

## Evaluation of Hearing Loss in Pilots

### Original Investigation

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### Abstract

**Objective:** High-intensity noise sources with an increase in air traffic and sudden changes in atmospheric pressure can cause hearing loss in pilots. The main goal of this research is to examine hearing loss due to age, the total flight hours and aircraft types and to evaluate the effects of personal conditions that can influence the hearing level.

**Methods:** We examined the data of 234 Turkish pilots aged between 25 and 54 years who were examined due to the aviation Law for annual control from January 2005 to January 2014 at Başkent University Medical Faculty, Ankara Hospital. The audiometric results of the pilots were used. While 1, 2, 3, 4, 6, and 8 KHz were used for the airway threshold, 1, 2, and 4 KHz were used for the bone conduction threshold.

**Results:** According to the data of the 234 pilots, there was a significant correlation between high- frequency hearing loss and the total flight hours and pilots' ages. The average hearing loss was higher, particularly in the left ear, in pilots using helicopters than in those using other aircraft types. There was no statistically significant correlation between hearing loss and diabetes, hypercholesterolemia, high blood pressure, anemia, obesity, and smoking.

**Conclusion:** A significant correlation was observed between high frequency hearing loss and the total flight hours, pilots' age, and aircraft types in our study.

**Keywords:** Pilot, aviation, noise, barotrauma, hearing loss

### Introduction

Temporary or permanent health problems may develop in pilots over time in relation to flights and flight hours. Hearing loss is one of the important health problems that the pilots encounter. Noise and barotrauma are the two important reasons that may lead to hearing loss in pilots.

The higher intensity of aircraft noise than that of other sound sources leads to the development of noise-induced hearing loss in pilots. The increase in air traffic creates problems such as noise pollution and noise-induced hearing loss (1). The negative impact of noise on the sense of hearing increases over time. Hearing loss in flight personnel may lead to dramatic results with increasing age and duration of noise exposure (2).

Barotrauma, which is seen as the second hearing loss factor in pilots, is the most prevalent medical problem experienced in flights and is considered as the most common aviation accident. Its incidence varies

between 8-17% (3). At present, barotraumas occur in spite of developing cabin technologies. Rosenkvist et al. (4) displayed that most pilots had 2-3 upper respiratory tract infections annually and 37% of them had experienced at least one barotrauma.

Hearing loss that may develop in pilots has been examined for different aircraft types and populations in literature studies (5-8).

The aim of this study was to determine the level of hearing loss in pilots in Turkey. This study was conducted in association with the age of the pilots, total flight hours, and aircraft type, taking into consideration the diseases affecting hearing, in order to show the impact of noise level in the aviation sector, pilots' duration of noise exposure, and atmospheric pressure change on hearing loss. Another aim was to increase the consciousness levels of the pilots individually and the awareness of flight surgeons about the reasons of hearing loss in pilots.



This study was presented at 37<sup>th</sup> Turkish National Congress of Otorhinolaryngology Head and Neck Surgery, 28 October-1 November, 2015, Antalya, Turkey.

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 Received Date: 27.10.2015  
 Accepted Date: 03.01.2016

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 www.turkarchotorhinolaryngol.org

DOI: 10.5152/tao.2015.1330

## Methods

This research was approved with the paper numbered 94603339/18.050.01.08.01-1077 (Project no: KA13/257) by Başkent University Medicine and Health Sciences Research Board on 20/11/2013, and supported by the Başkent University Research Fund. The study was conducted using the Başkent University Aviation Medical Unit Archive retrospectively.

The files of 1000 pilots who were admitted to Başkent University Medical School Ankara Hospital for their periodical evaluations, in accordance with the Aviation Law, between January 2005 and January 2014 were scanned.

The files of 234 pilots between the ages of 25 and 54 years that matched the criteria of the study were reviewed. Patient application forms, ear nose throat examination forms, biochemistry analysis results, and audiometry test results that were found in the files were examined. In the audiometry tests, the pure tone airway thresholds having frequencies of 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz and pure tone bone conduction thresholds having the frequencies of 1000 Hz, 2000 Hz, and 4000 Hz were evaluated.

