

# Hearing Loss in Diving – A Study amongst Navy Divers

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## Summary

Despite the commonly observed condition of middle and inner ear barotrauma among divers, there is little evidence of insidious and permanent development of sensorineural hearing loss associated with diving. An audiometric survey was performed on a group of 120 divers and 166 non divers from the Royal Malaysian Naval Base in Lumut, West Malaysia between July to December 1991. The results of this survey revealed that insidious development of high frequency sensorineural hearing loss may be associated with diving. At frequencies 4000, 6000 and 8000 Hz the divers had higher mean hearing levels than non divers and their hearing at those frequencies seemed to deteriorate faster. The etiology of this insidious hearing loss is multifactorial and may be related to inner ear barotrauma, decompression sickness or noise-induced deafness.

**Key Words:** Barotrauma, Decompression sickness, Sensorineural hearing loss

## Introduction

The most commonly observed medical condition in professional divers is middle ear barotrauma that results from inability of the ears to equalize changes in ambient pressure. This condition usually resolves spontaneously and without sequelae. Conversely, inner ear barotrauma causing more serious and permanent disability, such as sensorineural hearing loss and vestibular disturbance, is less commonly highlighted<sup>1</sup>.

Professional divers are regularly exposed to major changes in ambient pressure which is a physical stress to the ears. Decompression sickness affecting end organ, bubbles developing in the inner ear fluids, gas embolism and micro thrombi has been postulated to be possible causes in inner ear damage. They are also subjected to substantial noise from breathing gas, exhaust gas bubbles, communication systems, tools and other background noise in the sea<sup>2</sup>. All these hazards may cause insidious deterioration of the ear function. Wilkes *et al.* (1989) studied inner ear changes in minipigs and found that cochlear degeneration occurred in minipigs on a pressure schedule that is usually regarded as being safe for man<sup>3</sup>.

Molvaer and Alberktsen (1990) measured hearing acuity in 116 professional divers and found that at most frequencies the divers had higher thresholds than otologically normal subjects of the same age<sup>2</sup>. However, factors contributing to the onset and the duration at which this insidious deterioration of hearing from diving will result in unacceptable sensorineural deafness is still debatable.

In this study, our objective was to determine the hearing acuity of a population of divers in the Royal Malaysian Navy and compare it to a similar population who are non divers. The hearing thresholds were analysed against age and diving experience to see if the hearing acuity in divers deteriorate faster than in non divers.

## Materials and Methods

This is a cross sectional study. By random sampling, 120 diving personnel from the Diving Unit of the Royal Malaysian Naval Base in Lumut were selected. For comparison 116 non divers from the surface unit of the same Naval Base were

recruited in this study. Those personnel who had ear injury, ototoxic drug ingestion and other known non-diving-related causes of hearing loss were excluded from the study.

A standard questionnaire was used for all the subjects for data collection before hearing test was performed. This included an otologic history, documentation of the length of service as divers, diver profile and onset of hearing loss if present.

Ear examination was performed by the authors using the otoscope, to ensure absence of external or middle ear pathology or current middle ear barotrauma from recent diving.

Hearing was assessed using Pure Tone Audiometer in standard sound proof booth. Frequencies tested during audiometry for air conduction thresholds were 500, 1000, 2000, 4000, 6000 and 8000. Bone conduction thresholds were examined only if the air conduction thresholds exceeded 20dBHL and this did not include 6000 and 8000Hz.

In both groups, the severity of hearing loss was determined by taking average hearing levels at 500, 1000, 2000, 4000, 6000 and 8000Hz in the right and left ears. The mean hearing levels for both ears were used when the hearing acuity was analysed according to age group. A discrete frequency loss was considered present when the mean hearing level for the tested frequency is greater than 25dBHL.

## Results

All subjects were male. There were 120 divers and 166 non divers. All of them were healthy with no recent history of middle ear or inner ear barotrauma.

### Age

The age distribution of the divers and non divers is shown in Figure 1. The age ranged from 18 to 42 years. Generally, the divers were younger than the non divers with a mean age of 26.9 years (SD 4.4 yrs) and 29.7 years (SD 5.3 yrs) respectively. Nevertheless, the vast majority of subjects in the two groups were in the third decade of life.

