection of hearing damage than conventional PTA at lower frequencies.[24-27] However, there is a dearth of evidence assessing the relationship between hypertension and hearing loss using EHFA. To the best of our knowledge, only one population-based study has used EHFA testing to investigate the relationship between hearing sensitivity and hypertension.[19] Results from our study observed statistically significant trend in EHFA thresholds for EHFA $_{\text{(RE) 11.2, 12.5, 14, and 16 kHz}}$ and EHFA $_{\text{(LE) 12.5 and 16 kHz}}$ [Figure 4]. However, in EHFA, there was no significant association found between the groups with and without systemic hypertension.

The current study demonstrated audiological evaluation using the DPOAE objective measure to further investigate the association between hypertension and hearing sensitivity. Results from DPOAE measurement at frequencies between 1001 – 10,083 kHz demonstrate a weaker response in hypertension participants than in non-hypertensive participants [Table 3]. Soares *et al*.,[19] evaluated 40 people with and without hypertension in their study. This study results showed statistical significance for DPOAE amplitudes at 1501, 2002, and 3003 Hz, which were consistent with our findings. A cross-sectional study of 371 men and 639 women in the Japanese population concluded that hypertension was not associated with hearing loss in women.[28] In our study, significant correlations between systolic hypertension and DPOAE thresholds were observed for DPOAE $_{\text{(RE) 6348 and 10083 Hz}}$, DPOAE $_{\text{(LE) 1001, 1587, 2002, and 6348 Hz}}$ and between diastolic hypertension for DPOAE $_{\text{(RE) 3174 and 7669 Hz}}$ frequencies [Figure 5]. Correlation coefficients of 0.2 are considered negligible, while correlation coefficients of 0.3 are considered low positive correlation. A linear correlation coefficient less than zero signifies a negative relationship. Hence, our study was unable to use the regression line to model a linear relationship between hearing loss and hypertension in the population because there is no significant linear relationship between hypertension and hearing loss. In the current study, ANOVA analysis between DPOAE variables with BP levels resulted in no significant relationships and no interaction among BP levels.

There is a widespread literature showing an association between hypertension and hearing loss. Although some of the studies were able to establish a significant relationship between blood pressure and hearing loss, these findings are not consistent with our study findings.[11,29-32] There is currently no consensus regarding how blood pressure parameters and hypertension influence hearing threshold. Although the evidence for this is conflicting at this time, hypertension may result in or cause hearing loss in addition to harm to the previously mentioned target organs.[33] Our present study considered the differences observed between various procedures (PTA, EHFA, and DPOAE) between hypertensive and non-hypertensive participants.

There are some limitations to this study. First, it is important to mention that the present study was not based on limited sample size. Therefore, we suggest that future studies should be conducted with large number of hypertensive individuals. Second, data on personalized noise exposure in the occupational setting, which was an important factor in hearing loss in the driver population, could strengthen our investigation.

Conclusion

Hearing thresholds for the hypertensive auto-drivers were worse when compared with non-hypertensive workers. However, in this study, we did not observe statistical relationship between hearing loss and hypertension. According to this study, hypertension may not be a factor causing hearing loss. Because hearing loss is caused by a number of different intrinsic and extrinsic factors such as noise exposure, age, sex, the presence of

Table 3: Distribution of mean DPOAE hearing threshold among hypertensive and non-hypertensive drivers

