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Posturography measures and efficacy of different physical treatments in somatic tinnitus

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Abstract

Somatic modulation in tinnitus has been demonstrated by several studies although few investigations have been published on the efficacy of physical treatments in tinnitus subjects. In the present study the prevalence of somatic components to tinnitus were evaluated and the efficacy of two different physical treatments were compared: InterX® transcutaneous dynamic electrical stimulation and manual osteopathic therapy. Furthermore, posturographic measurements were analysed to verify the postural control in tinnitus subjects.

40 consecutive tinnitus patients, aged 18-65, were randomly selected for treatment (once a week for 2 months): 20 tinnitus subjects were treated with osteopathic manipulations, 20 with InterX®. They were evaluated pre and post therapy with audiogram up to 16 kHz, tinnitus pitch and loudness match, MML, THI questionnaire, posturography, structured interview with special attention on postural and movement influence on tinnitus, physical evaluation and osteopathic evaluation. 40 controls with no tinnitus, underwent audiological tests, postural and osteopathic evaluation for comparison.

In our population, tinnitus sufferers presented more frequently musculoscheletal strains assessed with osteopathic visit and postural problems assessed with posturography measures in comparison with controls. Posturographic test, showed an average oscillating areas significantly greater in tinnitus participants ($p \leq 0.05$), compared with control subjects. On the average in the treated groups, the enveloped areas were not significantly affected by either of the treatments. Tinnitus improved subjectively in most patients: loudness decreased, % time of awareness, % time of annoyance and quality of life was overall perceived as improved. This was mostly evident in subjects with muscular strain and tensions.

This study indicates the benefit of physical, manipulation therapy for those patients with somatic modulation of their tinnitus, further studies are needed to establish the diagnostic or prognostic role of posturographic measurements.

Keywords: tinnitus, somatic, posturography, physical therapy, osteopathy.

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INTRODUCTION

Tinnitus is an auditory sensation of sound in the ears or in the brain in the absence of external sounds[1]. The mechanisms generating this symptom are uncertain and the onset of tinnitus can be associated with non otologic causes. Several studies have shown that tinnitus can arise directly from a disorder of the head and upper neck through activation of the somatosensory system, which can trigger or modulate tinnitus in 64-80% of the participants[2-9].

Other studies have shown that tinnitus can be evoked or modulated by pressure on painful trigger points[10] in the upper back, neck or shoulders[11]. Also, it has been described that many tinnitus sufferers may present symptoms of temporomandibular joint (TMJ) or dental problems[12,13], cervical spine disorders[3,14], head, neck and shoulder pain[2,6].

An abnormal activity in the somatosensory system may result from such peripheral problems and the interaction of the somatosensory systems with the auditory system can provide a powerful feedback mechanism that may interfere with peripheral sensitivity[1]. Also, anomalous cross-modal interactions along the audiovestibular, visual and somatosensorial pathways could be responsible for the aberrant signals[5].

Recently, connections between the dorsal cochlear nucleus and afferent pathways from the cervical somatosensory system, respiratory and vocal centres as well as reticular formation have been demonstrated[15-17]. These connections can either increase or reduce the activity of areas of the dorsal cochlear nucleus and such activity can be affected by hearing loss[17].

These evidence have suggested to use therapeutic methods for tinnitus that are in the area of therapies for musculoskeletal disorders, such as electrical stimulation applied to skin or the use of manipulations or exercising[11,18-24].

The Transcutaneous Electrical Nervous Stimulation (TENS) is a clinical form of electrical stimulation of the somatosensory system. It is the electrotherapy most commonly used in physiotherapy for pain, muscle contractions, and inflammation in several neural and osteoarticular conditions as well as those affecting tendons and ligaments for it reduces pain[25,26].

The efficacy of this treatment for tinnitus could be justified by the fact that tinnitus has many similarities with the symptoms of neurological disorders such as paresthesia and central neuropathic pain. In fact, there is considerable evidence that the symptoms and signs of some forms of tinnitus and central neuropathic pain are caused by functional changes in specific parts of the central nervous system and that these changes are caused by expression of neural plasticity[27].

Also it has been shown by differentially blocking cutaneous and deep tissue primary afferents that TENS analgesia is primarily mediated by the activation of large diameter primary afferents from deep somatic tissues, rather than the cutaneous afferents[28], and for this reason it might interfere with the mechanisms of somatic modulation of tinnitus.

