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Characterisitics and maskability of self-reported tinnitus in Adult Nigerians

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Abstract

Background: Tinnitus or noise perception with no identifiable acoustic origin is a perplexing symptom to sufferers as well as to otolaryngologists saddled with managing such patients. With most studies from the continent focusing on etiologies and clinical types, there is paucity of information on psychoacoustic properties of tinnitus among Africans. Setting: Tertiary care otolaryngology clinics in Abuja. **Objective:** To determine characteristics and maskability of tinnitus seen in adult Nigerians who self-report tinnitus as the main presenting symptom. **Methods:** A prospective study involving 100 adult Nigerians seen at two specialist Otorhinolaryngology clinics in Abuja - National Hospital Abuja and CSR Otologics Specialist Clinics, Abuja between January 2008 and June 2014. Clinical and audiological history and findings were captured in the study protocol. Participants were then assessed to determine Tinnitus pitch match, loudness match, mask ability and minimum masking level as well as residual inhibition. **Results:** 100 participants aged 24 - 58 years were assessed. Male to female ratio was 1:1.4. Tinnitus was sudden in onset in 24%, and gradual in 76%, involved the right ear in 32%, left ear in 38% and both ears in 30%. 48% of participants have other symptoms apart from tinnitus, and 32% were on other medications known to induce tinnitus. 16% of participants gave history of exposure to significant loud sound. Only 16% of participants have significant otoscopic findings. Tinnitus abated with carotid pressure in 64%, with extra ocular muscle movement in 16%, with teeth clenching in 32%, with neck movement in 28%, and with movement of arms or legs in 8%. The mean difference in hearing threshold of ear with and without tinnitus was 12.09 dB HL. Tinnitus pitch match was 4 KHz in 44%, 3 KHz in 24%, and 2 KHz in 32%, while mean tinnitus loudness match was 41.24 dB SL. Tinnitus was maskable in 88% of subjects, with a residual inhibition of 2 to 76 seconds. **Conclusion:** Majority of adult Nigerians that self-report tinnitus have maskable tinnitus, and this should be considered when considering hearing augmentation for those with associated impaired hearing.

Keywords: otolaryngology, psychoacoustics, tinnitus.

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INTRODUCTION

Tinnitus, defined as the sensation of sound in the ear or head, with no identifiable acoustic source, remains a perplexing symptom for sufferers worldwide. Whilst in majority of cases, the symptom appears tolerable, there are other cases where tinnitus is of enough severity as to be the main presenting symptom. This clinically significant tinnitus, defined as tinnitus that adversely affects quality of life of sufferers is believed to be influenced by characteristics of tinnitus, among other variables[1]. The first reference to the need to measure psychoacoustic properties of tinnitus was attributed to Spaulding in 1903[2]. Measurement of such characteristics including tinnitus pitch, loudness, maskability and residual inhibition was generally adopted following CIBA foundation symposium on tinnitus in 1981[3], even though studies on tinnitus masking and residual inhibition began a decade earlier. The knowledge obtained from these led to use of tinnitus masking as a therapeutic tool and to further studies on tinnitus measurement. This has further strengthen tinnitus assessment and has led to development of psychoacoustic matching protocol[4].

With etiology largely unknown, and several factors believed to be associated with development of different types of tinnitus, research on tinnitus has focused mainly on moderators[5] and mediators[6] of tinnitus distress. The overall effect is large variety of different treatment options, with most producing partial or no benefit to the tinnitus sufferers[7]. The justification for measurement of tinnitus characteristics is its use in a treatment plan[8].

To date, there is paucity of data on measurement of tinnitus characteristics among Africans.

METHODS

This prospective study was carried out at two specialist Otorhinolaryngology clinics in Abuja - National Hospital Abuja and CSR Otologics Specialist Clinics, Abuja between January 2008 and June 2014. Inclusion criteria were 1) adult (age 18 years and above) with tinnitus as the main presenting symptom; 2) No evidence of identifiable ongoing chronic ear diseases like chronic suppurative otitis media, cholesteatoma, ear tumors; 3) No significant subjective hearing loss; 4) Willingness to participate.

The study protocol included clinical tinnitus parameters (age and sex of patient, sudden *versus* gradual onset, duration, ear(s) affected, worse affected ear, nature of tinnitus, presence of hearing loss, and exposure to loud sound prior to onset), medical history including drug history, general and otorhinolaryngological findings (blood pressure, pulse, ear, nose and throat assessment findings; tinnitus modulators (extraocular eye movement, limbs movement, carotid pressure, teeth clenching, and neck movement); pure tone audiometric assessment for both ears; and audiometer-based measurement of tinnitus parameters (tinnitus pitch matching, loudness matching, residual inhibition, mask ability and minimum masking level (MML).