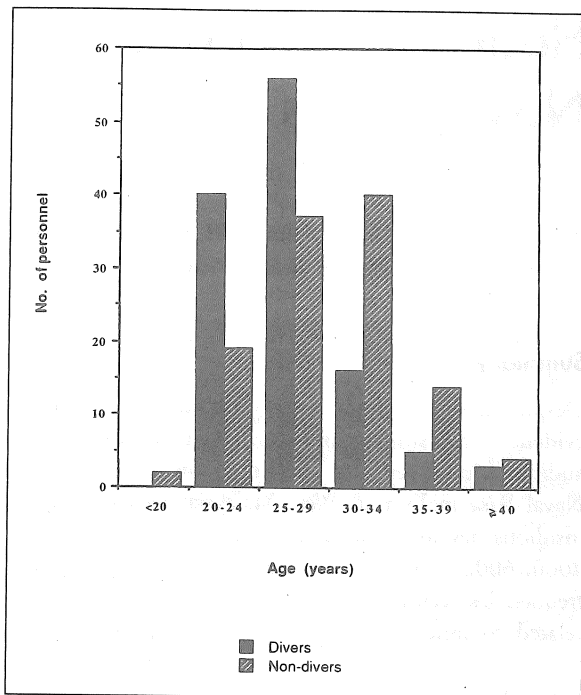


Fig. 1: Age distribution of divers and non divers

### Hearing Levels

The mean hearing level for each ear in the divers and non divers is shown in Figure 2.

In general, subjects in both groups demonstrated high frequency hearing loss. However, at 4000 and 8000Hz, divers seemed to have greater hearing loss than non divers both in the left and right ear. It is also noted that in the divers, the mean hearing levels of the left ear was higher than the right at all frequencies.

Figure 3 shows the mean hearing levels amongst the divers when analysed according to age groups. It demonstrates an obvious increase in hearing thresholds in the high frequencies as the age increases.

A similar pattern was obtained when the hearing acuity in the divers were analysed according to years of experience (Fig. 4). High frequency hearing loss was demonstrated in groups with experience of 5 to 9 years and in those more than 10 years. However it is not possible to attribute this hearing loss primarily to the

number of years of diving as in this situation, diving experience is proportionally related to age.

Nevertheless, in an attempt to ascertain whether there is an appreciably greater hearing loss in divers and whether or not this hearing loss is attributable to age, we compared the hearing levels of divers and non divers according to age group. This comparison is shown in Figures 5a, 5b, 5c and 5d.

Figures 5a and 5b show no difference in the hearing levels between the divers and non divers in the age groups of less than 25 year and 25-29 years respectively. It is noted that in the 25-29 year group, both divers and non divers has equal level of hearing loss at frequencies 6000 and 8000Hz.

However, Figures 5c and 5d show that in the age group 30-34 years and more than 35 years respectively, there is a significantly greater hearing loss amongst the divers at frequencies 4000, 6000 and 8000Hz compared to non divers. Accordingly we can infer that the hearing acuity in divers deteriorate faster in divers than in non divers and is seen after the age of 30 years.

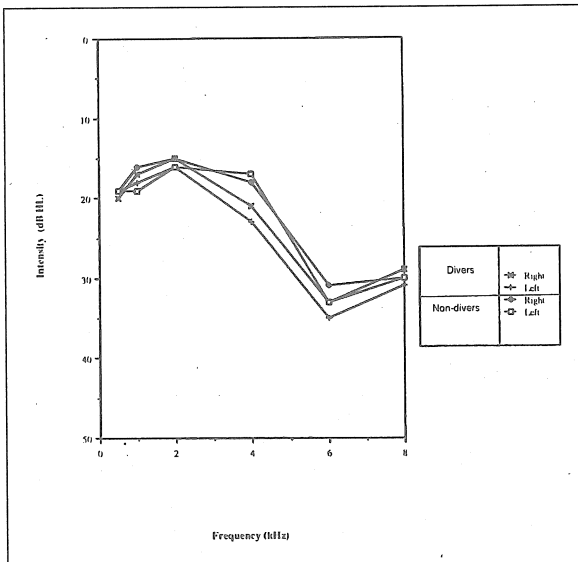


Fig. 2: The mean hearing level of the right and left ear of divers and non divers

Discussion

The acute and potentially serious complications of inner ear barotrauma such as membrane rupture, bleeding, perilymph fistula and decompression sickness