Pure tone audiometry evaluations were made with two types of clinical audiometers (AC-33/AC-40 audiometer; Interacoustics A/S, Middelfart, Denmark). The measurements were performed using TDH-39 standard earphone in a silent cabin. The thresholds (according to OSHA 1983, F1 and F2 tables) to be evaluated as hearing loss were determined for the men and women according to age-corrected values.

Furthermore, intergroup comparison was made by calculating the mean frequency thresholds of the groups.

Inclusion criteria to the study group were determined as follows:

- 1) Pilots were divided into 3 groups according to their ages;
  - 1.group: between the ages of 25-34 years
  - 2.group: between the ages of 35-44 years
  - 3.group: between the ages of 45-54 years
- 2) Pilots were divided into 3 groups according to the flight hours;
  - 1.group: those who flew between 200-1000 h
  - 2.group: those who flew between 1001-3000 h
  - 3.group: those who flew between 3001-10000 h
- 3) Pilots were divided into 3 groups according to the aircraft types;
  - 1.group: helicopter
  - 2.group: jet-aircraft
  - 3.group: propeller aircraft

4) The relationship of the pilots' body mass index with hearing loss was evaluated in 3 groups;

- 1.group: BMI value between 18.5-24.9 (normal weight)
- 2.group: BMI value between 25.0-29.9 (over weight)
- 3.group: BMI value between 30.0-34 (obese-Class 1 Obesity)

5) The relationship of the pilots having low values of hemoglobin (Hb) (anemia) with hearing loss was evaluated. An Hb value of 14-18 g/dL was accepted as normal. The results of three pilots below the normal level were examined in the study.

6) The relationship of the pilots having high total cholesterol with hearing loss was evaluated. Total cholesterol levels 200 mg/dL and below were accepted as normal. In our study, the results of 90 pilots having high total cholesterol levels were examined.

7) Pilots with hypertension diagnosis according to information in the patient examination application form were determined, and the relationship between hypertension and hearing loss was examined. The results of three pilots were examined in our study.

8) Pilots with a diabetes mellitus diagnosis according to information in the patient examination application form were determined, and the relationship between diabetes mellitus and hearing loss was examined. The results of 23 pilots were examined in our study.

9) The relationship between smoking in pilots and hearing loss was evaluated. The results of pilots who answered "yes" to that question in the patient examination application form "are you smoking" were examined.

## Statistical Analysis

The SPSS 20 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.) statistical package software was used for the evaluation of data. Variables were presented as mean  $\pm$  standard deviation, median (maximum-minimum), percentage, and frequency. The accordance of the data to the repeated measures analysis of variance was evaluated with Mauchly's test of sphericity and Box's M-test for homogeneity of variances. Repeated measures analysis of variance was used for comparing the means. If preconditions of parametric tests were not met, degrees of freedom were corrected using the Greenhouse-Geisser (1959) or the Huynh-Feldt (1976) test. Multiple comparisons were made with the Bonferroni Correction Test. The variables were evaluated after the preconditions of normality and homogeneity of variances control (Shapiro, Wilk, and Levene Test) were carried out. While analyzing data, One-Way Analysis of Variance was used for comparing 3 or more groups. When the Tukey HSD test could not be benefited, the Kruskal, Wallis, and Bonferroni-Dunn test, which is a multiple comparison test, was used. The relationship between two continuous variables

was evaluated through the Pearson correlation coefficient. In the lack of preconditions for a parametric test, the Spearman correlation coefficient was employed. Categorical data were analyzed by using Fisher’s Exact Test and the Chi-Square test. In cases when the expected frequencies were lower than 20%, evaluation was performed by the “Monte Carlo Simulation Method” for including these frequencies in the analysis. The values of  $p < 0.05$  and  $p < 0.01$  were accepted as statistically significant.

### Results

In the study according to the age groups, 83 pilots (35.5%) in the 1st group (between the ages of 25-34 years), 81 pilots (34.6%) in the 2nd group (between the ages of 35-44 years), and 70 pilots (29.9%) in the 3rd group (between the ages of 45-54 years) were examined.

In accordance with the increase in age, a significant correlation was detected among the groups at 1, 2, 3, 4, 6, and 8 KHz frequencies of the air conduction hearing of the right ear and at 2, 3, 4, 6, and 8 KHz frequencies of the air conduction hearing of the left ear (Table 1, Figure 1, 2). The number of pilots developing hearing loss depending on age is displayed in Table 2. In the study according to the flight hours the pilots flew, 73 (31.2%) in the 1st group (200-1000 h), 76 (32.5%) in the 2<sup>nd</sup> group (1001-3000 h), and 85 (36.3 %) (3001-10000 h) in the 3<sup>rd</sup> group were examined.

