



Effect of yoga training on the tinnitus induced distress

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ABSTRACT

The study addressed the efficacy of 12 weeks of yoga training in treating 25 patients with chronic tinnitus. Ten of the patients underwent magnetic resonance imaging (MRI) before and after training. A control group comprised 13 people reporting chronic tinnitus. All participants were assessed with the *Tinnitus Functional Index*.

After the 12-week yoga course, the areas considered to have benefited most were the sense of control of tinnitus, sleep, quality of life, and intrusiveness. The MRI studies indicated that connections in the white matter of the motor cortex appeared to be stronger as a result of training.

Yoga training has good potential to improve the daily functioning of patients with chronic tinnitus and can be considered a promising supporting method for tinnitus treatment.

1. Introduction

Many millions of people around the world are affected by tinnitus. Research carried out in various countries shows that the prevalence of tinnitus varies from 4.4 to 15.5% [1]. In Poland, the percentage of people with tinnitus is similar: about 20% of the adult population complain of tinnitus lasting longer than 5 min. About 4.8% of Poles say they experience chronic tinnitus [2]. In children, tinnitus has been reported to occur in 6–12% of 7-year-olds and 12-year-olds [3–5]. Clinical practice as well as research both indicate that tinnitus often results in cognitive dysfunction and strong negative emotions. Patients with tinnitus may also experience depression or anxiety. Symptoms often associated with tinnitus are depression, nervousness, sleep disorders, lack of effective rest, and concentration disorders [6–8].

Managing tinnitus is a challenge because it can be a symptom of a wide range of different pathologies and can be accompanied by many different comorbidities. If treating the direct cause of tinnitus is impossible or unsuccessful, it becomes necessary to treat the symptoms. In the Tinnitus Department of our institution, patients suffering from tinnitus caused by disturbances to the auditory system are symptomatically treated with sound therapy based on wide-band noise generators. One such device is a bedside noise generator or ear noise

generator. An effective alternative is a phone app which makes it possible to choose the most pleasant sound to listen to during the day. For patients with tinnitus and hearing loss, hearing aids with an in-built noise generator function can be used. In the case of troublesome one-sided tinnitus accompanied by profound hearing loss, a cochlear implant is the preferred option.

Psychological intervention based on Cognitive Behavioral Therapy (CBT) is a method we use for supporting basic treatment. CBT is conducted by a team of psychologists and is carried out as a part of individual consultations, or sometimes as week-long residential group therapy to teach patients how to deal with tinnitus-related distress. Residential intervention is treated as an on-going research project which at present consists of three thematic blocks: (1) psychological intervention therapy, (2) relaxation therapy using music therapy and body work, and (3) activating and improving concentration exercises. The aim of psychological intervention is to change the patient's negative attitude and reduce inappropriate behavioral responses to their tinnitus [9].

There is increasing interest in the potential of yoga as an intervention for mental health concerns [10]. Yoga is a multi-dimensional system of health and well-being that focuses on the functioning of the mind, with multiple mind-body practices including physical postures

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and movements, breathing exercises, relaxation, mindfulness, and meditation [11–16].

A general finding [11] is that, for a person with mild or moderate depression or anxiety, individually tailored yoga practice can be expected to lead to a 50–90% (median 80%) reduction of symptoms (and associated increase in positive emotions and wellbeing). This finding is based on the use of an experienced yoga teacher in conjunction with other forms of treatment or intervention. Yoga can also improve back-related dysfunction and pain through a positive effect on physical functioning of the back, cognitive awareness of back pain, and general stress reduction [12].

Recognising these sorts of benefits, we thought that yoga exercises might also be able to help patients suffering from chronic tinnitus. Yoga's ability to relax muscles and slow down breathing might reduce emotional tension, minimise stress, and improve sleep in tinnitus patients. Importantly, improvements in emotional and physical health might neutralize negative emotional reactions to tinnitus and help the patient habituate to the sounds, making the tinnitus less intrusive and annoying. Yoga might be regarded as a new element supporting sound therapy and psychotherapy, and so the aim of the study was to assess the effect of yoga training on tinnitus-related distress.

