Original Investigation

DOI: 10.4274/jarem.galenos.2025.16056

J Acad Res Med

Investigation of the Relationship Between Tinnitus Severity, Tinnitus Loudness, Hyperacusis and Anxiety Level in Individuals with Tinnitus

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Cite this article as: Ödemişlioğlu Aydın EA, Mungan Durankaya S, Alluşoğlu S, Kırkım G. Investigation of the relationship between tinnitus severity, tinnitus loudness, hyperacusis and anxiety level in individuals with tinnitus. J Acad Res Med. [Epub Ahead of Print]

ABSTRACT

Objective: The relationship between the effect of tinnitus on the individual and anxiety and hyperacusis should be investigated. The aim of the study is to examine the relationship between tinnitus loudness, tinnitus handicap level, hyperacusis level, and state and trait anxiety levels in individuals with subjective chronic tinnitus.

Methods: A cross-sectional approach was employed in this study. The study included 44 participants, consisting of 24 men and 20 women. The mean age of the participants was 53.7±16.6 years. The loudness of tinnitus was assessed using the visual analogue scale (VAS), while its severity was evaluated with the Tinnitus Handicap Inventory (THI). The Khalfa hyperacusis scale (HQ) was employed to determine the degree of hyperacusis, and the State and Trait Anxiety Inventory (STAI) was utilized to assess anxiety levels in 44 individuals experiencing subjective chronic tinnitus. Correlation and comparison analyses were conducted between the scales.

Results: A significant statistical correlation was observed between THI and VAS, HQ, and STAI ($p<0.05$). Anxiety levels differed significantly between individuals with and without hyperacusis ($p<0.05$).

Conclusion: Tinnitus severity is associated with tinnitus loudness, hyperacusis, anxiety scores. Accordingly, it can be said that as the tinnitus handicap score increases, perceived tinnitus loudness, hyperacusis, and state and trait anxiety also increase.

Keywords: Subjective tinnitus, tinnitus severity, tinnitus loudness, hyperacusis, state and trait anxiety

INTRODUCTION

Tinnitus refers to the perception of sound in the absence of an identifiable external acoustic source (1). An estimated 10%-15% of the population experiences tinnitus, with 5% of these individuals reportedly having clinically significant and distressing symptoms (2).

Although the majority of individuals with tinnitus adapt well, one in five reports emotional distress (3). Those affected often find tinnitus particularly intrusive, with common coexisting issues such as concentration difficulties, depression, anxiety, irritability, and sleep disturbances (4).

Studies indicate that individuals with tinnitus exhibit a higher prevalence of depression, anxiety, and somatic symptom disorders compared to those without tinnitus. Additionally, a positive correlation has been observed between tinnitus perception and depression levels (5). While hearing loss is recognized as a risk factor for tinnitus, research suggests that it does not play a significant role in the association between tinnitus and depression, anxiety, or somatic symptom disorders (6).

Another condition commonly observed in individuals with tinnitus is hyperacusis. Hyperacusis is characterized by a decreased tolerance to sounds that are typically perceived as normal by the majority of the population or that were previously considered normal by the individual before the onset of hyperacusis (7). Sixty percent of tinnitus patients are reported to experience significantly reduced sound tolerance, with 30% of these individuals also suffering from hyperacusis (8).

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Received Date: 22.03.2025 **Accepted Date:** 15.06.2025
Epub: 01.07.2025

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Hyperacusis has been shown to negatively affect various aspects of life, including quality of life, emotional well-being, hearing ability, sleep patterns, and concentration; in some cases, it may even lead to psychiatric disorders (9). A study found that participants with tinnitus accompanied by hyperacusis exhibited higher levels of stress, anxiety, depression, reduced quality of life, tinnitus distress, discomfort from sound, and heightened awareness of their symptoms (10).

Tinnitus and hyperacusis are difficult to assess because of their subjective perception, and the use of various assessment scales is crucial to evaluate the effects of tinnitus and hyperacusis on the individual. The Tinnitus Handicap Inventory (THI) is a well-established tool used to assess how tinnitus affects an individual's everyday life (11). The hyperacusis questionnaire (HQ), created by Khalfa, is designed to evaluate the presence, severity, and impact of sound sensitivity symptoms (12). Anxiety and depression are commonly observed in individuals with tinnitus (5). The State and Trait Anxiety Inventory (STAI) is a commonly used scale to measure the individual's level of anxiety (13). Research has indicated a connection between the results of the THI and the STAI (14).