A significant relationship was detected among the groups in the air conduction hearing of the right and left ears at all frequencies depending on the increase in flight hours (Table 1, Figure 3, 4). The number of total hearing losses depending on the flying hours and comparison of p-values among the groups are displayed in Table 3.

**Table 1.** Mean values of hearing thresholds among the groups according to age, flight hours, and aircraft type

			1 kHz		2 kHz		3 kHz	4 kHz		6 kHz	8 kHz	
			AC (dB)	BC (dB)	AC (dB)	BC (dB)	AC (dB)	AC (dB)	AC (dB)	BC (dB)	AC (dB)	
Age groups	25-34 years	Right ear	4.81	3.67	4.63	3.49	5.90	7.16	5.42	11.08	9.75	
			35-44 years	7.72	6.04	7.65	6.60	9.87	12.96	10.43	16.29	14.01
			45-54 years	8.35	6.50	9.28	8.14	14.07	20.78	17.92	23.07	24.57
			p-value	0.001	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001
	25-34 years	Left ear	6.14	4.75	4.81	3.55	7.28	7.65	5.96	10.60	10.42	
			35-44 years	7.90	6.41	8.64	6.79	10.80	13.76	11.29	16.29	14.32
			45-54 years	8.57	7.28	10.71	9.14	16.28	21.21	18.07	27.35	26.50
			p-value	0.095	0.068	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Flight hour	200-1000 h	Right ear	5.89	4.38	4.93	3.76	6.30	8.69	6.50	12.39	11.50	
			1001-3000 h	5.85	4.53	6.05	4.93	7.36	9.93	8.09	15.06	13.81
			3001-10000 h	8.64	6.88	9.82	8.76	14.76	20.11	17.17	21.23	20.88
			p-value	0.002	0.006	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	200-1000 h	Left ear	5.75	4.45	4.93	3.63	7.12	8.08	6.30	12.26	11.84	
			1001-3000 h	7.69	5.98	6.71	5.32	9.40	11.51	9.32	15.39	13.68
			3001-10000 h	8.76	7.58	11.52	9.58	16.29	20.82	17.70	24.11	23.23
			p-value	0.031	0.016	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Aircraft type	Helicopter	Right ear	7.44	5.56	8.40	7.10	11.53	15.96	13.52	18.92	18.63	
			Jet	6.30	4.93	6.57	5.41	8.15	10.61	8.35	14.10	13.56
			Propeller	6.78	5.47	5.95	5.13	9.10	12.60	10.27	15.89	14.17
			p-value	0.467	0.753	0.142	0.215	0.132	0.022	0.015	0.092	0.095
	Helicopter	Left ear	7.61	6.42	10.17	8.40	13.80	17.04	14.31	20.85	20.73	
			Jet	7.05	5.27	7.19	5.34	8.90	11.71	9.31	15.00	13.08
			Propeller	7.73	6.50	5.89	4.86	10.34	12.05	10.06	16.23	15.06
			p-value	0.829	0.477	0.018	0.028	0.036	0.024	0.030	0.035	0.009

AC:air conduction; BC: bone conduction

In the study according to the aircraft type the pilots flew, 88 of them (37.6%) in the 1<sup>st</sup> group (flying helicopter), 73 of them (31.2%) in the 2<sup>nd</sup> group (flying jet), and 73 of them (31.2%) (flying propeller) in the 3<sup>rd</sup> group were examined.

A significant difference was detected among the groups only in the air conduction hearing of the right ear on 1 KHz with regard to the number of pilots having hearing loss depending on the aircraft type. 29 pilots (33%) in the 1<sup>st</sup> group, 16 pilots (21.9%) in the 2<sup>nd</sup> group, and 10 pilots (13.7%) in the 3<sup>rd</sup> group for a total of 55 pilots had hearing loss. There was a significant relationship between the two variables (p-value: 0.022). There was a significant relationship among the groups in the measurements in the

air conduction hearing of the right ear at 4 KHz and in the air conduction hearing of the left ear at 2, 3, 4, 6, and 8 KHz frequencies with regard to mean threshold values (Table 1, Figure 5, 6). The number of air and bone conduction hearing losses at all frequencies depending on the aircraft type and comparison of p-values among the groups are displayed in Table 4.

