Cognitive Evaluation and Quality of Life Assessment in Patients with Subjective Tinnitus

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Abstract

Purpose: To investigate the effects of subjective tinnitus on cognitive functions.

Methods: There were 15 patients (10 bilateral, 5 unilateral) with tinnitus who were non-psychiatric in the study group. There were 14 controls (28 ears of them) that were healthy, non-psychiatric and did not have tinnitus. We used questionnaire form; Hospital Anxiety and Depression Scale (HAD); The SF-36 Health Survey; and the Montreal Cognitive Assessment (MoCA) test to evaluate cognitive functions of the subjects.

Results: In tinnitus patients, all HAD results (HAD-depression, HAD-anxiety and HAD-total) were insignificantly higher; and all SF-36 items were lower than the control group. In tinnitus group, MoCA scores (mean: 22.28 ± 3.90) were significantly lower then the control group (mean = 26.07 ± 1.74). In tinnitus group, higher MoCA scores were related to increased role limitations due to emotional problems (RE) and physical functioning (PF) values. As subjective tinnitus loudness level (STLL) values increased, HAD-Anxiety values increased and social functioning (SF) values were decreased. In well educated tinnitus patients, MoCA scores found significantly increased. Better Quality of life (QoL) results were found with better MoCA scores. The most important SF-36 items were PF, RE and social functioning (SF).

Conclusion: Subjective tinnitus had negative impact not only in quality of life, but also in cognitive function of the patients.

Key Words: Subjective tinnitus, Cognition, the SF-36 Health Survey, Hospital Anxiety and Depression Scale (HAD), the Montreal Cognitive Assessment (MoCA)

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INTRODUCTION

Tinnitus is an auditory phantom sensation. Approximately 2% of the people have tinnitus which affects their quality of lives (QoLs). Pain, sleep problems and depression were reported more in females with tinnitus[1]. In the brain, there are stuctural changes in thalamus, nucleus accumbens[2], inferior colliculus[3] and Heschl's gyrus medial part (mHG)[4].

Tinnitus severity and perception of it may depend on psychological factors[5], such as depression and anxiety[6]. Ooms, et al. reported that tinnitus patients had medium state and trait anxiety scores[7]. This shows their anxious reaction to the tinnitus. In Erlandsson and Archer's study[8], they reported that anxiety is an important factor for the tinnitus tolerance.

In the present study, we aimed to investigate the cognitive status of the tinnitus patients via Montreal Cognitive Assessment (MoCA) which had not used to evaluate cognition in patients with tinnitus[9]. Moreover, Quality of Life (QoL) assessment was also performed by SF-36 Health Survey[10,11]. We thought that the tinnitus noise may affect the mood of the tinnitus patients negatively, therefore we also applied the Hospital Anxiety and Depression Scale (HAD)[12-14].

MATERIALS AND METHOD

This retrospective study was conducted in the Neurology and Otorhinolaryngology Departments of Kirikkale University; and Otorhinolaryngology Department of Kirikkale "Yüksek İhtisas" Hospital. Ethics committee approval was taken from Adana Numune Hospital (Date: October, 23, 2014. No: ANEAH.EK. 2014/55). This study was continued according to the Declaration of Helsinki.

Subjects

The subjective tinnitus group (study group) was consisted of patients who attended to the Otorhinolaryngology Department. There were 12 patients (10 bilateral, 5 unilateral) who were non-psychiatric. 14 of the patients were male and one of them was female. In the control group, there were 14 subjects with normal hearing levels (13 male and 1 female) who did not have tinnitus and were non-psychiatric. All patients underwent ear, nose and throat examinations, and their medical histories were reviewed.

Patients with tinnitus were included into the study only if the results of their ear nose and throat examinations were normal.

In both groups, there was no history of acoustic trauma, head trauma, ear infection, diagnosed psychiatric diseases, obstructive sleep apnea; or diagnosed neurological diseases, such as Multiple sclerosis, dementia, cranial tumors.