InterX® is an interactive non-invasive skin neurostimulator for pain management (Figure 1). The device produces biphasic impulse current indicated for symptomatic relief and management of chronic pain, post traumatic strain and pain, muscle relaxation and muscle re-education. The main difference with the traditional TENS techniques is that InterX® is designed to sense the difference in skin potential and to dynamically adapt its stimulation to this modifying parameter through a process of interactive feedback. This could reduce the overstimulation occurring in some cases, reducing the risk for worsening of tinnitus.

Figure 1. the InterX® dynamic transcutaneous electrical neurostimulation. Painful areas or trigger points of the neck, upper back or around the ear muscles are treated by the therapist during the entire session with interX in tinnitus subjects. Cutaneous reactions or change in pain are monitored.

In the few studies that used TENS as treatment in tinnitus, improvement[21,22,24] as well as worsening of tinnitus in participants was described[24].

Many of the manipulative treatments used for musculoskeletal disorders such as chiropractic manipulations, osteopathy, and massages may be considered in tinnitus treatment not only in patients with somatic tinnitus, but also in some other patients because these therapies may elicit reflex effects on non-musculoskeletal symptoms.

In published data, chiropractic manipulations are used mainly for musculoskeletal disorders, but improvements of non-musculoskeletal symptoms after chiroprac-

tic manipulations have been described to occur in 2% to 10% of all patients treated and by 3% to 27% of those who complained to have non-musculoskeletal problems[29,30]. The success of spinal manipulative therapy, particularly of the atlanto-occipital joint, can be up to 82% of patients with dizziness (46% total relief, 36% high improvement). In contrast, only 10% of patients with tinnitus showed an improvement according to one study ($P<0.001$)[20].

In some cases, cervical problems, such as cervical degeneration or cervical instability, can present with symptoms mimicking Ménière's disease: dizziness, fluctuating hearing loss, and tinnitus[18,19,31]. Cervical problems in the generation of tinnitus should be taken into account, especially in the elderly with a later onset of symptoms.

Osteopathy is a well known system founded by Dr. A.T. Still (1828-1917), focusing on the diagnosis, treatment, prevention, and rehabilitation of musculoskeletal disorders and the effects of these conditions on a patient's general health. According to osteopathic textbooks, therapy for tinnitus aims at the identification of structural problems to correct; the relaxation of muscles especially in the neck, upper back and TMJ and the improvement of lymphatic local circulation. Up to now, no studies have been published on the efficacy of osteopathic treatment on tinnitus.

MATERIALS AND METHODS

40 consecutive individuals with tinnitus and otherwise healthy, aged 18-65, have been enrolled for the study. Patients and controls were initially evaluated and the patients were then randomly selected for treatment (1 treatment per week for 2 months): 20 were treated with osteopathic manipulations and 20 with InteriX®. 20 control subjects with no tinnitus underwent the evaluation protocol for comparison.

Individuals in current treatment with psycotropic medications or psychiatric disorders were excluded from the study. Also, individuals with recent history of neoplastic disease or chronic cardiovascular problems (including hypertension) were not recruited for this study. Furthermore subjects with severe or profound hearing loss across all frequencies were not included.

The evaluation protocol included: audiogram up to 16 kHz, DPOAE, tinnitus pitch and loudness match, MML, Tinnitus Handicap Inventory (THI) questionnaire that informed us about the anxiety and reactivity levels of subjects affected, posturography, structured interview with special attention on postural and movement influence on tinnitus; otological and physical evaluation with the research of trigger points and osteopathic evaluation. Time of awareness of tinnitus, subjective discomfort generated by tinnitus and degree by which tinnitus interfere with patients' daily life, were also evaluated by mean of a visual analogue scale (VAS 1-10). Tinnitus subjects were evaluated as well, at the end of treatment. Participants were asked to not associate other therapies for tinnitus (such as sound therapies or medications) while participating in the study.

Posturography measurements were performed with Chinesport Vertigo Static Platform SP400.

Osteopathic manipulations were performed by an experienced physiotherapist osteopath.

The transcutaneous electrical stimulations were all performed by the same physician with the InterX® 5000 equipment for 60 min once a week for each subject at 70 Hz stimulation.

The InterX® is an alcaline battery supplied device for transcutaneous electrical neurostimulation with impulse duration 68-668, frequency ranging 15,3-350 Hz and variable output voltage of 20-450, with output current bifasic 2-90 mA.