There was a significant difference in both frequencies and right and left ears as a result of multivariate analysis with regard to age groups, flight hours, and aircraft types (Table 5).

Of the pilots included in the study, there were 84 pilots (35.9%) in the 1<sup>st</sup> group (18-24.9), 136 pilots (58.1%) in the 2<sup>nd</sup> group (25-29.9)

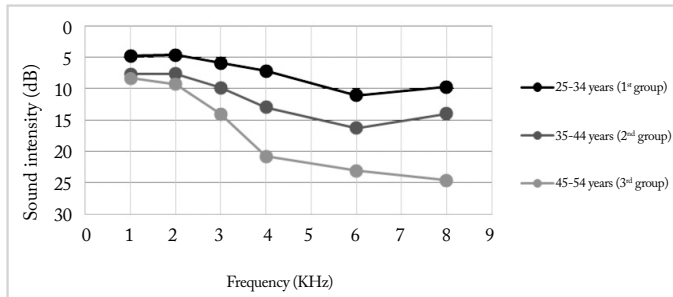


Figure 1. Sound intensity-frequency relationship in the the air conduction hearing of the right ear among the age groups

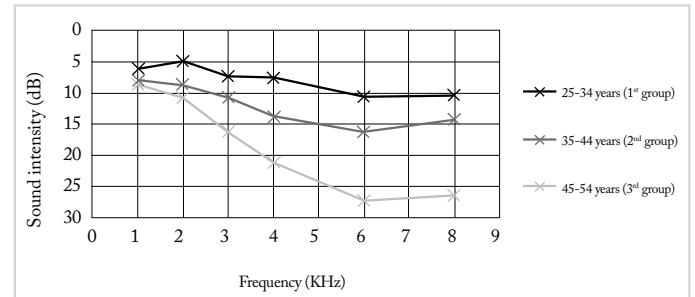


Figure 2. Sound intensity-frequency relationship in the air conduction hearing of the left ear among the age groups

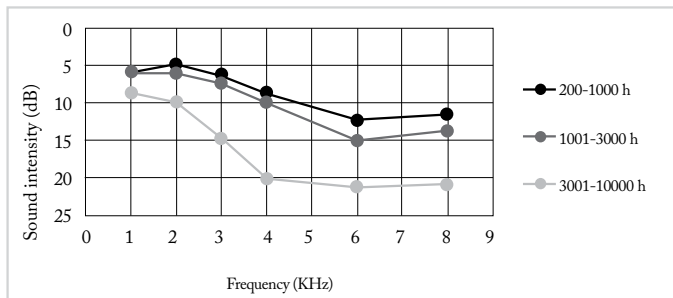


Figure 3. Sound intensity-frequency relationship in the air conduction hearing of the right ear according to flight hours

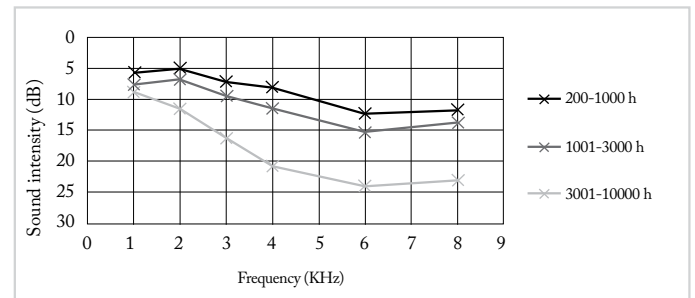


Figure 4. Sound intensity-frequency relationship in the air conduction hearing of the left ear according to flight hours

**Table 2.** Comparison of p-values and hearing loss at 1-8 kHz air conduction and bone conduction among the groups according to age