We used questionnaire, HAD scale, SF-36 and MoCA to evaluate cognitive functions of the patients. In this study, we used HAD Scale[12-14] to evaluate the emotional conditions of the patients with subjective tinnitus. The SF-36 Health Survey[10,11] was used to investigate the QoLs of the patients. The Montreal Cognitive Assessment (MoCA) test was applied to evaluate the cognitive functions[9].

All data was obtained as a retrospective manner.

Instrumentation

1. **Questionnaire for tinnitus:** For tinnitus severity, the questionnaire was asked to the patients. This form was based on a questionnaire of American Tinnitus Association. For the assessment of subjective tinnitus loudness level (STLL), the patients reported their tinnitus severity as "very quiet: 0-2, intermediate loudness: 3-7, very loud: 8-10 on 10 point scale[15]. The results were assessed as STLL; and tinnitus grade (1: Very mild, 2: Intermediate loudness, 3: Very loud).
2. **Audiological examination:** All patients were evaluated with 0.125 to 8.0 kHz audiological examination by AC-40 Audiometer (Interacoustics, Assens, Denmark). Air and bone hearing thresholds were detected. American National Standards Institute (ANSI-1969) standards were used[16].
3. **HAD scale:** It was used to determine anxiety and depression levels of the patients. In this scale, there was 14 items related to anxiety (7 items) and depression (7 items)[12]. Scores of each item were between 0 and 3; and a total score was between 0 and 21. Cut-off point was 8/21 for anxiety and depression[13].
4. **SF-36:** In this health survey, there were 8 domains (health concepts). In each of the domains, there were questions[10,11]. The SF-36 assesses eight health

concepts: Ten items in physical functioning (PF), 4 items in role limitations due to physical problems (RP), 2 items in social functioning (SF), 2 items in bodily pain (BP), 5 items in mental health (MH), 3 items in role limitations due to emotional problems (RE), 4 items in vitality (VT) and 6 items in general health perceptions (GH). Each items were scored between 0 to 100. Lower scores showed greater limitations in functions. After detailed information, the subjects filled the form.

5. **MoCA:** It is rapid screening instrument for mild cognitive dysfunction. Attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculation and orientation were assessed. In the MoCA test, the total score can be 30 points; and the score of ≥ 26 is normal[9].

Ear nose throat examination was performed in both groups. Questionnaire form for tinnitus severity was filled by the study group. All subjects in the study were applied HAD scale and MoCA; and mental health were evaluated. By SF-36, Ouality of lives of the subjects were evaluated.

Statistical analysis: Statistical Package for the Social Sciences (SPSS) Version 16.0 (SPSS Inc., Chicago, IL, USA) was used. Mann Whitney U test, Spearman's correlation rho efficient test and Linear Regression Analysis (Backward) were used. A p value < 0.05 was accepted as statistically significant.

Results

STLL was 4.8 ± 2.3 (Range 1.00 to 9.00) and tinnitus duration was 5.4 ± 8.3 years in the study group (Group 1).

Demographic features, smoking and alcohol consumptions of Group 1 and 2 were demonstrated on Table 1. Pure tone audiometry results of the groups were shown on Figure 1. The difference between tinnitus and control group was statistically significant at 4.0 kHz-air ($p = 0.005$), 8.0 kHz-air ($p = 0.004$), 2.0 kHz-bone ($p = 0.002$) and 4.0 kHz-bone ($p = 0.002$). In the other frequencies of air and bone hearing thresholds, there were no significant differences (all $p > 0.05$).

MoCA score in the tinnitus group was 22.28 ± 3.90 (Ranged 16.00 to 30.00). In the control group, it was 26.07 ± 1.74 (ranged 23.00 to 28.00). The difference was found to be statistically significant (Mann Whitney U Test) ($p < 0.001$).