Statistical treatment of data

The normality of data distribution was verified before comparing patient-group averages, by means of the Kolmogorov-Smirnov test at the 0.05 p-level. The t-test for paired experiments was used for evaluating the significance of therapic effects within groups of tinnitus patients. The homogeneity of variances was checked with Bartlett's test before comparing patient-group averages by means of LSD test or t-test with separate variance estimate[32].

RESULTS

All tinnitus subjects (30 males and 10 females) were aged 18-65 (average 48.5, median 50), the 40 controls (29 females and 11 males) were sex and aged matched ranging 21-65 (average 43.3, median 43).

Audiological evaluation

Audiometric measurements in tinnitus subjects showed: 12 (30%) normal hearing participants; 8 subjects (20%) had slight sensorineural hearing impairment in the high frequencies; 10 subjects (25%) were moderately hearing impaired in the high frequencies; 2 had severe hearing loss on high frequencies; one subject had slight sensorineural impairment in all frequencies, one with moderate sensorineural hearing impairment in all frequencies. 6 of these subjects (15%) had asymmetrical sensorineural hearing impairment.

The audiometrical tests of 30 control subjects (75%) showed normal hearing, 5 subjects had mild hearing impairment in the high frequency range, 2 had moderate sensorineural hearing impairment in the high frequencies and 3 subjects had a slight sensorineural hearing impairment across all frequencies.

Tinnitus was in the higher frequencies ($\geq$ 2000 Hz) in 29 subjects (72.5%), in the lower frequencies (<

750Hz) in 7 subjects (17.5%), and in the middle (≥ 750 to < 2000 Hz) frequencies in 4 subjects (10%).

Hyperacusis was reported in 4 subjects (10%).

The minimum duration of tinnitus was 2 months and the maximum 480 months (40 years) (average 68.2 months). Tinnitus was bilateral in 26 subjects (65%), left-sided in 7 cases (17.5%), right-sided in 4 subjects (10%), perceived as central in 3 cases (7.5%). All patients reported continuous tinnitus.

Although after the treatment there has not been significant variations in pitch and loudness match for tinnitus, subjective general tinnitus intensity and annoyance improvement was reported by 10 participants treated with osteopathic manipulation and 12 subjects treated with InterX®. 2 patients in the osteopathic group reported an increase in tinnitus annoyance. Improvement of somatic pain, muscle contraction or headache was reported by 36 subjects (90%).

Modulation of tinnitus

During initial clinical evaluation painful trigger points or muscle contraction in suboccipital region, neck, upper back, shoulders or TMJ were found in 33 (82,5%) of the tinnitus participants and in 18 (45%) of the controls.

Variations in tinnitus intensity were reported by 36 subjects (90%), while a variation of tinnitus frequency was reported by 15 participants (37.5%). Extensive jaw opening changed tinnitus intensity in 27.5% (11 subjects), while in 7.5% (3 subjects) of cases this action modulated tinnitus frequency. Tinnitus loudness changed also with chin protrusion in 30% of the subjects (12) while only 7.5 % (3) subjects reported changes in tinnitus frequency. 7.5% of the participants (3) had changes in tinnitus intensity while 2.5% (1 subject) reported frequency modulation with pressure on suboccipital trigger points. 5% of the subjects (2) had changes in tinnitus intensity with pressure on neck trigger points. In 12.5% of the subjects (5) tinnitus intensity and in 5% (2 subjects) tinnitus frequency varied with head rotations. In 5% of the subjects (2) tinnitus intensity and in 2.5% (1 subject) tinnitus frequency varied with rotations of the shoulders.

The greatest discomfort caused by tinnitus was associated with the following problems: loss of concentration (10 subjects, 25%); fears about tinnitus being a sign of some serious illness not yet diagnosed (8 subjects, 20%); feeling of a never-ending bother (8 subjects, 20%); anxiety and stress (6 subjects, 15%); tinnitus being responsible for sleeping sickness (5 subjects, 12.5%) or cause of increased hearing problems (3 subjects, 7.5%). 13 individuals (32.5%) had been treated with anxiolytic or antidepressant medications in the past as a consequence of sleeping disorders, increased anxiety/stress, or changes in their moods, all associated with tinnitus onset, but these medications were stopped 1 month prior to the enrolment in the study.

Among controls, only one subject declared regular use of benzodiazepines for sleep problem, and another one reported an incidental use in situations of particular distress in working environment.