2. Material and methods

2.1. Participants

The study (yoga) group consisted of 25 patients (14 women and 11 men) with chronic tinnitus which had lasted more than 6 months. The patients' ages ranged from 17 to 67 years ($M = 52.00$; $SD = 12.22$). The control group consisted of 13 patients reporting chronic tinnitus (9 women and 4 men), aged from 31 to 70 years ($M = 52.46$; $SD = 12.62$). Normally hearing tinnitus patients and tinnitus patients with hearing loss of not more than 30 dB were included in the study. Exclusion criteria were taking medication that might affect the central nervous system and spinal disease.

Ethical approval

Participants gave written informed consent after reading the reference information. The project was approved by the local ethics committee (approval number IFPS:KB/04/2016) and conformed to the tenets of the Declaration of Helsinki for medical research involving human subjects.

2.2. Study procedures

Patients in the yoga group took part in classes involving physical exercises and breathing exercises based on the philosophy of Ashtanga yoga. The exercises focused on the diaphragm and also stretched muscles of the body in the head, neck, back, chest, torso, limbs, and pelvis; all were designed to improve blood circulation and reduce tension in each muscle. The head and neck exercises aimed to improve circulation and oxygenation in those areas. The 90-min classes were conducted by a qualified yoga instructor and they took place twice a week for 12 weeks. Exercises were adapted to the physical ability of the participants. In addition, patients were instructed to perform recommended exercises on their own at home (2–4 times a week for 30 min). At each class participants were asked if they had practised yoga at home, and all confirmed they had.

ENT examinations and audiological assessments were conducted on all patients. Air and bone conduction thresholds from 0.125 to 8 kHz were determined in the right and left ears of all patients. Normal hearing was defined as an air threshold of 20 dB HL or less at all tested frequencies (BIAP, 1996).

2.3. Tinnitus Functional Index

Participants from both the study and control groups completed a TFI (Tinnitus Functional Index) questionnaire assessing the negative impact of tinnitus on their day-to-day life [17]. Results were compared before and immediately after therapy. The license for the TFI questionnaire was purchased from the Oregon Health & Science University for use in clinical and scientific research (from 04.2016 to 04.2021).

TFI is divided into 8 subscales that rate the following factors: intrusiveness, sense of control, cognition, sleep, auditory, relaxation, quality of life, and emotional. A score of 0 points means that tinnitus is having no impact and a score of 100 points means it is having a very large impact on that particular aspect of life. The scores for the total scale are calculated on the basis of all the subscales. Among all the available tinnitus questionnaires, TFI was selected because it is the only one validated for sensitivity to changes in tinnitus-related distress [18].

2.4. Statistical analysis

The study protocol contained two groups (the study group and a control group) and each was measured twice (before and after yoga training for the study group, and two measurements without any intervening treatment for the control group). A mixed design ANOVA with post hoc tests and Bonferroni adjustment was used to compare the results of all TFI subscales and the global score. The statistical significance threshold was $p < 0.05$. For statistical analysis, IBM SPSS Statistics v. 24 software was used.

In addition, 10 subjects participated in an MRI study before and after the series of yoga classes. MRIs of the subjects were acquired using a 3 T S Tim Trio VB17 whole-body magnetic resonance scanner with a 12-channel head matrix coil. T1-weighted images were acquired with the following acquisition parameters: TE = 2.21 ms, TR = 1900 ms, TI = 900 ms, flip angle = 9°, field of view = 260 × 288 mm, slice thickness = 0.9 mm, number of slices = 208, image matrix = 290 × 320, which gives an isotropic voxel size of 0.9 × 0.9 × 0.9 mm, pixel bandwidth = 200 Hz/pix, iPAT = 2, and TA = 5 min.

FreeSurfer 5.3 (<http://surfer.nmr.mgh.harvard.edu>) was used to derive measurements of individual brain regions. Analysis was carried out with the standard pipeline in Volume Based Stream (<http://surfer.nmr.mgh.harvard.edu/fswiki/FreeSurferAnalysisPipelineOverview>). To adjust for differences in brain volume, FreeSurfer volumetric measurements for individual brain regions were divided by the intracranial cavity volume (with ventricles). Structural segmentation was based on the Destrieux atlas, Desikan–Killiany atlas, and Mindboggle [19].

The goal was to check whether yoga training significantly changed the size of any brain structure. In the FreeSurfer software, the Oxford–Harvard brain atlas was used to segment the image of each subject's brain and we used all regions of the entire brain to make comparisons. We sought regions where there was a statistically significant difference in tissue volume. The measurements were conducted blind, without the experimenter knowing whether the images were taken before or after yoga. We compared the average size of each structure for 10 people before and after training using a paired *t*-test.

