Prediction of Hearing Aid Use Success in Adults with Sensorineural Hearing Loss Using Acceptable Noise Level Test and Self-Assessment Questionnaire

Original Article

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ABSTRACT

Background: The acceptable noise level (ANL) measures an individual's capacity to endure the noise present while continuous speech. This work aimed to investigate whether those having tolerance to high background noise levels (BNL) low ANLs could exhibit favourable outcomes when utilizing hearing aids.

Method: This study included 50 adults, aged between eighteen and fifty years, had moderate or moderately severe sensorineural hearing loss (SNHL). Patients were divided into two groups: Group I (GI): included 31 subjects who were regular hearing aids users "(using the hearing aids more than 8 hours/ day).". Group II (GII): included 19 subjects who were irregular hearing aids users "part time users".

Results: Area under the curve (AUC), sensitivity, specificity, positive predictive value (PPV), negative predictive *value (*NPV*)*, accuracy for unaided ANL in differentiation between aided regular, irregular conditions. Unaided ANL test had AUC *P* 0.825 which means that it is good in differentiation between aided regular and irregular conditions. At cut off 7.0 sensitivity was 80.0, specificity 62.5, PPV 72.7, NPV 71.4 and accuracy 72.2 and this was statistically significant.

Conclusion: ANL has the capability of accurately predicting the hearing aids' success rate. Individuals utilizing hearing aids consistently could tolerate greater amounts of background noise (BNL), as shown by low (ANLs), sporadically exhibit less tolerance to background noise, as indicated by high ANLs. ANLs as well as Abbreviated Profile of Hearing Aid Benefit (APHAB) scores give distinct and valuable data on utilizing hearing aids.

Key Words: Acceptable noise level**,** aphab questionnaire, hearing aid, hearing loss.

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INTRODUCTION

The acceptable noise level (ANL) refers to the minimum signal-to-noise ratio (SNR), which and could tolerate while listening to speech at the maximum comfortable level (MCL)[1]. the ANL test quantifies an individual's tolerance for background noise during the continuous speech listening[2]. ANL process represents a valid, straightforward as well as easily applicable[1].ANL is calculated through subtracting the individual's background noise level (BNL) from most comfortable level (MCL). a low ANL exhibits a greater tolerance to background noise, in contrast, a high ANL suggests a poor tolerance to background noise[3]. age, gender, hearing sensitivity, as well as f background noise types do not seem to have an impact on ANL. the ANL test is based on the concept that it has exhibited a greater accuracy level while predicting the degree of hearing aids' us[4, 5]. An Arabic variant of ANL exists, serving as a standardized tool for quantifying acceptable noise levels[6].

The objectives of the work to investigate whether those having tolerance to high background noise low acceptable noise levels could exhibit favourable outcomes when utilizing hearing aids.

MATERIAL AND METHODS

This study included 50 adults had moderate or moderately severe sensorineural hearing loss (SNHL) attending the audiology unit, tanta university hospital. the participants' ages fell between eighteen and fifty years, who underwent a categorization into two groups: group I (GI): included 31 subjects who were regular hearing aids users "(using the hearing aids more than 8 hours/ day)". group II (GII): included 19 subjects who were irregular hearing aids users "part time users".

It was approved by the research ethics committee in october 2019 (15-10-2019). it was done in the period between march 2021 to november 2021. the hearing threshold level of patients ranged from 40 to 70 db HTL in both ears. an informed consent was obtained. basic

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audiological evaluation was done a) pure tone audiometry (PTA) including air conduction in the frequency range between 250 and 8000HZ B) bone conduction in the frequencyrange between 500 and 4000HZ) speech audiometry including: speech recognition threshold (SRT) utilizing Arabic bisyllablic word[7]. as well as word discrimination (WD) score utilizing Arabic phonetically balanced word and immittancemetry.they also subjected to ANL test "Arabic version"[6]. as well as aphab questionnaire "Arabic Version"[7].

RESULTS

The participants' demographic data are summarized in (Table 1). 13 patients had moderate SNHL, and 37 patients had moderately severe SNHL. 26 patients fitted with hearing aids in the right side and 24 equipped on left side. the mean of hearing aids use reached 10.9 ± 6.22 years they were subdivided into two groups: group I (GI): it included 31 persons who were regular hearing aid users = full-time ones (using the hearing aids less than 8 hours/ day) group II (GII): it included 19 persons who were irregular hearing aid users= part-time users (using the hearing aids less than 8 hours/ day. (Most comfortable level (MCL): it was performed in two conditions (aided and unaided) for all patients. for the unaided conditions, for GI, the mean ± SD of MCL for G1 66.0 ± 5.25. in GI aided conditions,the mean ± SD MCL was 44.5 ± 8.39. the mean ± SD of MCL in GII was 66.4 ± 7.20 and in GII aided conditions, the mean ± SD MCL was 49.3 ± 9.68. there was high statistically significant difference between regular unaided vs aided, irregular unaided vs aided, regular unaided vs irregular aided and regular aided vs irregular unaided (Table 2).