Postural evaluation

In all examined tests (open eyes, closed eyes, clenched teeth, open mouth, head extended backwards), the average pre-treatment oscillation envelope areas were significantly greater in tinnitus subjects ($P \leq 0.05$), compared with controls (Figure 2).

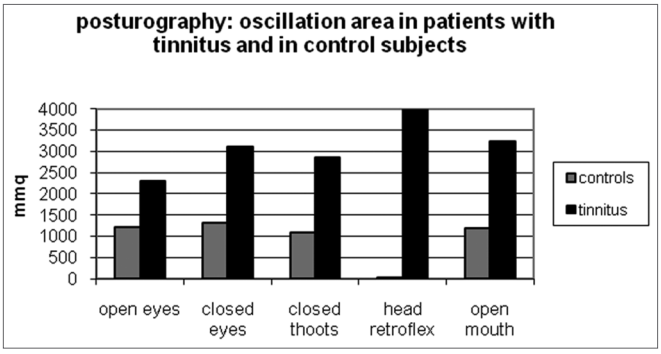

Figure 2. Oscillating areas at posturography in tinnitus participants and control subjects.

The post-treatment average oscillation envelope areas diminished in individual subjects but did not overall vary significantly in both treatment groups: InterX® or osteopathic.

THI questionnaire

The pre-treatment THI scores ranged between 14 and 98 points (average 51.4) The average pre-treatment THI scores did not differ between the two treatment groups. Both treatments were associated with a significant decrease of the THI score ($P \leq 0.05$).

For the InterX® patients, the average THI index decreased by 15.1 points (–27%; $P < 0.0007$), whereas the average reduction after ostheopatic manipulation was of 8.5 points (–16.2%; $P < 0.037$).

Visual Analogue Scale (VAS) scoring

All participants were asked pre and post-treatment to quantify, with subjective percent rates: the intensity of tinnitus, the time of awareness of tinnitus during the day; the time of annoyance during the day; the degree of tinnitus annoyance and the effect on perceived quality of life. The average scoring of the perceived intensity did not decrease significantly for the osteopathic manipulation group (0.45 average points) while decreased by 1.45

points in the InterX group (P<0.006). The average decrease in awareness was 11 points in the ostheopatic manipulation group (P<0.06) and 25.3 points in the InterX® group (P<0.003). The time during which the participants were bothered by their tinnitus decreased by 9.75 points in the ostheopatic manipulation group (P<0.038) and by 20.25 points in the InterX® group (P<0,006). The degree of annoyance was scarcely significantly reduced after osteopathic treatment (1.4 points; P<0.3), while in the InterX® group it was significantly reduced by 2.2 points (P<0.0003). The perceived quality of life did not change after osteopathic treatment (P<0.25) while it improved after InterX® treatment (2.4 points reduction; P<0.0006).

DISCUSSION

In our population, tinnitus subjects presented a much higher prevalence of musculoskeletal strain and contraction compared with non-tinnitus individuals. This may account for the subjective improvement in tinnitus annoyance and discomfort obtained after physical treatment. This was more evident after transcutaneous electrical stimulation with the dynamic system InterX® compared with manual osteopathic manipulations.

Since the early 1980s, transcutaneous electrical nerve stimulation (TENS), have been reported for pain relief in humans[33-39] as well as in experimental animals[40,41] and tinnitus has many similarities with central neuropathic pain[42-44].

InterX® could be a more appropriate device for TENS stimulation in tinnitus subjects since it dynamically adapt the stimulation to the electrical potential of the skin automatically measured by the InterX® while delivering the stimulation. In fact, for traditional TENS there is no definite agreement with regards on the benefit on tinnitus and this could be influenced by the parameters used for the stimulation or the difference mechanisms generating tinnitus in different subjects.

Kapkin and colleagues[24] reported a rate of tinnitus worsening after TENS therapy of 16.6% (7/42) with 42.8% (6/14) in the placebo and the rate of improvement after therapy was 42.8% (18/42). However, an improvement was seen in 28.5% (4/14) of the controls. This is in agreement with other studies that showed electrical stimulation of the median nerve at the wrist could cause tinnitus to increase in some individuals and decrease in others[27], therefore the protocol of stimulation sequence could greatly influence the results and a dynamic adaptation of the stimulation could be more effective in treating tinnitus. In fact, Herráiz and colleagues[22] report improvement of tinnitus in 46% of their sample of 26 individuals with tinnitus receiving 2 hours treatment daily (alternated stimuli, 150 pps, pd 10 micorsec, 0-60 mA amplitude, mean amplitude 27 mA) for 10 days. If tinnitus was intermittent and not associated with other symptoms, results were more consistent underlying the importance of identifying tinnitus sufferers having some clinical clues to somatic influence on tinnitus such as painful trigger points and modulation of tinnitus with head and neck or jaw movements that could benefit from the physical treatment. Also, locating the electrodes in certain fixed positions (e.g. C2) can affect tinnitus only in a small group of subjects[45].