The chronicity of tinnitus and its effects on individuals are shaped not only by auditory factors but also by cognitive-emotional and psychological components. However, studies evaluating the level of tinnitus severity holistically with perceived loudness, hyperacusis, and anxiety levels are limited. This study aims to reveal the dynamic relationships between the subjective and psychological components of tinnitus by analyzing the determinants of tinnitus handicap level in individuals with subjective chronic tinnitus. In this study, it is hypothesized that the level of handicap caused by tinnitus is related to the perceived tinnitus loudness, hyperacusis, and state and trait anxiety levels. The findings may shed light on individualized assessment and intervention approaches in tinnitus management.

METHODS

This research was designed as a cross-sectional study. It was approved by the İzmir Bakırçay University Non-Interventional Clinical Research Ethics Committee (decision no.: 1560, date: 17.04.2024) and conducted in compliance with the principles outlined in the Helsinki Declaration. All participants provided written informed consent prior to their inclusion in the study.

Participants

The sample size was determined based on an effect size of 0.5, a power of 0.90, and a significance level of 0.05 (Type I error) with analysis based on the t-test method using the G*Power program, reaching 44 participants (15). The study involved 44 patients who visited the Hearing, Speech, and Balance Unit of the Department of Otorhinolaryngology at Dokuz Eylül University Hospital, reporting subjective, chronic tinnitus complaints. Two patients diagnosed with Meniere's disease were excluded due to the exclusion criteria of the study. A detailed history of tinnitus was taken from each patient. The data obtained were recorded in the information form. The study included patients who had chronic subjective tinnitus for a minimum of three months and presented with a Type A tympanogram. Individuals with psychological, neurologic, and otologic complaints; systemic diseases that may cause objective tinnitus; and hearing aid users were excluded.

Audiological Assessment

Air and bone conduction hearing thresholds were measured through pure tone audiometry using the MADSEN clinical audiometer (Madsen Astera 2, Otometrics, Denmark). Air conduction testing was carried out with TDH39 supra-aural headphones, and bone conduction testing was performed using the B71 bone conduction vibrator, both in a soundproof booth. Air conduction thresholds were assessed at octave frequencies ranging from 250 to 8000 Hz, while bone conduction thresholds were measured at octave frequencies between 500 and 4000 Hz, following the modified Hughson-Westlake method.

Acoustic immittance measurements were performed using the Otometrics Diagnostic Clinical device (Otometrics, Denmark). Middle ear pressure, compliance, and the equivalent volume of the external ear canal were measured using an acoustic stimulus at 226 Hz and an intensity of 85 dB sound pressure level. The type of tympanogram was classified according to the Jerger classification.

Scales

The visual analogue scale (VAS), THI, HQ, and STAI were administered to the individuals included in the study.

VAS

The VAS was employed to evaluate the perceived loudness of tinnitus. Participants rated the intensity of their tinnitus on a scale from 0 (no tinnitus) to 10 (extremely loud). Higher scores reflect a stronger perception of tinnitus loudness.

Tinnitus Handicap Inventory

This scale evaluates the effect of tinnitus on quality of life, offering insights into its severity and intensity. The scale was originally developed in 1996 (16), and its Turkish validity and reliability were assessed in 2007 (11). The THI contains 25 questions, categorized into three subscales: functional, emotional, and catastrophic. Responses are scored as follows: "No" = 0 points, "Sometimes" = 2 points, and "Yes" = 4 points, with the total score reflecting the sum of these values. Higher scores represent a greater burden of tinnitus and a more pronounced negative effect on quality of life (11).

Hyperacusis Questionnaire

The scale comprises 14 items in a 4-point Likert format, divided into three subscales: attention, social, and emotional. Responses are rated as follows: "No" (0 points), "Yes, a little" (1 point), "Yes, quite a lot" (2 points), and "Yes, a lot" (3 points). The total score is obtained by adding the individual responses, and hyperacusis is evaluated based on this score.