3. Results

3.1. Questionnaire results

Descriptive statistics (means and standard deviations) of the TFI scores for the initial and follow-up measurements are shown in Table 1.

The interaction effect of ANOVA was statistically significant for the TFI global score and for 5 of 8 of its subscales: Intrusiveness, Sense of control, Sleep, Auditory, and Quality of life.

The interaction effect for the TFI global score was $F(1,38) = 6.55$, $p = 0.015$, $e [2] = 0.154$. Following the 12-week yoga training course

Table 1
TFI scores for the initial and follow up measurements in the study and control group.

	Study group				Control group			
	Initial		Follow-up		Initial		Follow-up	
	M	SD	M	SD	M	SD	M	SD
Intrusiveness	50.40	25.48	36.13	17.29	46.75	22.30	53.15	30.97
Sense of control	46.63	27.68	19.99	18.58	32.52	30.92	29.74	24.99
Cognition	42.16	26.29	18.51	15.97	34.52	26.76	27.50	25.89
Sleep	46.20	34.83	26.29	26.33	33.46	23.24	34.10	29.48
Auditory	28.59	24.91	19.20	22.90	22.02	25.27	35.58	29.05
Relaxation	48.48	28.60	29.60	22.58	32.20	23.68	34.01	22.07
Quality of life	36.77	29.11	21.36	20.79	25.65	28.56	31.65	26.83
Emotional	37.76	26.75	23.91	21.10	28.69	25.92	22.28	17.74
TFI global score	42.12	21.96	24.37	16.92	31.98	19.08	33.50	20.03

the TFI global score significantly decreased in the study group ($p < 0.001$), while in the control group it was similar in the initial and follow-up measurement ($p = 0.804$).

For the Intrusiveness subscale the interaction effect was $F(1,38) = 5.25$, $p = 0.028$, $e[2] = 0.127$. Intrusiveness was significantly lower after yoga training in the study group ($p = 0.010$), while in the control group it was similar for both measurements ($p = 0.388$).

For the Sense of control subscale the interaction effect was $F(1,38) = 6.01$, $p = 0.019$, $e[2] = 0.143$. The scores decreased significantly after yoga training in the study group ($p < 0.001$), while in the control group they were similar in both measurements ($p = 0.726$).

For the Sleep subscale the interaction effect was $F(1,38) = 4.83$, $p = 0.034$, $e[2] = 0.118$. The scores were significantly lower after yoga training in the study group ($p = 0.01$); in the control group both measurements were similar ($p = 0.933$).

For the Auditory subscale the interaction effect was $F(1,38) = 5.57$, $p = 0.024$, $e[2] = 0.134$. The effect was statistically significant but there was no difference after yoga training in the study group ($p = 0.108$), while in the control group the scores were slightly higher in the follow-up than in the initial measurement ($p = 0.094$).

For the Quality of life subscale the interaction effect was $F(1,38) = 5.24$, $p = 0.028$, $e[2] = 0.127$. The scores decreased significantly after yoga training in the study group ($p = 0.008$), while in the control group both measurements were similar ($p = 0.434$).

The interaction effect was not statistically significant for the Cognition subscale $F(1,38) = 2.61$, $p = 0.115$, $e[2] = 0.068$; Emotional subscale $F(1,38) = 1.00$, $p = 0.324$, $e[2] = 0.027$; or for the Relaxation subscale $F(1,38) = 3.60$, $p = 0.066$, $e[2] = 0.091$.

The interaction effect of the TFI global score is shown in Fig. 1.

3.2. Magnetic resonance imaging results

The results of segmenting MRI images showed that there were significant changes (-5.4% , $p < 0.0018$) in the thickness of the right anterior circular sulcus of the insula, a part of the cortex which receives a direct projection from the basal part of the ventral medial nucleus of the thalamus and which has a particularly large input from the central nucleus of the amygdala. The anterior insula itself also projects to the amygdala. The volume of grey matter in the subparietal sulcus was also reduced (-6.6% , $p < 0.0009$), a volume which separates the precuneus from the posterior part of the cingulate gyrus.