Hearing loss		1 kHz		2 kHz		3 kHz		4 kHz		6 kHz		8 kHz													
		AC		BC		AC		BC		AC		BC													
		-	+	-	+	-	+	-	+	-	+	-	+												
25-34 years	Right ear	64	19	72	11	62	21	67	16	54	29	-	-	48	35	59	24	50	33	-	-	43	40	-	-
35-44 years		46	35	60	21	47	34	51	30	53	28	-	-	54	27	64	17	49	32	-	-	41	40	-	-
45-54 years		41	29	47	23	37	33	45	25	50	20	-	-	45	25	50	20	47	23	-	-	32	38	-	-
p-value		0.011		0.014		0.013		0.024		0.653		-		0.481		0.436		0.618		-		0.734		-	
25-34 years	Left ear	58	25	68	15	59	24	69	14	51	32	-	-	52	31	58	25	53	30	-	-	36	47	-	-
35-44 years		41	40	54	27	46	35	55	26	54	27	-	-	58	23	66	15	50	31	-	-	43	38	-	-
45-54 years		37	33	43	27	34	36	41	29	42	28	-	-	43	27	48	22	38	32	-	-	34	36	-	-
p-value		0.025		0.014		0.016		0.003		0.664		-		0.343		0.130		0.457		-		0.460		-	

AC: air conduction; BC: bone conduction

**Table 3.** Comparison of p-values and hearing loss at 1-8 kHz air conduction and bone conduction among the groups according to flight hours

Hearing loss		1 kHz				2 kHz				3 kHz				4 kHz				6 kHz				8 kHz			
		AC		BC		AC		BC		AC		BC		AC		BC		AC		BC		AC		BC	
		-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
200-1000 h	Right ear	51	22	60	13	55	18	61	12	50	23	-	-	45	28	60	13	45	28	-	-	37	36	-	-
1001-3000 h	54	22	61	15	48	28	53	23	57	19	-	-	56	20	59	17	51	25	-	-	38	38	-	-	
3001-10000 h	46	39	58	27	43	42	49	36	50	35	-	-	46	39	54	31	50	35	-	-	41	44	-	-	
p-value		0.042		0.076		0.006		0.002		0.088		-		0.036		0.019		0.549		-		0.950		-	
200-1000 h	Left ear	51	22	60	13	52	21	60	13	48	25	-	-	51	22	56	17	46	27	-	-	34	39	-	-
1001-3000 h	43	33	57	19	46	30	55	21	52	24	-	-	55	21	61	15	51	25	-	-	39	37	-	-	
3001-10000 h	42	43	48	37	41	44	50	35	47	38	-	-	47	38	55	30	44	41	-	-	40	45	-	-	
p-value		0.032		0.001		0.013		0.005		0.187		-		0.047		0.062		0.118		-		0.812		-	

AC: air conduction; BC: bone conduction

**Table 4.** Comparison of p-values and hearing loss at 1-8 kHz air conduction and bone conduction among the groups according to aircraft type

Hearing loss		1 kHz				2 kHz				3 kHz				4 kHz				6 kHz				8 kHz			
		AC		BC		AC		BC		AC		BC		AC		BC		AC		BC		AC		BC	
		-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
Helicopter	Right ear	50	38	60	28	56	32	63	25	62	26	-	-	61	27	66	22	60	28	-	-	42	46	-	-
Jet		49	24	57	16	46	27	52	21	47	26	-	-	44	29	55	18	41	32	-	-	36	37	-	-
Propeller		53	20	63	10	45	28	49	24	49	24	-	-	43	30	53	20	45	28	-	-	40	33	-	-
p-value		0.091		0.022		0.979		0.83		0.707		-		0.336		0.936		0.283		-		0.602		-	
Helicopter	Left ear	48	40	57	31	53	35	64	24	55	33	-	-	54	34	63	25	54	34	-	-	41	47	-	-
Jet		40	33	54	19	44	29	49	24	48	25	-	-	47	26	52	21	43	30	-	-	36	37	-	-
Propeller		49	24	55	18	43	30	53	20	45	28	-	-	52	21	57	16	45	28	-	-	37	36	-	-
p-value		0.174		0.254		0.993		0.665		0.883		-		0.382		0.553		0.912		-		0.837		-	