The highest possible score on the scale is 42. A score below 15 suggests no hyperacusis, a score between 15 and 28 indicates

suspected hyperacusis, and a score of 29 or above signifies definite hyperacusis. The scale's Turkish validity and reliability were assessed previously (17).

State and Trait Anxiety Inventory

The inventory comprises two subscales, each consisting of 20 items, aimed at evaluating an individual's state and trait anxiety. The State Anxiety Scale gauges how a person feels at a specific moment under particular conditions, while the Trait Anxiety Scale measures how they generally feel, regardless of their immediate environment or situation. Developed by Spielberger in 1983 and later adapted into Turkish by Öner and Le Compte in 1985, the scale uses a four-point Likert format. It includes both direct and reverse-scored items. For reverse-scored items, responses with a weight of 1 are changed to 4, and those with a weight of 4 are changed to 1, before calculating the total score. The score range for each subscale is from 20 to 80. Higher scores reflect higher anxiety levels, while lower scores indicate lower anxiety levels (13).

Statistical Analysis

Data analysis was conducted using IBM SPSS Statistics V26. Descriptive statistics were reported as frequency and percentage for categorical variables, and as median, interquartile range, mean, and standard deviation for numerical variables.

The normality of numerical variables was evaluated using the Shapiro-Wilk test, along with histogram and box plot visualizations. Relationships between numerical variables were examined using the Pearson correlation coefficient, as the normality assumption was met. Comparisons between two independent groups were conducted using the t-test. A significance level of 0.05 was established.

RESULTS

Among the 44 participants in the study, 24 were male (54.5%) and 20 were female (45.5%). The average age of the participants was 53.7±16.6 years. Table 1 provides an overview of the demographic characteristics of the participants.

No significant correlation was observed between age and the VAS, THI, HQ, STAI-S, or STAI-T scores ($p>0.05$). Additionally, there were no gender-based differences in the scale scores ($p>0.05$).

The correlation analysis exploring the relationships between VAS, THI, HQ, STAI-S, and STAI-T scores revealed a low but statistically significant positive correlation between THI and VAS scores ($r=0.340$, $p=0.024$). As the level of tinnitus severity increases, the perceived tinnitus loudness increases. A moderate, statistically significant positive correlation was observed between the THI and HQ scores ($r=0.423$, $p=0.004$). As the tinnitus severity increases, the severity of hyperacusis also increases. A statistically significant positive correlation was observed between the THI score and the STAI-S score at a low level ($r=0.388$, $p=0.009$), and between the THI score and the STAI-T score at a moderate level ($r=0.510$, $p<0.001$). As the tinnitus severity increases, both the state and trait anxiety levels also increase.

A moderate statistically significant positive correlation was observed between the HQ score and the STAI-S score ($r=0.474$, $p=0.001$), as well as between the HQ score and the STAI-T score ($r=0.501$, $p=0.001$). There is a positive relationship between the level of hyperacusis and both state and trait anxiety levels. As the level of hyperacusis increases, anxiety levels also increase. A moderate, statistically significant positive correlation was observed between the STAI-T and STAI-S scores ($r=0.548$, $p<0.001$). Table 2 presents the correlations among VAS, THI, HQ, STAI-S, and STAI-T.

When hyperacusis scores were grouped, 25 participants (56.8%) were in the no hyperacusis group, 16 participants (36.4%) were

Table 1. Information about the participants

	Mean±SD	Median (IQR)
Age (years)	53.7±16.6	
Duration of tinnitus (month)		48 (114.75)
Tinnitus localization	n	%
Left	17	38.6
Right	11	25.0
Both (right and left ears)	14	31.8
Head	2	4.5

n: Number of participants, SD: Standard deviation, IQR: Interquartile range

Table 2. Correlation between VAS, THI, STAI-S, STAI-T

Variables	VAS	THI	HQ	STAI-S
THI				
r	**0.340***			
p	**0.024**			
n	44			
HQ				
r	-0.040	**0.423****		
p	0.796	**0.004**		
n	44	44		
STAI-S				
r	-0.041	**0.388****	**0.474****	
p	0.794	**0.009**	**0.001**	
n	44	44	44	
STAI-T				
r	0.056	**0.510****	**0.501****	**0.548****
p	0.716	**<0.001**	**0.001**	**<0.001**
n	44	44	44	44