Table 1: Demographic data of the studied participants:

	No.	%
Age	30.4 ± 11.21	
Sex		
Male	30	60.0
Female	20	40.0
Duration of HA use (Years)	10.9 ± 6.22	
Regularity		
Regular	31	62.0
Irregular	19	38.0
Degree of hearing loss		
Moderate	13	26.0
Moderately severe	37	74.0
Side		
Right	26	52.0
Left	24	48.0

Data are presented as mean SD or number (%). HA: Hearing-aid.

Table 2: Comparing MCL, BNL, ANL among both studied groups within unaided and aided conditions in dB:

	Groups				*P Value*	Post hoc. Test
	Regular		Irregular			
	Unaided	Aided	Unaided	Aided		
MCL	66.0 ± 5.25	44.5 ± 8.39	66.4 ± 7.20	49.3± 9.68	<0.001*	*P*1 <0.001* *P*2 <0.001* *P*5 <0.001* *P*6 <0.001*
BNL	57.1 ± 5.99	39.1 ± 8.29	56.3 ± 7.51	36.7± 10.35	<0.001*	*P*1 <0.001* *P*2 <0.001* *P*5 <0.001* *P*6 <0.001*
ANL in dB	8.9 ± 1.93	5.5 ± 1.06	10.2 ± 2.82	12.5 ± 2.82	<0.001*	*P*1 <0.001* *P*4 <0.001* *P*6 <0.001*

Data are presented as mean SD. MCL: the maximum comfortable level. BNL: background noise level. *p <0.001 (High Significance). Post hoc. (Pairwise comparison after Kruskal Wallis test). *P*1= GI unaided vs aided. *P*2= GII unaided vs aided *P*3= GI unaided vs GII unaided. *P*4= GI aided vs GII aided *P*5= GI unaided vs GII aided *P*6= GI aided vs GII unaided .

Background noise level (BNL): it was performed in two conditions (aided and unaided) for all patients. for the unaided conditions, for GI, the mean ± SD of BNL was 57.1 ± 5.99 and in GI aided conditions, the mean ± SD BNL was 39.1 ± 8.29.for the unaided conditions, in GII the mean ± SD BNL in GII was 56.3 ± 7.51 and in GII aided conditions, the mean ± SD BNL was 36.7 ± 10. there was a highly significant difference between regular unaided vs aided, irregular unaided vs aided, regular unaided vs irregular aided and regular aided vs irregular unaided (Table 2).

Acceptable noise level (ANL) results: ANL was measured through subtracting BNL from MCL according to Mahmoud *et al*[6]. ANL = MCL – BNL. in GI unaided conditions, the ANL range 6.0 – 12.0 with a mean ± SD. 8.9 ± 1.93 while in aided conditions the ANL range exhibited[4-8] the mean ± SD. ANL was 5.5 ± 1.06. in GII unaided conditions, the range of ANL for GII was (6-15) with a mean ± SD. 10.2 ± 2.82 and in aided, the ANL range was (9-17) with the mean ± SD. ANL 12.5 ± 2.82. there was a highly significant difference between regular unaided vs aided, regular aided vs irregular aided and regular aided vs irregular unaided (Table 2).

There were no significant associations between ANL, age, hearing impairment degree and hearing aid usage duration (Table 3). area under the curve (AUC), sensitivity, specificity, positive predictive value (ppv), negative predictive value (NPV), accuracy for unaided ANL in differentiation between aided regular, irregular conditions. unaided ANL test had AUC *p* 0.825 which means that it is good in differentiation between aided regular and irregular conditions. at cut off 7.0 sensitivity was 80.0, specificity 62.5, ppv 72.7, NPV 71.4 and accuracy 72.2 and this was statistically significant (Table 4)

Table 3: Correlation between ANL and Demographic data in both studied groups:

	ANL							
	Regular				Irregular			
	Unaided		Aided		Unaided		Aided	
	r_s	*P*	r_s	*P*	r_s	*P*	r_s	*P*
Age	0.178	0.338	0.130	0.486	-0.114	0.641	0.219	0.368
Degree of HL	-0.060	0.749	- 0.275	0.134	0.353	0.138	0.384	0.105
Duration of HA use	0.073	0.696	- 0.053	0.779	0.102	0.679	0.285	0.237

R_s: Spearman correlation. ANL: The acceptable noise level. HL: Hearing loss. HA: hearing-aid.

Table 4: ROC curves analysis for the optimal cut off points for the Unaided ANL in differentiation between aided regular, irregular conditions

	AUC	*p*	Cut off	Sensitivity	Specificity	PPV	NPV	Accuracy
ANL	0.825	0.021*	7.0	80.0	62.5	72.7	71.4	72.2

AUC: Area Under a Curve. *p value:* Probability *value.* NPV: Negative predictive *value*. PPV*:* Positive predictive *value.* *: Statistically significant at $p \leq 0.05$.

DISCUSSION

Our research was aimed at predicting the hearing aid success in patients having moderate to moderately severe sensorineural hearing impairment using the Arabic version of the ANL test and self-assessment questionnaire.