Table 1. Demographics of Group 1 and 2

		Group 1		Group 2		p	X2
		n	%	n	%		
Gender	Male	23	92.0	26	92.9	0.906	0.014
	Female	2	8.0	2	7.1		
Education	Primary school	11	44.0	14	50.0	0.270	1.219
	Secondary school	9	36.0	10	35.7		
	High school	1	4.0	4	14.3		
	University	4	7.5	0	0.0		
Active Hand	Right handed	24	96.0	26	92.9	0.624	0.240
	Left handed	1	4.0	2	7.1		
Smoking	Yes	7	28.0	12	42.9	0.401	0.704
	No	18	72.0	16	57.1		
Alcohol Consumption	Yes	2	8.0	4	14.3	0.475	0.510
	No	23	92.0	24	85.7		
Frequency of Alcohol consumption	1/week	0	0.0	4	100.0	0.025	5.000
	2-3/week	2	100.0	0	0.0		

	Mean	Std. Dev.	Mean	Std.Dev.	p
Age	49.8	6.0	47.4	4.8	0.231
BMI	27.6	2.24	29.2	4.2	0.011
Alcohol consumption-duration (years)	10.0	0.0	15.0	5.7	0.264

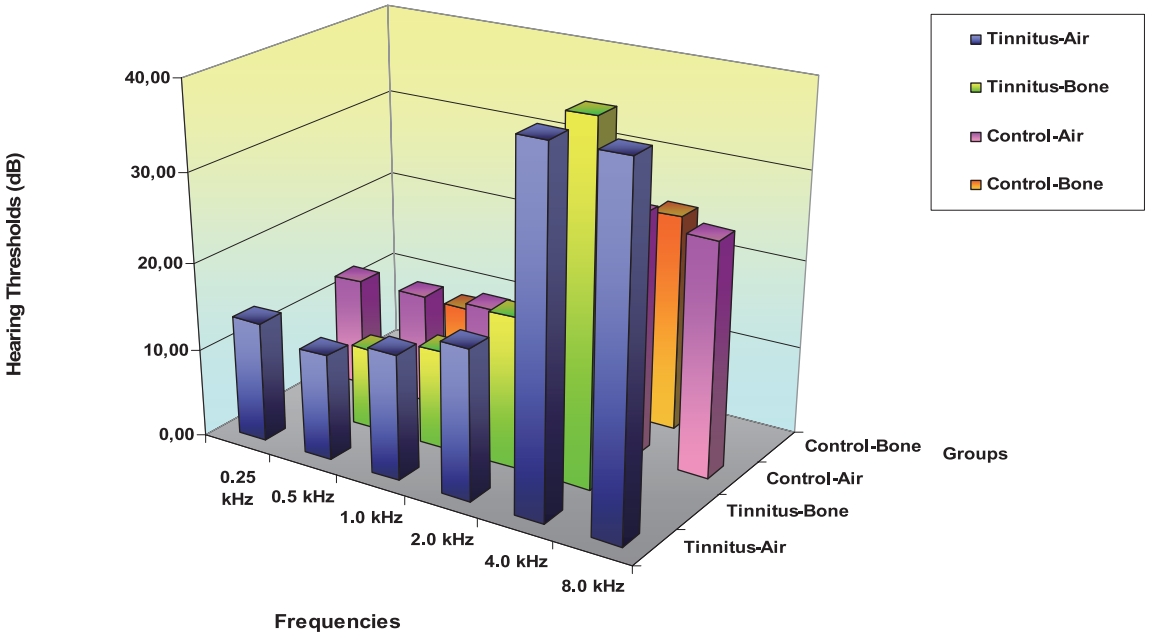

Figure 1: Pure tone audiometry results

The difference between Tinnitus and control group was statistically significant at 4.0 kHz-air (p=0.005), 8.0 kHz-air (p=0.004), 2.0 kHz-bone (p=0.002) and 4.0 kHz-bone (p=0.002).

