EFFECTS OF TINNITUS ON POSTURAL CONTROL AND STABILIZATION: A PILOT STUDY

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ABSTRACT

Introduction: *The aim of this study was to evaluate the tinnitus's impacts on postural control.*

Material and methods: *Sixty-six subjects (age: 46,71 ± 15,12 years, height 166,32 ± 8,88 cm, weight 64,85 ± 12,57 kg) with idiopathic tinnitus were recruited for the study and were tested. Each subject underwent to 'Romberg test', 'Static balance' and 'posture analysis'. Static balance and posture analysis were performed two times, with open and close eyes, and were measured through the FreeMed posturography system.*

Results: *showed that subjects had worse Baropodometric performances respect to benchmarks; moreover according to literature the results show that these patients had significant differences between open eyes and closed eyes conditions on total length ($p < 0.0001$), on absolute Root Mean Square ($p < 0.0001$), on x Root Mean Square ($p < 0,05$) and on y Root Mean Square ($p < 0.0001$) confirming that vision signals provide better stability. However this pilot study evidences that tinnitus population had a poor postural control probably due to tinnitus that is negatively affecting the subject's postures.*

Conclusion: *our results seem to confirm that tinnitus, as negatively influences auditory perception, also could damage balance. Further studies are necessary to confirm this pilot.*

Key words: *Tinnitus, Speech motor control, Balance*

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Introduction

Involving an high percentage (ranging from 10 to 25%) of the general population, tinnitus is a common symptom associated to different pathologies and defined as "perception of a sound which results exclusively from activity within the nervous system without any corresponding mechanical, vibratory activity within the cochlea"[(1)].

In Italy an epidemiologic study based on questions to general population upon auditory dysfunctions evidenced a tinnitus prevalence percentage in 14.5% (8% in normal hearing subjects, 30.5% in presence of auditory dysfunctions)[(2,3)], but the incidence increases to 70-85% among hearing-impaired patients[(4-10)].

In most cases, despite appropriate medical examination, the origin of tinnitus remains unknown but it is well reported in literature that tinnitus and hearing impairment are often associated; either sensorineural hearing loss (SNHL) as well as acoustic trauma are considered the main causes of tinnitus. Tinnitus can be associated to other inner ear dysfunctions like sudden hearing loss and it can be also a part of otological and neurological diseases such as Meniere's disease, conductive hearing loss, acoustic neuroma or severe head injury[(11-17)].

Other etiological factors have emerged from the widest epidemiological studies of tinnitus prevalence and actually they were considered as potential causes of tinnitus and/or cofactors.

As reported by Hoffman these factors include frequent conditions such as vascular disease, diabetes, hypertension, autoimmune disorders and degenerative neural disorders[5,15,17-19]. Therefore tinnitus can be associated to abnormal posture.

Postural stabilization is based on multiple sources of information namely, somatosensory, proprioceptive, vestibular, visual, oculomotor, and auditory[20,21]. The correct posture is provided if data sourced from the periphery are concordant; in presence of an impaired periphery source (i.e.: vestibular system), to maintain the equilibrium another periphery source improves its activity (postural compensation). Because of tinnitus is strictly correlated to cochlear dysfunction also in presence of a normal hearing, it is reasonable to think that tinnitus could negative influencing postural control; in this view the informations coming from visual and oculomotor systems could better balance in tinnitus subjects.

To date numerous studies have been conducted using static stabilometry to evaluate the influence of the stomatognathic system on postural control[22-24], but there are no date between the role of visual and oculomotor systems among tinnitus subjects. The aim of this pilot study was to evaluate the tinnitus's impacts on the quality of postural control and the influence in stabilization of visual and oculomotor systems (either with open and closed eyes) in tinnitus subjects.

Material and methods

Sixty-six subjects affected by tinnitus who were referred to the Audiology Section of the Palermo University were enrolled to the study. The cohort (mean age: 46,71 ± 15,12 years, mean height 166,32 ± 8,88 cm and, mean weight 64,85 ± 12,57 kg), consisted of 40 females and 26 males (Table 1). The study protocol was completely explained to patients and written informed consent was obtained from each subject. The study design was approved by the Palermo University Human Research Ethics Committee. Exclusion criteria included presence of neuropsychomotor or systemic or rheumatologic diseases and to be or have been undergone to physical therapy, speech therapy, or orthodontics treatment (for less than 6 months); pain complaint in the lower limbs; labyrinth diseases; squint; trauma or malformation in the cervical and facial regions; and use of analgesic, anti-inflammatory, or muscular relaxants or antidepressive medicine.