AC: air conduction; BC: bone conduction

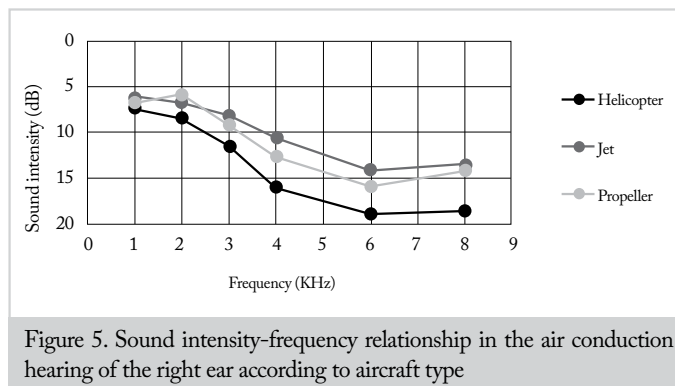


Figure 5. Sound intensity–frequency relationship in the air conduction hearing of the right ear according to aircraft type

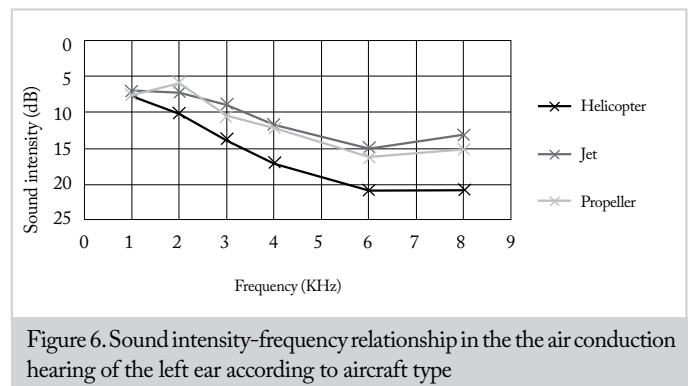


Figure 6. Sound intensity–frequency relationship in the the air conduction hearing of the left ear according to aircraft type

and 14 pilots (6%) in the 3<sup>rd</sup> group (30-34.9) according to body mass index results. No significant difference was detected with respect to hearing loss in both ears depending on body mass index ratios.

Hemoglobin results of 231 pilots (98.7%) included in our study were found within normal range and they were below the normal range in 3 pilots (1.3%). Total cholesterol results were found

within the normal range in 144 pilots (61.5%) and above the normal range in 90 pilots (38.5%). Measurements of arterial blood pressure were found within normal range in 231 pilots (98.7%) and above the normal range in 3 pilots (1.3%).

In total, 23 pilots (9.8%) included in the study had a diagnosis of diabetes mellitus and 91 pilots (38.9%) smoked. No significant

**Table 5.** Mean values of hearing thresholds among the groups according to age, flight hours, and aircraft type

			1 KHz		2 KHz		3 KHz	4 KHz		6 KHz	8 KHz	p	
			AC (dB)	BC (dB)	AC (dB)	BC (dB)	AC (dB)	BC (dB)	AC (dB)	BC (dB)			
Age groups	25-34 years	Right ear	4.81	3.67	4.63	3.49	5.9	7.16	5.42	11.08	9.75	0.001**	
			35-44 years	7.72	6.04	7.65	6.6	9.87	12.96	10.43	16.29		14.01
			45-54 years	8.35	6.5	9.28	8.14	14.07	20.78	17.92	23.07		24.57
	25-34 years	Left ear	6.14	4.75	4.81	3.55	7.28	7.65	5.96	10.6	10.42		
			35-44 years	7.9	6.41	8.64	6.79	10.8	13.76	11.29	16.29		14.32
			45-54 years	8.57	7.28	10.71	9.14	16.28	21.21	18.07	27.35		26.5
Flight hour	200-1000 h	Right ear	5.89	4.38	4.93	3.76	6.3	8.69	6.5	12.39	11.5	0.04*	
			1001-3000 h	5.85	4.53	6.05	4.93	7.36	9.93	8.09	15.06		13.81
			3001-10000 h	8.64	6.88	9.82	8.76	14.76	20.11	17.17	21.23		20.88
	200-1000 h	Left ear	5.75	4.45	4.93	3.63	7.12	8.08	6.3	12.26	11.84		
			1001-3000 h	7.69	5.98	6.71	5.32	9.4	11.51	9.32	15.39		13.68
			3001-10000 h	8.76	7.58	11.52	9.58	16.29	20.82	17.7	24.11		23.23
Aircraft type	Helicopter	Right ear	7.44	5.56	8.4	7.1	11.53	15.96	13.52	18.92	18.63	0.001**	
			Jet	6.3	4.93	6.57	5.41	8.15	10.61	8.35	14.1		13.56
			Propeller	6.78	5.47	5.95	5.13	9.1	12.6	10.27	15.89		14.17
	Helicopter	Left ear	7.61	6.42	10.17	8.4	13.8	17.04	14.31	20.85	20.73		
			Jet	7.05	5.27	7.19	5.34	8.9	11.71	9.31	15		13.08
			Propeller	7.73	6.5	5.89	4.86	10.34	12.05	10.06	16.23		15.06
p	0.01*		0.001**		0.04*	0.036*		0.02*	0.001**				