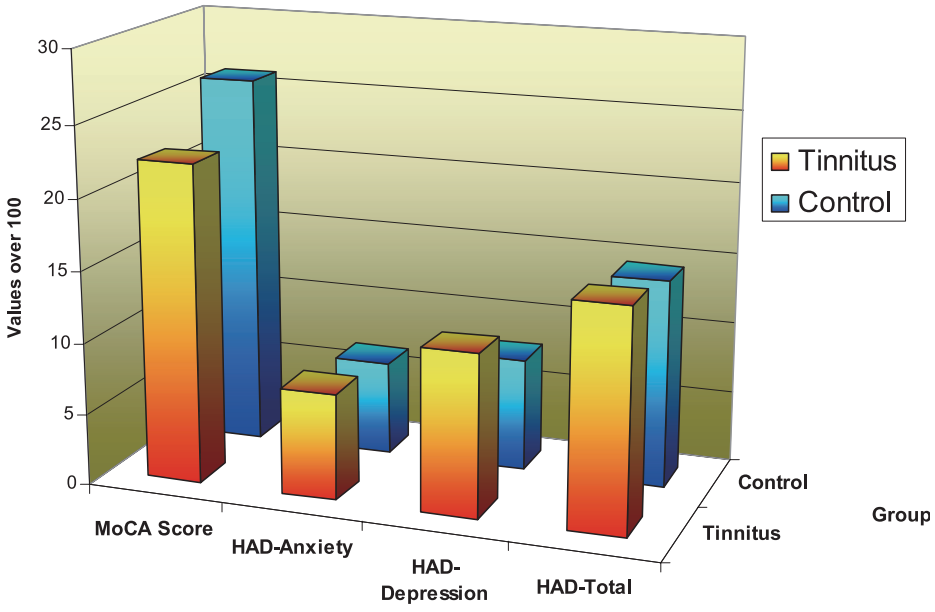

Figure 2: HAD and MoCA results of the Tinnitus and control groups¶

*By Mann Whitney U Test, the difference of MoCA values between the Tinnitus and control groups was statistically significant (p=0.000).

SF-36 result of the study groups were shown on Table 1 and Figure 2. There were significant differences for all SF-36 items ($p < 0.05$).

In tinnitus group, all HAD results (HAD-depression, HAD-anxiety and HAD-total) were found to be numerically higher than those of the control group ($p > 0.05$). HAD results were demonstrated in Table 2. In the tinnitus group, HAD-depression values were higher than the cut-off value of 8 (Table 2).

Correlations for MoCA Scores, HAD-results and SF-36 items in the tinnitus group were analyzed by Spearman's correlation rho efficient test:

- Gender: In males, mean MoCA Score was higher, HAD-Anxiety score was lower than females. "Physical functioning", "role limitations due to physical problems", "emotional problems", "vitality" values of SF-36 Health Survey were higher, and "mental health" values was lower than females ($p < 0.05$).
- Age: In older tinnitus patients, "Physical functioning", and "role limitations due to physical problems" values increased ($p < 0.05$). There was a significant positive correlation between older age and "Physical functioning", and "role limitations due to physical problems" values ($p < 0.05$).
- Education: Education; and "role limitations due to physical problems" and "emotional problems" values increased together ($p < 0.05$). Higher educational status was positively correlated with "role limitations due to physical problems" and "emotional problems" values ($p < 0.05$).
- BMI: In tinnitus patients, BMI increase was related to increased HAD-Anxiety values and decreased "emotional problems" values ($p < 0.05$).
- Features for tinnitus: As STLL values increased, HAD-Anxiety values increased and "social functioning" scores decreased ($p < 0.05$). As Tinnitus grade values increased, "social functioning" values decreased ($p < 0.05$).
- Brinkman Index: As Brinkman Index values increased, "physical functioning", "role limitations due to physical problems" and "emotional problems" values increased. Whereas, no significant correlation was detected for smoking (Yes or No) results ($p > 0.05$).
- Alcohol consumption: As alcohol consumption was present, HAD-Anxiety values increased ($p < 0.05$).
- MoCA Scores: As MoCA Scores increased in tinnitus group, "physical functioning" and "emotional problems" values also increased ($p < 0.05$).

Table 2: Age, MoCA Score, HAD results and SF-36 Health Survey Results of Group 1 and 2*