Tinnitus pitch matching and loudness matching were carried out in a sound-proof booth, according to the technique earlier described by Vernon & Meikle in 1981[9] using a clinical audiometer (InterAcoustic, AD629E, Denmark).

For tinnitus pitch matching, the contralateral ear was selected (or the better ear in bilateral tinnitus) and starting at 1000 Hz, a combination of two frequencies (1000 Hz/2000 Hz, 2000 Hz/3000 Hz, 3000 Hz/4000 Hz, 4000 Hz/6000 Hz, and 4000 Hz/8000 Hz) set at the threshold for the ear with tinnitus, was consecutively played and participant asked to compare which frequency of the tone fed is as close as possible to his tinnitus.

Tinnitus loudness match was obtained by feeding tones, starting at 10-20 dB SL below the threshold for the ear with tinnitus (or the worse ear in bilateral tinnitus) into the contralateral ear (or better ear in bilateral tinnitus), and gradually increasing in 1 dB increments until participant judge the tone to be as loud as the tinnitus being heard.

MML was determined using broadband noise, first set to the hearing threshold for the ear with tinnitus (or the worse ear in bilateral tinnitus) and the noise is gradually increased in 1dB increments until the patient reported that the tinnitus is inaudible. Inability to obtain MML is reported as lack of tinnitus maskability.

For residual inhibition measurement, the threshold obtained from MML was used. Auditory stimulation was carried out for 60 seconds at MML + 10 dB using same broadband noise that was used to determine MML, and patient instructed to specify whether tinnitus disappears, or tinnitus perception changes in any way, with reduction reported as percentage, or whether there is no change. The duration of such temporary change (in seconds) noted after the broad band noise was turned off was reported as residual inhibition.

Data obtained from each participant was entered into excel spreadsheet and statistically analyzed.

RESULTS

A hundred and five patients were recruited, but five were excluded from the study because their tinnitus either fluctuates and was not present at time of assessment, or because of bilateral symmetrically-loud tinnitus. The age range of the participants studied was 24 - 58 years (Mean = 39, Std. Dev. = 14.97). Majority were females (n = 56), with male-female ratio of 1.4:1. The mean age for male participants was 36.9 years (Std. Dev. 11.37), while the mean age for female participants was 43.4 years (Std. Dev. 13.78).

The self-reported tinnitus was sudden in onset in 24% (n = 24) and gradual in onset in 76% (n = 76). There was a slight left ear preponderance of self reported tinnitus (n = 38) than those with right ear affectation (n = 32) and bilateral ear affectation (n = 30).

52% (n = 52) of participants reported tinnitus as the only symptom, while remaining 48% have other symptoms. 8% of participants have pulsatile tinnitus, and the remaining 92% with persistent tinnitus described their symptoms as ringing (48%), humming (28%), Cricket-like sound (8%), and changing mixture of sounds (n = 8%). Only 16% of participants gave history of exposure to very loud sound prior to onset of tinnitus. 32% of participants were on anti-hypertensive medications known to be associated with tinnitus, and 24% have ongoing allergy and were on medications.

Clinical assessment revealed abnormal otoscopic findings in 16%, elevated blood pressure in 12%, and abnormal pulse in 4%.

The self-reported tinnitus abated with carotid pressure in 64%, with extra ocular muscle movement in 16%, with teeth clenching in 32%, with neck movement in 28%, and with movement of arms or legs in 8%.

The mean pure tone average (PTAv) threshold difference between the ear with tinnitus (or worse ear in bilateral cases) and the ear without tinnitus (or better ear in bilateral cases) was 12.092 dB HL (Std. Dev. 14.087). Using the Wilcoxon Signed Ranks test to compare different ear threshold however revealed this is not statistically significant (p = 2.0, > 0.05) (Table 1).

Table 1. Wilcoxon Signed Ranks Test of Pure Tone Average Thresholds Between Ear with Tinnitus and That Without.