In our sample, somatic modulation of tinnitus was quite common (82,5%) and therefore the physical treatments could be an option to consider in most subjects.

In a study by Aydemir and colleagues[21], after TENS treatment the subjective improvement of tinnitus measured by VAS scale was only marginally significant ($p = 0.059$). However, after electrical stimulation, there was statistically significant improvement regarding tinnitus severity scores, tinnitus handicap inventory scores, NHP fatigue, social isolation, and emotional problems scores. Also, many parameters were measured by the SF-36 ($p < 0.05$), such as physical functioning, general health, vitality, social functioning, role limitations due to emotional problems, and mental health. Since tinnitus is often associated to other complaints, physical treatments could be useful to reduce these other accompanying symptoms because other aspects other than tinnitus may improve with the physical treatment generating a better coping attitude and improved quality of life.

Also, tinnitus can be triggered or modulated by various afferences of the sensitive or somatic system such as skin stimulation[46], gaze[47,48] or speech[49]. Therefore, specific exercise or physical treatments can be effective at least in some cases. Also, manipulative treatments can be used in responsive tinnitus subjects such as those with painful trigger points[11].

Although in our study the efficacy in reducing tinnitus annoyance was less significant after osteopathic treatment compared to the InterX® group, a benefit was evident in some individuals. More research is needed to identify the characteristics of potential responses. Many of the manipulative treatments used for musculoskeletal disorders such as chiropractic manipulations, osteopathy, and massages may be considered in tinnitus treatment not only in patients with somatic tinnitus, but also in subjects presenting other associated symptoms (insomnia, irritability etc.) since these therapies may elicit reflex which have effects on non-musculoskeletal symptoms.

In published data, chiropractic manipulations are used mainly for musculoskeletal disorders, but improvements of non-musculoskeletal symptoms after chiropractic manipulations have been described to occur in 2% to 10% of all patients treated and by 3% to 27% of those who complained to have non-musculoskeletal problems[29,30]. The success of spinal manipulative therapy, particularly

of the atlanto-occipital joint, can be up to 82% of patients with dizziness (46% total relief, 36% high improvement). In contrast, only 10% of patients with tinnitus showed an improvement according to one study ($P<0.001$)[20].

In some cases cervical problems, such as cervical degeneration or cervical instability, can present with symptoms mimicking Ménière's disease: dizziness, fluctuating hearing loss, and tinnitus[18,19,31]. Cervical problems in the generation of tinnitus should be taken into account, especially in the elderly with a later onset of symptoms.

The use of osteopathy could be especially useful in somatic tinnitus especially when postural asymmetry is present, but also in individuals with tinnitus that mimics chronic pain since osteopathic treatment can interfere with the mechanisms of modulation of pain[50].

Osteopathic manipulative medicine is an approach to patient care that incorporates diagnostic and therapeutic strategies to address body unity issues, enhance homeostatic mechanisms, and maximize structure-function interrelationships[50]. Too little is known on the applications of such treatments in tinnitus, but given the prevalence of somatic modulation on tinnitus it would be important to further explore these possibilities.

CONCLUSIONS

These preliminary results confirm that somatic modulation of tinnitus is a very common finding as demonstrated by other authors. Physical treatments allow improving not only muscle contraction and pain of upper back and neck somatic muscles, but they can be used to significantly reduce tinnitus annoyance. The choice of treatment may influence the rate of success and it is therefore important to evaluate different methodologies to possibly point out the most effective in different tinnitus individuals, for example dynamic transcutaneous stimulation may be more effective than the classical TENS static applications. Also duration of treatment may change its effectiveness in chronic tinnitus subjects.

Differences in postural control were found between tinnitus sufferers and controls, but further studies are needed to better understand the possible patophysiological mechanisms underlying these differences and to use the posturography analysis to identify or monitor changes in somatic tinnitus.

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