	Groups								
	Group 1 (Study)				Group 2 (Control)				p
	Mean	SD	Minimum	Maximum	Mean	SD.	Minimum	Maximum	
Age	49.84	6.07	40.00	59.00	47.42	4.80	36.00	56.00	0.231
MoCA score	22.28	3.90	16.00	30.00	26.07	1.74	23.00	28.00	0.000
HAD results									
HAD-dep	11.32	16.22	3.00	88.00	7.92	4.20	3.00	17.00	0.299
HAD-anx	7.44	2.70	0.00	11.00	6.57	3.82	3.00	18.00	0.052
HAD-total	15.56	4.86	5.00	22.00	14.50	7.10	7.00	35.00	0.138
SF-36 Items									
PF	87.40	15.41	50.00	100.00	99.28	1.78	95.00	100.00	0.000
RP	66.00	42.62	0.00	100.00	100.00	0.00	100.00	100.00	0.000
SF	78.50	16.34	50.00	100.00	98.21	6.55	75.00	100.00	0.000
BP	59.60	22.43	22.50	100.00	92.67	8.41	77.50	100.00	0.000
MH	57.60	19.21	20.00	100.00	85.42	18.64	40.00	100.00	0.000
RE	77.32	36.92	0.00	100.00	96.42	13.11	50.00	100.00	0.012
VT	57.20	19.52	20.00	100.00	78.92	18.37	40.00	100.00	0.000
GH	56.30	18.31	25.00	87.50	89.18	9.16	70.80	100.00	0.000

Abbreviations: *SD: Standard deviation, PF: Physical functioning, RP: Role limitations due to physical problems (RP), SF: Social functioning, BP: Bodily pain, MH: General mental health, RE: Role limitations due to emotional problems, VT: Vitality, GH: General health perceptions. p value shows the results of "Mann Whitney U Test".

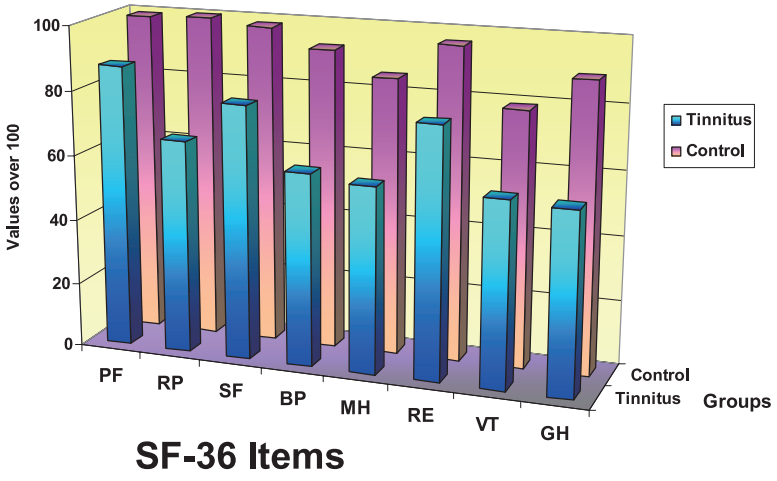

Figure 3: SF-36 Items of the Tinnitus and Control Groups*

*PF: Physical functioning, RP: Role limitations due to physical problems (RP), SF: Social functioning, BP: Bodily pain, MH: General mental health, RE: Role limitations due to emotional problems, VT: Vitality, GH: General health perceptions.

The difference between the Tinnitus and control groups was statistically significant for all SF-36 items by Mann Whitney U Test: PF (p=0.000), RP (p=0.000), SF (p=0.000), BP (p=0.000), MH(p=0.000), RE (p=0.012), VT (p=0.000) and GH (p=0.000).