Alpha	Tails	n	T	Mean	Variance	Std. Dev	Z score	*p* value	Sig
0.05	2	92	24	2139	65952.5	256.512	8.2355	2	No

The mean tinnitus loudness match among the 100 participants was 41.24 dB SL (Std. Dev. 18.194). There is strong positive correlation of PTAv with tinnitus loudness in participants with bilateral tinnitus (r = 0.99 for right ear, r = 0.91 for left ear). This strong correlation was also noted between ipsilateral PTAv and tinnitus loudness for left ear (r = 0.89) but not for right ear (r = 0.54) nor for contralateral ear (r = 0.39). Figure 1 illustrates difference in tinnitus parameters measured according to gender of the participants.

Tinnitus pitch match was 4000 Hz in 44%, 3000 Hz in 24%, and 2000 Hz in 32%, with a mean pitch match of 3000 Hz and a range of 2000 Hz to 6000 Hz (Std. Dev. 1058.3) for all cases. The mean tinnitus pitch match in male participants (n = 44) was 2909.09 Hz (Std. Dev. 834.85) and in female participants (n = 56) was 3285.71 Hz (Std. Dev. 913.87).

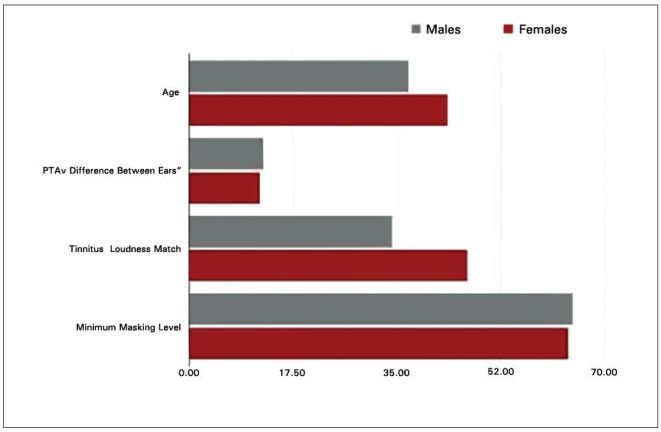

Figure 1. The Mean of Measured Tinnitus Psychoacoustic Parameters compared by genders in 100 adult Nigerians who self-reported tinnitus.

Tinnitus was maskable in 88% of subjects with mean minimum masking level (MML) of 62.087 dB SL (Std. Dev. 22.715). All cases seen with non-maskable tinnitus had tinnitus affecting the left ear, and all were males. 5/12 of these non-maskable tinnitus have pulsatile tinnitus. There appears to be no significant difference between the measured MML in males (64.5 dB SL, Std. Dev 21.78) compared to females (63.8, Std. Dev. 17.1). Overall, there was weak positive correlation between MML and tinnitus loudness (r = 0.22). The correlation of MML with tinnitus loudness per ear affected is as shown in Table 2.

Table 2. Pearson's Correlation Coefficient of Minimum Masking Level with Tinnitus Loudness in 100 Adult Nigerians with Self-Reported Tinnitus.

Patient Group	Total Number (n)	Pearson's Correlation Coefficient
All	100	0.221544
Bilateral Tinnitus	32	0.234606
Right Tinnitus	36	0.696627
Left Tinitus	32	-0.357356*

* Note the negative correlation of MML with tinnitus loudness for left ear.

The mean residual inhibition in 88 subjects with maskable tinnitus was 26.09 seconds (Std. Dev. 29.09, range 2 - 78 seconds). There was a weak correlation (r = 0.326) of MML with residual inhibition. Table 3 is a breakdown of tinnitus parameters measured according to the ear in which tinnitus was felt.

DISCUSSION

When confronted with individuals with troublesome tinnitus, the desire of every clinician is to do the utmost that could relieve the symptom. However, a large number of tinnitus is subjective, presenting clinician with challenges in screening and diagnosis, necessary to

Table 3. The Mean and Standard Deviation of Measured Tinnitus Parameters in 100 Adult Nigerians with Self-Reported Tinnitus.

	Tinnitus Loudness (dB SL)	Tinnitus Pitch Match (Hz)	Minimum Masking Level (dB SL)	Residual Inhibition (Sec)
	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)
* Bilateral Tinnitus	36.75 (11.62)	2500 (925.82)	58.25 (16.99)	18.75 (20.33)
Right Ear Tinnitus	51.75 (24.610)	3500 (534.52)	82.50 (9.69)	37.50 (35.52)
Left Ear Tinnitus	35.89 (13.49)	3333 (866.02)	50.33 (10.37)	31.80 (30.38)

* Tinnitus characteristics in the worse affected ear.

select the relevant treatment. Measurement of tinnitus psychoacoustic parameters, when made as an inherent part of tinnitus therapy, could achieve this[10].