r: Correlation coefcient, n: Number of participant, VAS: Visual analog scale, THI: Tinnitus Handicap Inventory, HQ: Hyperacusis questionnaire, STAI-S: State Trait Anxiety Inventory- State, STAI-T: State Trait Anxiety Inventory-Trait, *Correlation is significant at the 0.05 level, **Correlation is significant at the 0.01 level

in the suspected hyperacusis group, and 3 participants (6.8%) were in the full hyperacusis group. Since the participants were not equally distributed across the hyperacusis groups, no statistical analysis was conducted among the three groups. The suspected hyperacusis and full hyperacusis groups were combined to form a hyperacusis group. The scale results were compared between the group without hyperacusis and the group with hyperacusis. No significant difference was found in the VAS and THI scores between the groups, but anxiety levels differed significantly ($p<0.05$). The group with hyperacusis had higher mean state and trait anxiety scores than the other group. Consequently, anxiety levels tend to be higher in individuals with hyperacusis. The t-test comparison of the scales in patients with and without hyperacusis is presented with a box plot in Figure 1. Scale comparisons of the groups with and without hyperacusis are presented in Table 3. In addition to statistically significant group differences in STAI-S and STAI-T scores, effect size calculations indicated large effects, (Cohen's d=0.95 and 0.81, respectively), suggesting clinically meaningful differences in anxiety levels between groups.

The average air conduction hearing thresholds of individuals with tinnitus in the 250-8000 Hz range are presented in Table 4. Eight participants had bilateral air conduction hearing thresholds below 25 dB in the 250-8000 Hz range, indicating normal hearing. In 22 participants, thresholds were normal according to the pure-tone air conduction average at four frequencies (0.5, 1, 2, 4 kHz) in both ears, but hearing loss increased towards higher frequencies. In 14 participants, mild-to-moderate sensorineural hearing loss progressively worsening at higher frequencies was observed bilaterally. Overall, participants exhibited hearing loss that became more pronounced at higher frequencies, as indicated by their average hearing thresholds. Pure-tone averages were created for both ears at 0.5, 1, 2, and 4 kHz. The relationship between pure-tone averages and the VAS, THI, HQ, and STAI scales was examined, but no statistically significant correlation was observed ($p>0.05$).

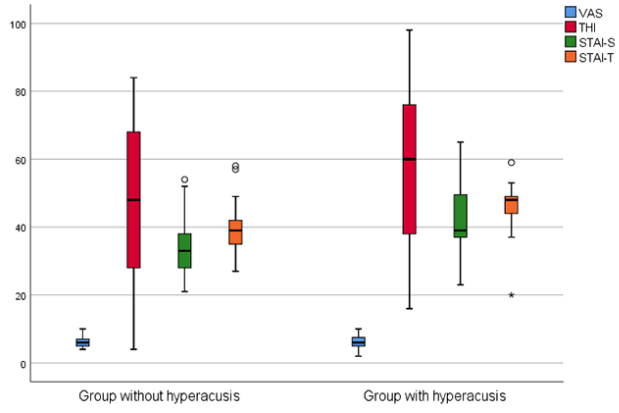

Figure 1. T-test comparison of scales in patients with and without hyperacusis box-plot

DISCUSSION

This study examined the connection between tinnitus severity, perceived tinnitus loudness, hyperacusis, and anxiety in individuals with subjective chronic tinnitus. The goal was to assess the impact of tinnitus on daily life and explore associated factors.

A study examining potential risk factors for tinnitus in patients with anxiety disorder found that the lifetime prevalence of tinnitus was greater in individuals with anxiety disorder compared to those without it (18). Several studies indicate that personality traits, as well as anxiety and depression, might worsen tinnitus symptoms. According to Andersson and Vretblad, anxiety sensitivity could be a contributing factor to tinnitus-related distress (19). A study reported that individuals with high anxiety sensitivity experienced greater tinnitus discomfort and more negative life impacts than those with normal sensitivity, regardless of hearing loss level. Tinnitus distress and tinnitus handicap have been shown to be predictable based on elevated levels of anxiety sensitivity (20).