The anthropometric characteristics of all participants were collected; particularly height and weight were measured through a stadiometer (Seca 22 ± 1 mm approximation, Hamburg, Germany. Each subject underwent to Romberg test maintaining an upright and standardized Romberg position (feet placed side-by-side forming an angle of 30° with both heels separated by 4cm)[18,19]. During all posturography test, the subjects were required to open eyes (OE) during the first analysis and to closed eyes (CE) during the second analysis; for our purposes, we compared both conditions: eyes open versus eyes closed, respectively. The data collected were converted in accordance with instructions provided by the manufacturer and, finally, transformed into coordinates of the center of pressure (CoP). The following parameters of the statokinesigram were considered: total length of the recording in mm (L), pressure centre coordinates on the frontal (X; right-left) (Xmean) and sagittal (Y; forward-backward) (Ymean) areas and parameters related to the temporal variability on axis antero-posterior and lateral average (Root Mean Square/ Absolute RMS; xRMS; yRMS). Static balance and posture analysis were measured using the FreeMed posturography system. This platform develops a sampling frequency up to 400Hz in real time. The sensors, coated with 24K gold, guarantee repeatability and reliability of the instrument (produced by Sensor Medica, Guidonia Montecelio, Roma). The equipment contained the Freestep software (by Sensor Medica) and, Bipedal Stabilometry. A Freemed baropodometric platform and Free- Step v.1.0.3 software were used to measure stabilometric parameters. The platform's surface was 555 x 420 mm, with an active surface of 400 x 400 mm and 8-mm thickness. Normal parameters were considered: a total length raging between 307 and 599 mm; a X mean value raging between -10 and +12 mm and, a Y mean value raging between - 40 and - 29 mm. All subjects were asked to stand on both feet over the baropodometric platform for 51.2 seconds.

Statistical analysis was performed through StatSoft's STATISTICA software (Windows, Vers. 8.0; Tulsa, OK); paired t-test ($P<0.05$) was used to detect differences between open eyes and close eyes performances.

Results

Baropodometric performance results of tinnitus cohort evidenced significant differences respect to normal parameters relative to total length mean value and Y mean value, while X mean value was superimposable with benchmarks. The higher mean values of tinnitus cohort corresponding to poor performances evidenced a postural control alteration in these subjects.

Moreover inside the cohort the performance in OE condition were significantly lower compared with those in CE condition (Table 1 and Figures 1, 2, 3 and 4). Total length mean value (L) with open eyes (L-OE) was 701,4 ± 239,2 mm respect to 772,1 ± 257,1 mm in closed eyes condition (L-CE) with statistical significant difference ($p < 0.0001$).

	OE	CE	P values
L (mm)	701,4 ± 239,9	772,1 ± 257,1	0.0001
X mean (mm)	9,71 ± 11,34	10,41 ± 11,87	ns
Y mean (mm)	11,13 ± 11,14	12,60 ± 13,96	ns
Absolute RMS (mm)	0,62 ± 0,20	0,69 ± 0,24	0.0001
xRMS (mm)	0,37 ± 0,11	0,39 ± 0,14	0.05
yRMS (mm)	0,49 ± 0,18	0,56 ± 0,29	0.0001

Table 1: Posturography parameters relative to opened (OE) and closed (CE) condition.

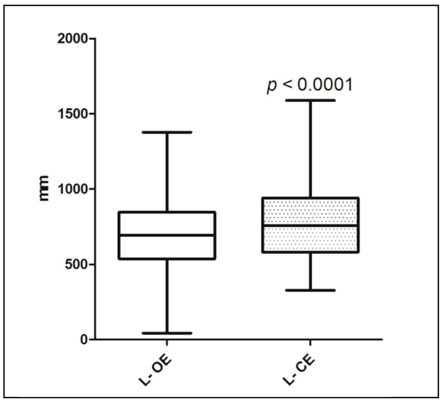

Figure 1: total length (L) relative to opened (OE) and closed (CE) condition.

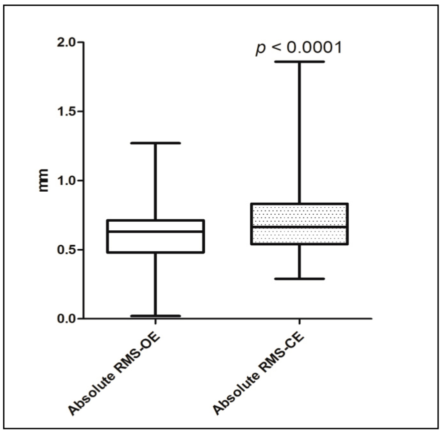

Figure 2: Absolute Root Mean Square (RMS) relative to opened (OE) and closed (CE) condition.

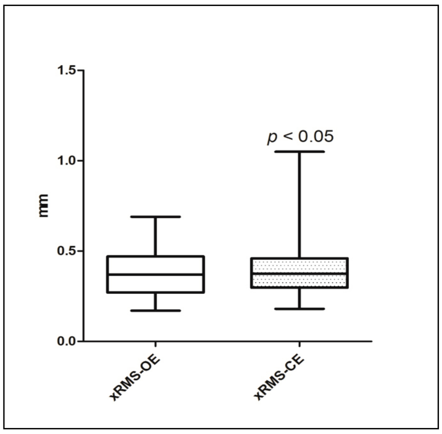

Figure 3: The figure is showing the parameters related to the temporal variability on axis anteroposterior (xRMS) relative to opened (OE) and closed (CE) condition.