Our study population consisting of adult patients that self-reported tinnitus showed a gender-bias in favor of women. Even though conflicting data about the role of gender in tinnitus distress exist in literature, it has been shown, irrespective of age, that women were more annoyed by tinnitus and perceived more stress than men did[11]. The slight left ear preponderance of self-reported tinnitus in our study is supported by observation of others that otoneurologic diseases like tinnitus occur more frequently in the left ear than in the right[12].

Our study did not observe statistically significant difference in hearing threshold between ear that has tinnitus and the unaffected ear (or the better ear in bilateral cases). Ordinarily, this might be interpreted to mean lack of cochlear theories in explaining tinnitus generation in our sample of patients. However, this observation might be a limitation of audiometer-based tinnitus assessment. Perhaps, a study involving otoacoustic emission measurement would show significant difference. Ishak et al.[13] observed significantly more abnormal transient otoacoustic emission in ears with tinnitus compared to the control.

The mean tinnitus loudness observed in this study was 41.24 dB SL. This measured parameter was higher in the female participants (Figure 1). We are not aware of any report of gender differences in tinnitus loudness match, to date. We believe this observation might be the reason why women were found to be more annoyed by tinnitus and perceived more distress than men do.

The median tinnitus pitch match in our female participants was 4000 Hz (range 2000 to 8000 Hz) while in the males it was 3000 Hz. This observation might be due to the limitation of diagnostic audiometer used, which excludes detection of patients with tinnitus frequency more than 8000 Hz. That notwithstanding, none of our participants matched their tinnitus above 4000 Hz. An extended frequency audiometer may perhaps give different result. The median tinnitus frequency reported by Mahboubi et al.[14] in 20 subjects, using extended frequency audiometer was 6000 Hz.

Majority of our study participants demonstrated maskability of their tinnitus when tested with supra threshold broad band sound. However, when acceptance of masking is computed from masking indicator (obtained by subtracting the loudness match from MML) according to Vernon et al.[15], only 32/88 will likely accept masking. This however needs further studies especially in our peculiar environment.

Our observation of non-maskable tinnitus seen exclusively in males, and exclusively affecting the left ear deserves further studies. Non-maskable tinnitus are believed to originate from exogenous or extra aural sources[16], and this might explain why they are difficult to mask.

We obtained a mean residual inhibition (RI) time of 26.09 seconds in 88% of participants. This is different from the figure of 60 seconds to several hours obtained by Souliere et al.[17] in a study that measured RI of tinnitus following cochlear implantation. Okusa et al.[18] reported residual inhibition with a duration ranging from several hours to one week in 20/62 patients with tinnitus using electrical promontory stimulation. The difference might be explained by the masker duration. Residual inhibition has been demonstrated to be related to the logarithm of the masker duration, for masker duration of 10 seconds to 10 minutes[19]. Our observed correlation between MML and residual inhibition is similar to observations of previous studies[20,21].

It is also of interest that the mean residual inhibition observed was highest for right ear tinnitus, and lowest for bilateral tinnitus. In fact all the measured tinnitus parameters were highest for right ear tinnitus (Table 3). This laterality might be related to perhaps existence of right ear dominance among the population. Tsai et al.[22] had earlier demonstrated that tinnitus laterality is dependent on the magnitude of inter aural audiometric asymmetry where threshold difference is greater than or equal to 15 dB.

One interesting observation we found difficult to explain was the maskability of tinnitus in all cases with bilateral tinnitus, with variable residual inhibition. Terry et al.[19] observed that contralateral masking did not produce residual inhibition. We however obtained residual inhibition ranging from 2 to 50 seconds in participants with bilateral tinnitus when the worse ear was exposed to MML + 10 broad band sound for 60 seconds. Souliere et al.[17] similarly observed contralateral tinnitus suppression and residual inhibition in 42% of cases whose tinnitus was suppressed by cochlear implantation. Further studies are needed to fully comprehend this phenomenon of contralateral tinnitus masking, especially in cases with bilateral tinnitus.

SUMMARY

This prospective, hospital based study is perhaps the first to highlight psychoacoustic parameters of tinnitus seen in adult Nigerian Africans who self-reported tinnitus. It demonstrated that majority of such adults have maskable tinnitus, and highlighted the phenomenon of contralateral residual inhibition that could pave way for possible contralateral ear masking therapy in individuals with bilateral asymmetric tinnitus.

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