There was also an increase of white matter volume in the right paracentral area (4.57% , $p < 0.04$) which controls motor and sensory innervation of the contralateral lower extremity. Fig. 2 illustrates areas taken from the Oxford–Harvard anatomical atlas (the Atlas is available in digital form) which we used to prepare our own illustration of the areas affected. The orange arrows in Fig. 2 indicate the regions where we found statistically significant changes after yoga training.

4. Discussion

We assumed that yoga might be able to reduce tinnitus-related distress. The results indicate a significant improvement in the day-to-day functioning of tinnitus patients who did yoga compared to the control group who did not. After the 12-week yoga training course the TFI global score had significantly decreased in the study group, while in the control group it was about the same at the initial and follow-up measurements. The individual subscales of the TFI questionnaire showed that, after practicing yoga, patients experienced improvements in most of the measured aspects of their lives. The most beneficial areas, as rated by 5 of the 8 TFI subscales, were: sense of control of tinnitus, sleep, quality of life, intrusiveness, and auditory. Four of the above-mentioned areas accorded with our expectations. Surprisingly, however, an improvement was also observed on the auditory subscale. Although the effect was statistically significant, there was no difference after yoga training in the study group ($p = 0.108$).

The improvements we measured cannot be compared with other studies since no research on the effect of yoga-based physical activity and breathing exercises on patients with tinnitus can be found in the literature. There is only a report of Qigong intervention being beneficial for tinnitus patients [20]. Qigong is a set of breathing and movement exercises that claims to improve health through reducing stress and activating the body. In the tinnitus study reported, Qigong participants experienced an improvement in tinnitus severity as measured by a Visual Analog Scale and a TBF-12 questionnaire in comparison with a control group.

The positive effect of yoga on tinnitus-related distress can be explained through the way it allows the patient to learn how to control their body, breathe deeply, and reduce muscle tension. With time, this leads to relaxation and a sense of tranquillity. Regular yoga exercises can also improve mood and reduce mental tension.

We hypothesize that practicing yoga may change the size of certain brain structures in tinnitus patients. During yoga training the participants were encouraged to strengthen control over their muscles as well as be sensitive to feelings throughout their body. Over time, increased activity of the somatosensory cortex might translate into stronger white matter connections. We assume that yoga training may have been the cause of the increase in volume of the right paracentral white matter.

There are several papers on the subject of tinnitus and fMRI studies of the tonotopic organization of the auditory cortex [21–23]. Poepl et al. [24] observed rTMS-induced neuroplastic changes underlying therapeutic responses in brain areas, but we were not able to find any work in which an MRI examination of patients with tinnitus after yoga therapy was performed. Our results are limited due to the lack of a control group. The MRI results should be treated with great caution due to the small group studied, and the interpretations are speculative. Nevertheless, the reduction of gray matter in the area of insula, an integrating area which has direct connections with the amygdala, might