- HAD results:
  - ✯ As HAD-Depression values increased, HAD-Anxiety and HAD-total values increased; and "social functioning", "bodily pain" and "vitality" values decreased ($p < 0.05$).
  - ✯ As HAD-Anxiety values increased, HAD-Depression and HAD-Total values increased; and "role limitations due to physical problems", "emotional problems", "social functioning", "vitality" and "mental health" values decreased ($p < 0.05$).
  - ✯ As HAD-total values increased, HAD-Depression and HAD-Anxiety values increased; and "bodily pain", "vitality" and "mental health" values decreased ($p < 0.05$).
- SF-36 Health Survey Results:
  - ✯ As GH increased, RP, "vitality" and "mental health" values increased ($p < 0.05$).
  - ✯ As PF increased, MoCA Scores; and "role limitations due to physical problems" and "social functioning" values increased ($p < 0.05$).
  - ✯ As "role limitations due to physical problems" increased, HAD-Anxiety values decreased; and GH, "physical functioning", "emotional problems" and "bodily pain" values increased ($p < 0.05$).
  - ✯ As "emotional problems" increased, MoCA Scores; and "role limitations due to physical problems" values increased; and HAD-Anxiety values decreased ($p < 0.05$).
  - ✯ As "social functioning" increased; HAD-Depression, HAD-anxiety and HAD-total values decreased; and "physical functioning", "bodily pain", "vitality" and "mental health" values increased ($p < 0.05$).
  - ✯ As BP increased, HAD-Depression and HAD-total values decreased; and "role limitations due to physical problems", "social functioning", "vitality" and "mental health" values increased ($p < 0.05$).
  - ✯ As "vitality" increased; HAD-Depression, HAD-anxiety and HAD-total values decreased; and "general health perceptions", "social functioning", "bodily pain" and "mental health" values increased ($p < 0.05$).
  - ✯ As "mental health" increased; HAD-Depression, HAD-anxiety and HAD-total values decreased; and

"general health perceptions", "social functioning", "bodily pain" and "vitality" values increased ($p < 0.05$).

The affects of confounding factors (I-Covarietes*: Education; Active hand; tinnitus duration; STLL; Pure tone Average (PTA), and II- Covariates ¶: HAD-Depression, HAD-Anxiety, HAD-total; and each of the SF-36 items) on MoCA scores were analyzed by Linear Regression Analysis (Backward) in the tinnitus group. This is a step-by step analysis:

I-For Covarietes*:

- In well educated tinnitus patients, MoCA score was higher ($p = 0.000$, $\beta = 0.835$)
- When tinnitus duration was longer, MoCA scores showed an increase ($p = 0.000$, $\beta = 0.465$)
- In left handed tinnitus patients, MoCA score showed a reduction ($p = 0.000$, $\beta = -0.248$)

II-For Covarietes¶:

- As HAD-Anxiety values increased, MoCA score also increased ($p = 0.009$, $\beta = 0.554$)
- When "physical functioning" ($p = 0.025$, $\beta = 0.433$); "emotional problems" ($p = 0.000$, $\beta = 0.816$); and "social functioning" ($p = 0.001$, $\beta = 0.612$) values of SF-36 increased, MoCA score increased.

DISCUSSION

In the present study, subjective tinnitus patients constituted the study group. STLL in tinnitus patients was 4.8 ± 2.3; and tinnitus duration was 5.4 ± 8.3 years. Hearing thresholds of tinnitus group was higher at 4.0 and 8.0 kHz. In tinnitus group, all of HAD results were found to be insignificantly higher than the control group. HAD-depression values of the tinnitus group were higher than the cut-off value of 8. Higher HAD values may be due to psychological distress and problems in tinnitus pathophysiological process. QoLs of tinnitus group also seem to be affected by tinnitus; and All SF-36 items were significantly lower than the control group. The effects of tinnitus on cognitive functions were also investigated. MoCA test was used for evaluation of cognitive functions. In tinnitus group, MoCA score (Mean: 22.28 ± 3.90) was significantly lower then in the control group (Mean = 26.07 ± 1.74). Our tinnitus patients' MoCA scores was lower than the normal range. Lower MoCA test score shows mild cognitive dysfunction due to tinnitus.