A significant variation was documented between regular unaided vs aided; regular aided vs irregular aided and regular aided vs irregular unaided. these results were in accordance with the Arabic study[6].they exhibited comparable findings to prior documented ones from english research[8].

ANL results in unaided regular hearing-aid (HA) users was lower than unaided ANL in irregular ha users (± 8.9, ± 10.2 respectively) this agreed with [1, 9, 10] the results of our study disagreed with[11]. as their participants were assessed utilizing the australian ANL test exhibited a lower mean. this might be due to different modes of delivery. typically, in most research, speech as well as noise were delivered either via earphones to one ear (unilaterally) or simultaneously to both ears (bilaterally) within the free field.

A prior study[11]. discovered a correlation between personality traits as well as ANL values, addressing that those having type a personalities exhibited a significantly less tolerance to background noise as opposed to those having type b personalities[12]. nichols and gordon-hickey, [8].addressed, subjects with greater self-control levels exhibited less ANL *values*, showing stronger tolerance to background noise as opposed to those having lower self-control ones.

Our results showed no correlation between ANL and degree of hearing loss which agreed with mahmoud and his colleagues' study[6]. these results also agreed with many studies[8,13,14]. however, this disagreed with Walravens

et al.[15] who addressed a notable yet significant positive correlation between ANL as well as PTA frequencies 500, 1000, 2000, and 4000 HZ., suggesting that those having worse PTA exhibited greater ANLS.

Many research addressed no significant correlation between audiogram configuration as well as ANL, yet based on jonas Brännström and Olsen,[16] findings, it exhibited significance. additionally, the ANL could exhibit greater values when the audiogram's slope is such that the average threshold before the 1 kHZ frequency exhibits significant variation from that of greater Frequencies[16,17].

Our results showed that better ANL in aided than unaided condition and better ANL in aided regular ha users than irregular ha users. our study disagreed with Nabelek *et al*.[1] reporting that mean anls were consistent among unaided as well as aided conditions, which disagreed with Walravens *et al*.[15] addressing that the ANL for those wearing hearing aids part-time exhibited less values compared to those wearing these devices full-time.

There are two potential explanations for the disparity regarding results. initially, variations existed among the participants' familiarity with hearing aids across different research. the ANL test's developers have specifically targeted those possessing a maximum of three years of experience with hearing aids[4]. no significant correlation between ANL and age, this agreed with Freyaldenhoven *et al*.[9] ,Mahmoud *et al*.[6]. on the contrary, freyaldenhoven and smiley[18] reported that children's anls exhibited comparable *values* to adults' ones.

In accordance to our results, Mahmoud *et al*.[6].found no statically significant difference between ANL in normal listeners as well as ANL in those having hearing impairment, supporting the fact that ANL may not be dependent on hearing sensitivity. these findings aligned with most of the research[13, 14, 18]. on the contrary, koch *et al*.[19]. reported that those having hearing impairment exhibited less anls values as opposed to normal ones.

In contrast to our findings, Walravens *et al*.[15] .addressed, ANL was linked to the hearing impairment degree. our results agreed with Nabelek *et al*.[1]. Nabelek *et al* [20] Freyaldenhoven *et al*.[9]. who found no correlation between duration of hearing aid use and no association was documented among ANL as well as usage hours or successful hearing aid usage.

There were no statistically significant associations between ANL and APHAB scores questionnaire. these results agreed with the Freyaldenhoven *et al*.[9]. Koch *et al*.[19].the current study showed that ANL is good in differentiation between aided regular and irregular conditions. this comes in agreement with Jonas Brännström and Olsen,[16] results. however, it does not agree with Nabelek *et al*.[20]. and Taylor,[21].

The APHAB questionnaire was fair in differentiation between aided and unaided. like Sultan *et al*'s findings, addressing a high sensitivity of APHAB in differentiation between aided and unaided groups[22, 23].

The results of Freyaldenhoven *et al*.[9] addressed , the APHAB'S EC as well as bn subscales of could predict hearing aid outcomes with an accuracy of 61.0 % and 59.8 % respectively, possessing an almost decrease of 25 % as opposed to the 84.8 % accuracy obtained when utilizing the unaided ANL approach[20].

The integration of the ANL with the ease of communication (EC) as well as background noise (BN) subscales of the APHAB yielded a substantial rise in prediction accuracy, reaching 91 %. such findings suggest that the predictive model's effectiveness is improved when utilizing both the ANL test along with the EC and BN subscales of the APHAB.

CONCLUSION

ANL has the capability of accurately predicting the hearing aids' success rate. individuals utilizing hearing aids consistently could tolerate greater amounts of background noise, as shown by low ANLS. in contrast, individuals utilizing hearing aids sporadically exhibit less tolerance to background noise, as indicated by high ANLS. ANLS as well as APHAB scores give distinct and valuable data on utilizing hearing aids.

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CONFLICT OF INTERESTS

There are no conflicts of interest.

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