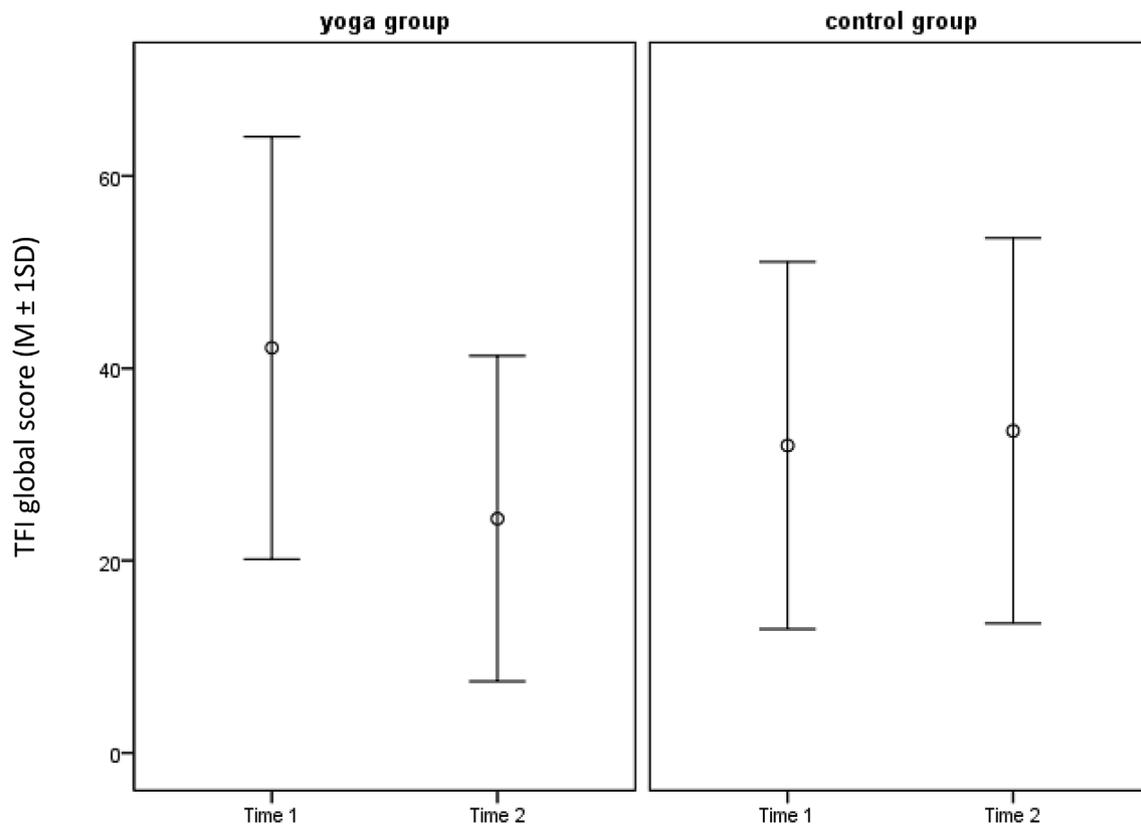


Fig. 1. Comparison of TFI global scores in the yoga group (left) and control group (right) at two time points. In the yoga group the TFI global score was significantly lower after 12 weeks of yoga training than before training ($p < 0.001$).

be associated with a degree of emotional calming due to yoga training. In addition, increasing the volume of white matter in the paracentral area may be associated with an increase in the number of connections to motor areas as a result of physical exercise. The effect was described in the right, but also occurs in the left hemisphere, but in this case below the level of significance. An increase in the number of subjects could make the result statistically significant in both hemispheres.

4.1. Limitations of the study

The results of a longer-term study would help give a more complete assessment of the impacts of yoga on the day-to-day life of tinnitus

patients.

5. Conclusions

1. Performing physical and breathing exercises based on the Indian philosophy of yoga has a beneficial effect on patients with tinnitus-related distress.
2. Yoga exercises can be considered as one of several supportive therapies for patients with chronic tinnitus.

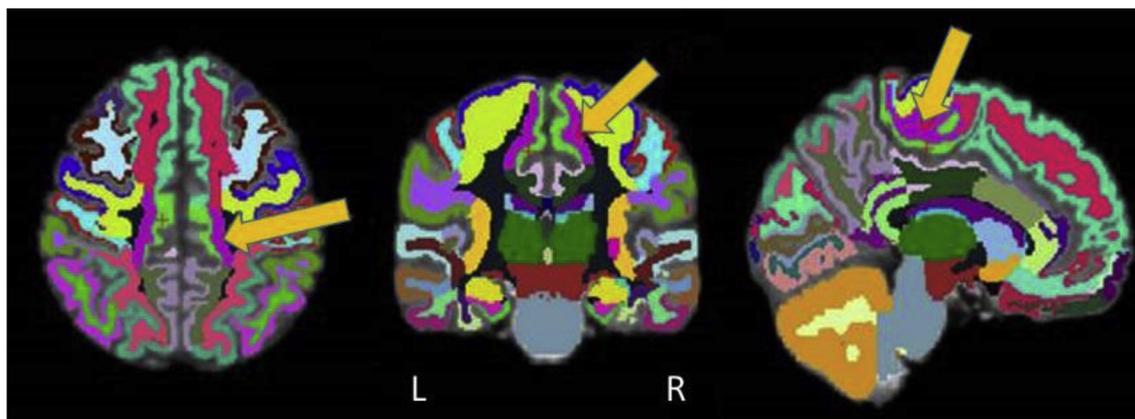


Fig. 2. Brain structures affected by yoga training. The orange arrows point to the right paracentral white matter (purple) which connects sensorimotor areas with the thalamus and cerebellum. We detected a significant increase (4.6%) in the volume of white matter in this structure after yoga training. The right paracentral white matter is responsible for connections to the lower parts of the body. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Sources of support

None.

Declaration of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ctcp.2019.04.003>.

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