BP classifications	Normal level	Elevated level	Stage 1 hypertension	Stage 2 hypertension
RE_1001_SNR	1.5±6.4 (-8.8-16.1)	-3.7±8.4 (-24.6-13.3)	-2.4±9.2 (-19.1-17.0)	0.2±16.1 (-25.0-70)
LE_1001_SNR	-0.2±7.8 (-15.1-14.6)	-2.3±6.3 (-17.3-12.3)	-4.2±5.6 (-16.4-8.9)	-5.8±7.6 (-24.7-16.7)
RE_1257_SNR	0.6±9.2 (-14.1-18.5)	-1.4±7.6 (-16.9-15.4)	-1.4±12.7 (-32.4-22.0)	-0.1±12.9 (-22.9-70)
LE_1257_SNR	1.5±9.2 (-15.6-16.8)	-1.8±9.0 (-23.8-16.8)	-1.2±8.3 (-14.5-16.8)	-1.8±7.4 (-21-17.7)
RE_1587_SNR	3.0±9.9 (-16.8-21.9)	0.02±8.8 (-15.5-22.2)	-0.9±11.4 (-31.5-19.1)	2.8±17.5 (-29.6-70.0)
LE_1587_SNR	4.8±8.9 (-12.1-20.4)	0.1±9.7 (-20-23.3)	3.1±9.2 (-16.2-20.9)	-1.9±8.4 (-19.5-13.4)
RE_2002_SNR	3.5±9.1 (-14.3-15.1)	1.5±8.6 (-11.3-14.2)	-0.05±12.8 (-28-23)	0.4±13.7 (-22.1-70)
LE_2002_SNR	4.7±8.9 (-13.4-19.8)	-0.2±10.1 (-19.3-17.7)	3.0±10.1 (-15.5-24)	-0.9±7.4 (-14.6-12.5)
RE_2515_SNR	4.9±18.9 (-20.4-70)	-0.8±8.4 (-11.2-21)	-3.1±11.9 (-23.2-17)	-0.6±8.7 (-18.6-19.7)
LE_2515_SNR	0.2±10.7 (-20.6-19.9)	-0.6±10.5 (-17.4-21.7)	-0.6±10.6 (-17.9-21)	-1.8±8.6 (-17.1-14)
RE_3174_SNR	3.2±18.5 (-16-70)	-2.6±7.4 (-21.3-13)	-1.0±9.0 (-13.4-16)	-4.5±8.3 (-22.7-13.5)
LE_3174_SNR	-2.8±10.2 (-18-22.3)	-2.3±9.5 (-19.3-18.3)	-2.1±10.1 (-19.6-18.8)	-4.7±8.4 (-20.9-16.5)
RE_4004_SNR	-0.5±12.1 (-23-25.5)	-3.9±9.7 (-16.8-17)	-2.0±10.6 (-24.3-19)	-4.6±8.9 (-24-16.3)
LE_4004_SNR	-2.2±10.9 (-17.3-26)	-2.8±9.7 (-20.6-21.7)	-4.4±9.5 (-18.5-15)	-4.9±9.0 (-21.3-18.6)
RE_5042_SNR	3.4±18.9 (-19.5-70)	-3.7±7.6 (-14.5-23)	-4.2±12.5 (-23.2-25.6)	-3.9±7.9 (-21-17.4)
LE_5042_SNR	-2.3±10.7 (-17.5-19.7)	-2.2±9.5 (-15.1-24.4)	-1.6±8.5 (-15.2-12.6)	-4.7±8.8 (-27.3-17.1)
RE_6348_SNR	1.7±11.4 (-19-18.8)	-5.9±10.4 (-27.4-28)	-2.9±11.9 (-19.4-22)	-5.2±8.9 (-22.8-17.3)
LE_6348_SNR	-3.1±10.0 (-17.1-18.8)	-5.1±9.5 (-17.1-24.6)	-3.5±9.1 (-31.8-11.9)	-5.9±7.8 (-25.6-19)
RE_7669_SNR	-0.7±11.2 (-19.9-20)	-5.3±8.3 (-19.5-17)	-6.1±8.1 (-21.6-12)	-4.7±6.3 (-17.4-14)
LE_7669_SNR	-3.9±8.2 (-20.7-11)	-8.3±9.5 (-26.0-19.8)	-5.9±7.1 (-17.4-12.2)	-6.8±6.4 (-19.3-9.2)
RE_10083_SNR	-3.2±12.8 (-19-23.9)	-4.9±10.5 (-20.3-25)	-6.1±9.9 (-36.7-16.6)	-7.4±6.6 (-18.9-10)
LE_10083_SNR	-4.1±7.6 (-17.2-15.6)	-7.9±8.5 (-23.9-21.9)	-5.2±7.9 (-18.2-12.4)	-5.2±5.7 (-16.6-9.5)

diabetics, and other auditory effects such as tinnitus, speech intelligibility, and so on. Hence, determining the exact influence of one single factor in the deterioration of the auditory system is extremely difficult. Additional study and analysis are required to evaluate the complex relationship between hypertensive participants and auditory health. Moreover, the quality of life for a group of urban drivers who work in high-risk occupations could be improved by implementing health promotion initiatives and raising awareness about hearing health.

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Conflicts of interest

The authors declare that they have no competing interest.

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