A study comparing individuals with chronic tinnitus and normal hearing to healthy controls found significantly higher depression levels in the tinnitus group, with no differences in anxiety or personality traits. However, within the tinnitus group, tinnitus severity was positively correlated with anxiety, anxiety sensitivity, and neurotic personality traits (21). In a study measuring anxiety and depression levels in individuals with tinnitus, both state and trait anxiety were found to be associated with the THI (22). Crocetti et al. (14) found that THI and STAI-T were associated with VAS, which measures tinnitus severity. The studies examining the link between anxiety

Table 3. T-test comparison of scales in patients with and without hyperacusis

Variables	Group without hyperacusis (n=25)		Group with hyperacusis (n=19)		p-value	Cohen's d
	Mean	SD	Mean	SD		
VAS	6.2	1.8	5.8	2.2	0.572	0.19
THI	47.1	21.8	57.8	26.8	0.149	0.43
STAI-S	33.6	8.5	42.7	10.8	**0.010***	0.95
STAI-T	39.3	7.7	45.7	8.1	**0.004****	0.81

n: Number of participants, SD: Standard deviation, VAS: Visual analog scale, THI: Tinnitus Handicap Inventory, HQ: Hyperacusis Questionnaire, STAI-S: State Trait Anxiety Inventory- State, STAI-T: State Trait Anxiety Inventory- Trait, Cohen's d values represent effect sizes for group comparisons. Small effect: d=0.2, medium: d=0.5, large: d=0.8 (Cohen, 1988). *p<0.05, **p<0.01 (Group differences are statistically significant)

Table 4. 250-8000 Hz mean air conduction hearing thresholds

Mean hearing thresholds of all participants		
	Right Median (IQR)	Left Median (IQR)
250 Hz	10 (10)	10 (10)
500 Hz	10 (15)	10 (15)
1000 Hz	15 (15)	15 (15)
2000 Hz	20 (25)	20 (20)
4000 Hz	32.5 (40)	32.5 (42.5)
6000 Hz	40 (38.75)	45 (38.75)
8000 Hz	45 (53.75)	52.5 (40)

IQR: Interquartile range

and tinnitus in individuals with tinnitus reveal a significant association between anxiety and tinnitus severity. In our study, a statistically significant positive correlation was found between tinnitus severity and both state and trait anxiety. The study findings also show that state and trait anxiety levels are positively correlated. It can be stated that as the tinnitus handicap level increases, both state and trait anxiety levels also increase.

Yakunina and Nam (23) found that tinnitus loudness measured by VAS did not correlate with psychoacoustically matched tinnitus loudness and minimum masking level (MML). However, it correlated with subjective tinnitus distress measures such as the THI score, daily tinnitus duration measured by VAS, discomfort and distress levels, and depression score. It has been reported that tinnitus loudness determined by VAS is influenced much more by emotional distress and depression than by hearing loss. Rating the perceived tinnitus loudness is associated with the extent to which an individual is affected by tinnitus, and patients who are more disturbed by tinnitus tend to rate its loudness higher (23). In the study by Cho et al. (22), it was shown that VAS loudness is associated with THI, but not with depression or STAI. In our study, the VAS score shows a significant positive relationship with THI but not with the HQ and STAI scales. While perceived tinnitus loudness is related to the impact of tinnitus on daily life, it may not be directly related to hyperacusis and anxiety levels. As the negative impact of tinnitus on daily life intensifies, the VAS score correspondingly increases.

Psychological distress, including anxiety and depression, is considered a crucial factor in the accurate diagnosis and effective treatment of hyperacusis. Regardless of normal hearing function, it is recommended that patients presenting to the clinic due to hyperacusis should also be evaluated for psychological distress for an accurate diagnosis. Research has demonstrated that individuals with hyperacusis exhibit higher anxiety and depression scores than those in the control group (24). In the study by Erinc and Derinsu (17), participants who scored lower on the Beck Anxiety Scale had lower hyperacusis scores, while those who scored higher had higher hyperacusis scores. Jacquemin et al. (25) found that the group with hyperacusis scored higher on the Tinnitus Functional Index, Hospital Anxiety and Depression Scale, and VAS (loudness) than the group without hyperacusis. As a result, it has been proposed that the presence of hyperacusis may signal a greater need for treatment. Clinicians should be mindful of the increased risk of comorbid anxiety and depression in patients with hyperacusis (25). Individuals with hyperacusis complaints exhibit greater tinnitus distress along with more pronounced symptoms of anxiety and depression. These findings highlight the impact of hyperacusis on emotional well-being (26).