AC: air conduction; BC: bone conduction

difference was detected among the groups between hemoglobin levels, total cholesterol levels, arterial blood pressure measurements, diabetes mellitus, smoking, and hearing loss.

## Discussion

In our study, it was seen that age, flight hours, and the aircraft type flown correlated with hearing loss in pilots; in particular, a high frequency hearing loss.

Hearing loss has been linked to noise in most studies on aviation-related hearing loss (5-9). The most intensive noise problem in aviation is seen in high-performance combat aircrafts, propeller aircrafts, and helicopters. The noise that they create in the environment arises during lift off, landing, low flying, and firing duties. Although it changes with aircraft type and distance, the noise level is reported to be 120-160 dB on average and approximately 70 dB in civil aviation (1). Besides this, auditory sensation begins to decrease within the 1000-6000 Hz frequency interval over the age of 30 years as a result of aging (2).

Lindgren and Wieslander (5) evaluated hearing of pilots in a Swedish commercial airline and revealed that the impact of age on hearing loss was not different from that in the normal population without noise exposure. It was seen that noise exposure

levels and duration of noise exposure for the pilots were below Swedish occupational standards. In accordance with this study, Büyükçakır (10) found no significant relationship between age and hearing loss in Turkish pilots.

Nair et al. (8), in the study conducted on 1000 personnel in the Indian Military Forces, obtained significant results at all frequencies when they evaluated the relationship between age and hearing loss. Kuronen et al. (6), in the study among Finnish military pilots, found the hearing loss level to be 60 dB. In our study, the hearing levels of the pilots were not compared with the normal population. Although the mean hearing loss for 4 KHz was below 60 dB, a significant difference was detected among the groups at the frequencies between 1-8 KHz with regard to hearing loss among the groups formed according to age. It was also seen in the multivariate analysis results that age was effective on hearing loss at all frequencies and in both ears.

Another factor considered to be effective on hearing loss in aviation is the aircraft type flown.

Raynal et al. (7), in the study conducted on jet, transport, and helicopter pilots in France, found that even if transport pilots flew longer, the threshold values at 8 KHz frequency were better

than the other pilots. They also found that in general, left ear thresholds were lower in all groups and that the threshold values at 3 KHz frequency were low in helicopter pilots who had longer flight hours.

In the study of Büyükçakır (10), conducted on Turkish pilots, a significant relationship could not be detected between the aircraft type and hearing loss. Similarly, Fitzpatrick (9) also could not find any significant relationship between aircraft type and hearing loss in American pilots. When the seating plan of the pilots in the aircraft is considered, their left ears are more close to the window. Therefore, the left ear is more affected than the right ear from the noise in the aircraft and airport noise.

In accordance with the literature, according to the statistical results in which mean values for all frequencies with regard to aircraft type were compared, while only 4 KHz air and bone conduction results in the right ear was significant, hearing loss results of the air conduction hearing of the left ear at all frequencies between 2-8 KHz and left ear bone conduction at 2 KHz and 4 KHz frequencies were found significant. Hearing thresholds of helicopter pilots were lower than other groups. It was also seen in the multivariate analysis results that aircraft type was effective on hearing loss at all frequencies and in both ears.

In the study conducted on Turkish pilots, Büyükçakır (10) detected significant differences between hearing loss levels and flight hours. Kuronen et al. (6), in the study among Finnish military pilots, also found significant differences among the groups formed according to the flight hours (200-10000 hours) at 1, 2, and 4 KHz frequencies. Similarly Nair et al. (8), in the study they conducted on the Indian Military Forces, also obtained significant results at all frequencies when they evaluated the relationship between flight hours and hearing loss. In our study, in accordance with the literature when flight hours were considered, statistically significant differences among the groups were detected at all frequencies observed between 1-8 KHz.