Cognitive impairment may be related to brain disorders. Thinking changes are psychological stressor; and insomnia and anorexia are findings of depression-associated cognitive impairment[17]. Hallam, et al[18] mentioned that tinnitus outpatients report significantly more everyday cognitive failures than do controls. According their conclusion, cognitive inefficiency in tinnitus participants is related to the control of attentional processes[18]. Rossiter, et al[19] suggested that tinnitus affects cognition to the extent that it reduces cognitive capacity needed to perform tasks that require voluntary, conscious, effortful, and strategic control. Andersson and McKenna[20] concluded that tinnitus is likely to disrupt cognitive functioning, and there are some indications that tinnitus patients have impaired capacity to perform certain cognitive tasks. Andersson[21] reported that at least 20% of them will report major distress because of tinnitus in the domains of annoyance, insomnia, auditory intrusions, and concentration problems. In tinnitus patients, mHG is found as smaller. In male tinnitus patients, corpus callosum (CC) posterior midbody was also smaller than male controls; and in female tinnitus patients, the anterior midbody, and the genou of CC were larger than female controls. CC function is excitatory. In tinnitus patients, stronger interconnectivity may facilitate a positive feedback between tinnitus generators in two hemispheres[22]. The relationship between tinnitus severity and psychological variables were investigated by researchers. Anxiety is an important factor for the perception of subjective tinnitus severity[7]. In subjects with bothersome tinnitus, deficits in learning rates, immediate recall of heard words and use of serial order encoding strategy were detected[23]. During resting EEG, there was increased functional alpha connectivity between orbitofrontal cortex, insulai subgenual anterior cingulate and parahippocampal (PHC) areas and auditory cortex in females. In males with tinnitus, significant differences were detected in posterior cingulate cortex which may be related to cognitive and memory related aspects of the tinnitus perception[1].

In our study, HAD-Depression values were higher than cut-off values (over than 8) in tinnitus group, but no clinical depression was present. This may be due to tinnitus induced decrease in mood conditions of the patients. As a result, MoCA score was affected and

detected as decreased. In males, MoCA score and SF-36 items were higher; and HAD-Anxiety scores were lower than females. Males generally work outside of home, they expose to the external stimuli from the environment more than females. The effects of tinnitus on psychological and cognitive health; and at the end, on QoLs were not too much in male tinnitus group. Female are more sensational; their spending time out of the home is less than males; and negative effects of tinnitus psychological and cognitive functions may be more in this group.

In older tinnitus patients, "Physical functioning", and "role limitations due to physical problems" values of SF-36 increased. As the time goes on, the patients with tinnitus may be used to live with their tinnitus. In well educated patients, SF-36 items were better. The possible explanation was as more educated people can feel themselves better. They may read more books, they may spend time with internet more; and they may feel pathological tinnitus sounds less.

As STLL values increased, HAD-Anxiety values increased and "social functioning" values decreased. As tinnitus severity values increased, "social functioning" values decreased. Tinnitus severity is more important than existence; and more severe tinnitus leads more disorders in patients.

Alcohol consumption was related to higher HAD-Anxiety values. In people prone to anxiety, alcohol consumption may be more; and when tinnitus is added to the scheme, HAD-anxiety levels rised in these individuals. In our study, higher HAD values were related to lower QoL results. Moreover, increase of the MoCA scores in tinnitus group was related to increased SF-36 items. Higher MoCA scores show better cognitive functions. In these individuals, QoLs were observed as better.

The most relative SF-36 items with MoCA scores significantly were "physical functioning", and "role limitations due to physical problems". The positive correlation was detected between these items of SF-36 and MoCA. It could be stated that better QoLs in tinnitus patients were seen with higher MoCA Scores.

In well educated tinnitus patients, MoCA scores increased. Education level is important for better cognitive functions, even if in tinnitus patients. In longer tinnitus duration, MoCA scores increased. In chronic and long-lasting tinnitus, patients may adapt to their tinnitus and cognitive functions may not be affected negatively. In tinnitus patients with increased HAD-Anxiety values, MoCA score increased. It was thought that increased anxiety might be a stimulating agent for the patient and MoCA score got better.

Better QoL results in SF-36 continued with better MoCA scores. The most important SF-36 items are "physical functioning", "role limitations due to physical problems" and "social functioning". In left handed tinnitus patients, MoCA score decreased; whereas in right-handed ones, MoCA score increased. In right-handed individuals, left hemisphere of brain is dominant which is mainly responsible for intellectual issues.

CONCLUSION

Subjective tinnitus is a chronic disorder and patients' QoLs were affected negatively. These patients are prone to depression and anxiety. MoCA score was also affected and it was lower than the normal limits of 26 over 30 in these patients. In well educated tinnitus patients, MoCA score went on in normal ranges. In tinnitus patients, "Physical functioning", and "role limitations due to physical problems" and "social functioning" items of SF-36 positively correlated with MoCA which is a new assessment tool for cognitive functions.

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