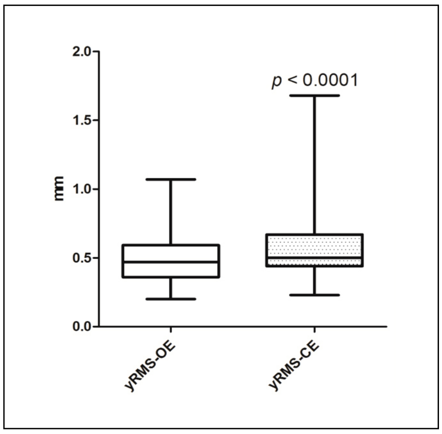

Figure 4: The figure is showing the parameters related to the temporal variability on axis lateral average (yRMS) relative to opened (OE) and closed (CE) condition.

Root Mean Square resulted 0,62 ± 0,20 mm and 0,69 ± 0,24 mm respectively for open eyes (Absolute RMS-OE) and closed eyes (Absolute RMS-CE) with significant difference ($p < 0.0001$). Also the study of X Root Mean Square (0,37 ± 0,11mm for xRMS-OE and 0,39 ± 0,14 mm for xRMS-CE) and of Y Root Mean Square (0,49 ± 0,18 mm for yRMS-OE and 0,55 ± 0,23 mm for yRMS-CE) showed statistical significant difference ($p < 0.05$).

No statistical differences were evidenced in tinnitus cohort among the OE and CE conditions relative to pressure centre on the frontal (X mean) and sagittal plane (Ymean): Xmean results were: Xmean - OE: 9,71 ± 11,34 mm; Xmean - CE: 10,41 ± 11,87 mm ($p>0,05$); Y mean results were Ymean - OE: 11,13 ± 11,14 mm; Ymean 12,60 ± 13,96 mm ($p>0.05$). Finally the performances between the genders showed no significant difference ($p>0.05$).

Discussion

In this pilot study we assessed stabilometric parameters of patients, affered to Audiology Section of Palermo University, with complaints of tinnitus with the purpose to study the influence of tinnitus on body balance and the visual sensorial interactions (opened and closed eyes) through posturography. Posturography is a technique that study posture and informs us about the vestibular-spinal function and the compensation reached at this level by any damage to the balance system (i.e. cochlear dysfunction), regardless of what happens in other levels.

Stabilometry assesses posture balance through the quantification of posture oscillations from the orthostatic position in a force platform. It involves monitoring of pressure centers (CoP) displacement to the lateral (or frontal) direction (X) and anterior-posterior (sagittal) direction (Y). Our results evidenced that overall tinnitus patients presented instability in the orthostatic position in relation to reference parameters. It is confirmed by Matsushima who found that tinnitus represents a factor in increasing unsteadiness in people because of cochlear dysfunction(28).

Another aspect that we took into account during the assessment was the effect of visual deprivation. It is expected that subjects with tinnitus and cochlear dysfunction have more visual dependency and therefore, upon closing their eyes, they present more affections in their stabilometric parameters. All postural parameters in fact were significantly lower for the eyes opened condition as opposed to the eyes closed condition (Romberg test). These results confirm that vision signals provide better stability in tinnitus subjects, as showed by Kapoula and Le in 2006 and by Bianco in 2014(29,30). Importantly, we found significant difference in the parameters concerning the total length and related to the temporal variability on axis antero-posterior and lateral-average.

Moreover, we found differences in pressure centre coordinates on the frontal and sagittal areas although no significant. However, we wondered how much these results were influenced by tinnitus and how much by stress that it caused to the subject. Emotional responses play a part in motor integration, hyperactive tendon reflexes were found in anxious patients probably caused by an increased discharge of gamma efference and, in addition, there may be stiffness of muscles around the neck and shoulders caused by the increased sympathetic nerve tone(31,32).

Further studies are necessary to make conclusions on this matter. Matsushima et al. showed as reducing the increased sympathetic nerve tone and anxiety improved muscle stiffness, eventually improving static balance(28). They analyzed the effects of electrical stimulation in subjects with tinnitus. They showed that the parasympathetic nerve tone became predominant after electrical stimulation and it promote also the decrease of the previous increased sympathetic nerve tone and the anxiety muscle stiffness(33,34).

Moreover, the influence of tinnitus on postural control might be mediated via activation of the vestibular system. In 2006, Alessandrini et al. showed a significant increase, in presence of stimulus, of body sway at low and middle frequencies on the lateral plane and in the closed-eyes condition(35). Nevertheless, Kapoula, Z et al. in 2001 confirmed the our conclusions(36); his cohort showed a worsening in close eyes condition. Even Kapoula support the hypothesis that the influence of tinnitus on postural control might be explained through the stimulation of the vestibular system caused by the tinnitus itself. In 2010, Amanda, B. et al described the effects of electrical stimulation and the manual osteopathic therapy in 40 subjects(37). Two months later, all subjects showed tinnitus improved and quality of life was overall perceived as improved. In conclusion our results are in accordance with the literature; the tinnitus negatively influences the balance. Nevertheless, it is unclear whether the common tinnitus treatments are acting on posture. The study is a preliminary study and it is work in progress. Currently there is no control group and this is the principal limit of study but the preliminary results are very attractive. Future studies are necessary to confirm this pilot.

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