A study utilizing the Tinnitus Primary Function Questionnaire (TPFQ) to assess the functional impact of tinnitus found a positive correlation between the TPFQ and HQ. The findings of this study indicate that hyperacusis may affect the severity of tinnitus. Additionally, having an HQ score of 28 or higher significantly increases the likelihood of reporting tinnitus (27). Cederroth et al. (10) found a significant association between hyperacusis and tinnitus, especially in cases of severe tinnitus. In this study, participants with both tinnitus and hyperacusis exhibited worse outcomes across various factors, including stress, anxiety, depression, quality of life, tinnitus distress, sound loudness, discomfort, and awareness, compared to those without hyperacusis (10).

In our study, a positive significant relationship was found between HQ and THI, STAI-S, and STAI-T. As the level of hyperacusis increased, both the tinnitus severity and anxiety scores also increased. Consistent with findings in the literature, this study also shows that hyperacusis is associated with tinnitus and emotional state. In our study, anxiety scores were higher in the group with hyperacusis than in the group without hyperacusis. No significant differences were observed in the VAS and THI scores between the groups with and without hyperacusis. The lack of differences in other scales between the groups could be due to the small number of participants in the full hyperacusis group and the merging of this group with the suspected hyperacusis group to form the "group with hyperacusis". It is recommended that evaluations be repeated in a larger sample with a more balanced distribution of the complete hyperacusis and no hyperacusis groups. Our findings highlight the importance of assessing anxiety levels in individuals with hyperacusis.

Aazh et al. (28) found that THI is related to VAS, HQ, and HADS, which measures anxiety and depression. In the same study, age was not found to be significantly related to THI and HQ. Furthermore, no significant correlation was observed between THI scores and the hearing thresholds of the better or worse ear. Udupi et al. (29) showed that the perceived tinnitus handicap level is related to depression but not to hearing loss, age, or gender. Although tinnitus is highly prevalent among patients with hearing loss, other studies have found no significant correlation between tinnitus

severity and hearing thresholds (30). Our study's finding of no correlation among age, gender, average hearing thresholds, and the scales aligns with results reported in the literature.

Study Limitations

In our study, a three-category comparison was not possible due to the uneven distribution of data across the hyperacusis scale categories. Specifically, the full hyperacusis group included only three individuals, which would have compromised statistical power and generalizability. Therefore, the suspected hyperacusis and full hyperacusis groups were combined for analysis. It is recommended to compare scale scores in a larger sample with a more balanced distribution across categories. Additionally, a categorical evaluation between those with and without hearing loss could not be performed. Although the participants' hearing configuration was generally characterized by high-frequency hearing loss, there were individual differences. Future studies could better evaluate the impact of hearing loss on the scales by focusing on participants with specific degrees and configurations of hearing loss, which may help reduce its potential effects. In our study, the age range was 18-81, covering a broad span. More specific findings could be obtained by narrowing the age range and focusing on a specific age group.

CONCLUSION

In conclusion, the tinnitus severity experienced by individuals with subjective chronic tinnitus is positively correlated with VAS, HQ, and STAI. Therefore, it is important to consider common comorbidities such as hyperacusis and anxiety when evaluating individuals with tinnitus. It is suggested that a holistic approach should be adopted in the treatment for individuals with tinnitus.

Ethics

Ethics Committee Approval: It was approved by the İzmir Bakırçay University Non-Interventional Clinical Research Ethics Committee (decision No: 1560, date: 17.04.2024).

Informed Consent: All participants provided written informed consent prior to their inclusion in the study.

Footnotes

Author Contributions: Concept - E.A.Ö.A., S.M.D.; Design - E.A.Ö.A., S.M.D.; Data Collection and/or Processing - E.A.Ö.A.; Analysis and/or Interpretation - E.A.Ö.A., S.M.D., S.A., G.K.; Literature Search - E.A.Ö.A.; Writing - E.A.Ö.A., S.M.D., S.A., G.K.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors report that no financial support was received for this study.

Data availability statement: The datasets generated and/or analyzed during this study are available from the corresponding author upon reasonable request.

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