There are studies on pilots conducted in the literature with regard to smoking and hearing loss. Lindgren and Wieslander (5) have found the impact of smoking on hearing loss not different from the normal population not having noise exposure. Nair et al. (8) detected the impact of smoking on hearing loss as significant. Ren et al. (11) and Shargorodsky et al. (12) in their studies could not detect a significant relationship between smoking and hearing loss. We also did not obtain a significant result about smoking. In line with this information, it may be concluded that smoking is not a primary cause of hearing loss, but rather a factor increasing hearing loss.

With regard to systemic diseases, Vicente et al. (13) found a significant relationship between blood glucose levels of workers and high frequency hearing loss. Ren et al. (11) found statistical difference in hearing loss at 4 KHz and 8 KHz frequencies

in middle-aged smoking patients with type 2 diabetes mellitus. Boomsma and Stolk (14) have shown in their studies that diabetes affects hearing loss. In our study, 23 pilots had a diagnosis of diabetes mellitus. 65% of the pilots had hearing loss at 4 KHz in the right ear and 52% of them had hearing loss in the left ear; however, the impact of diabetes on hearing loss was not significant. We are of the opinion that pilots should be regularly examined taking into consideration that keeping blood glucose levels under control may increase hearing loss.

In the study of Yousefi Rizi and Hassanzadeh (15), they investigated the effect of hypertension on the formation of noise induced hearing loss in 80 workers from different jobs. A significant relationship was found between hypertension and hearing loss. Saad et al. (16) also found a significant relationship in workers between hearing loss, hypertension, and body mass index. Boomsma and Stolk (14) also indicated that hypertension and anemia were risk factors for hearing loss; however, there was no significant relationship between them. While Shargorodsky et al. (12) did not detect a significant relationship between hypertension, diabetes mellitus, smoking, obesity, and hearing loss, they indicated a low risk, but significant relationship, between hypercholesterolemia and hearing loss. We also did not detect a significant relationship in our study between hypertension, hypercholesterolemia, anemia, body mass index, and hearing loss. We can link this to the necessity of pilots to watch their weights since they are not allowed to fly in case of obesity.

Another reason for hearing loss occurrence in pilots is seen to be the barotrauma effect (17-19). One of the limitations of our study was that we could not obtain information about the barotrauma histories of pilots due to the fact that we could not interview the pilots individually or by way of questionnaire since the study was retrospective. Another limitation of the study was that the hearing losses of the pilots were not compared with a control group or normal population.

## Conclusion

In conclusion, it can be considered that an increase in the age of pilots and duration of exposure to noise causes hearing loss at particularly high frequencies. This makes us think that when hearing losses at frequencies involving speech frequency progress, speech tests would be affected. It was observed that pilots, particularly helicopter pilots, were under a high risk depending on the aircraft type and that, in particular, left ear hearing loss was higher. Although we could not obtain information about the use of hearing protection, it may be concluded that it is necessary to use hearing protection since hearing loss, particularly at high frequencies, was found to be significant. In line with this information, it must be indicated that the pilots should protect themselves from the potential noise sources in their social lives in addition to occupational noise as generally, the primary cause of hearing loss and the sense of responsibility should be developed for preventing cochlear damage that may occur.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the ethics committee of Başkent University Institutional Review Board and Ethics Committee (Project no: KA13/257) and supported by Başkent University Research Fund.

**Informed Consent:** Written informed consent was not obtained from patients who participated in this retrospective study.

**Peer-review:** Externally peer-reviewed.

**Author Contributions:** Concept - H.A., E.A., S.T.B.; Design - H.A., E.A.; Supervision - H.A., E.A., S.T.B.; Resources - H.A., E.A., S.T.B.; Materials - H.A., E.A., S.T.B.; Data Collection and/or Processing - H.A.; Analysis and/or Interpretation - H.A., E.A., S.T.B.; Literature Search - H.A., S.T.B.; Writing Manuscript - H.A., E.A., S.T.B.; Critical Review - H.A., E.A., S.T.B.

**Acknowledgements:** The authors would like to thank Mustafa Agah Tekindal for his support for performing statistical analysis of this study.

**Conflict of Interest:** No conflict of interest was declared by the authors.

**Financial Disclosure:** The authors declared that this study has received no financial support.

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