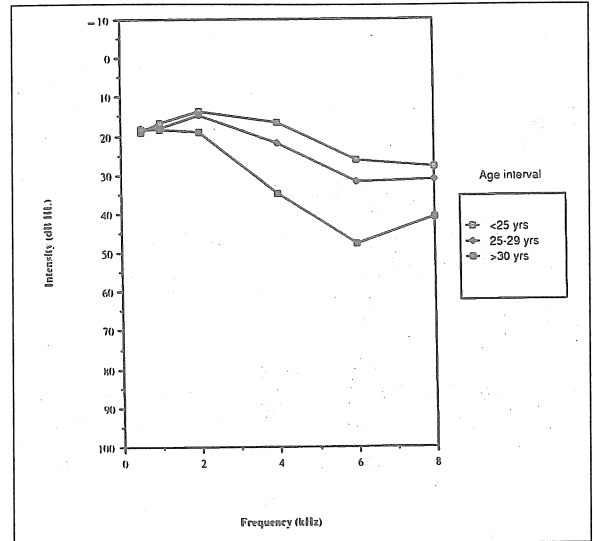


Fig. 3: The mean hearing level of divers according to age group

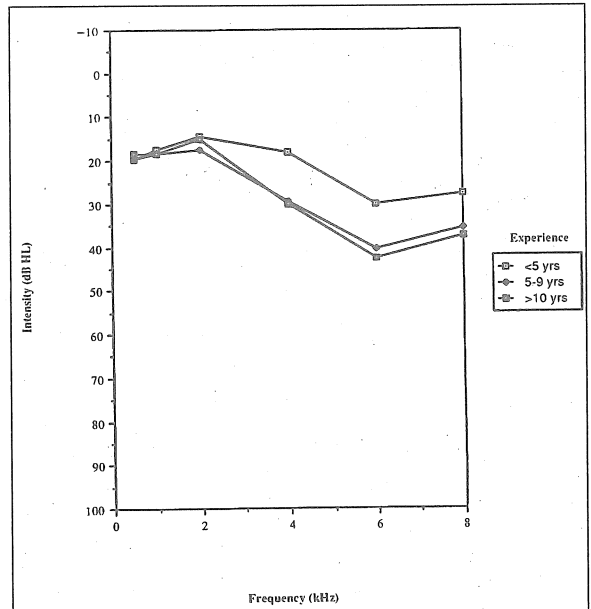


Fig. 4: The mean hearing level in divers according to experience (years of diving)

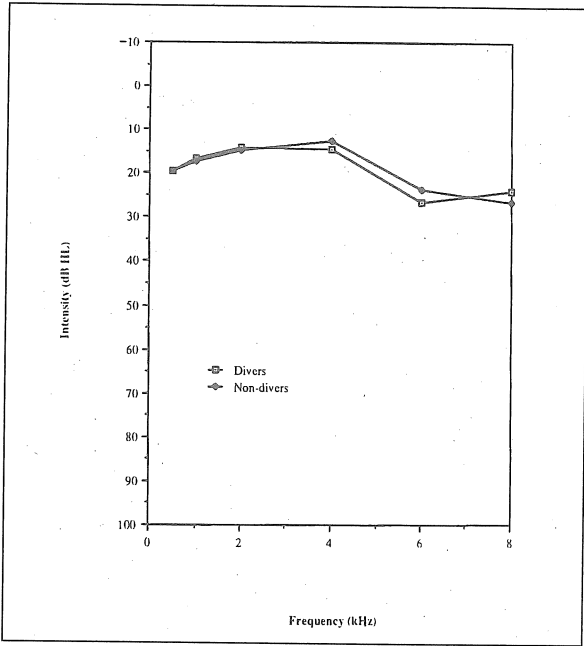


Fig. 5a: The mean hearing level of divers and non divers of age group less than 25 years

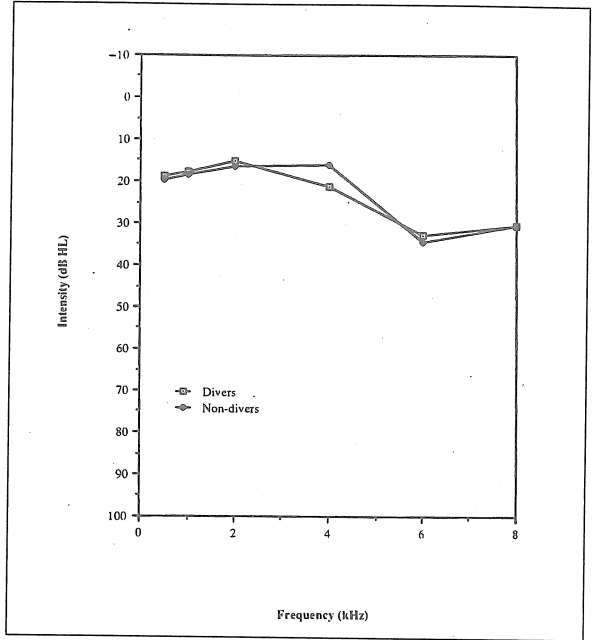


Fig. 5b: The mean hearing level of divers and non divers of age group 25-29 years

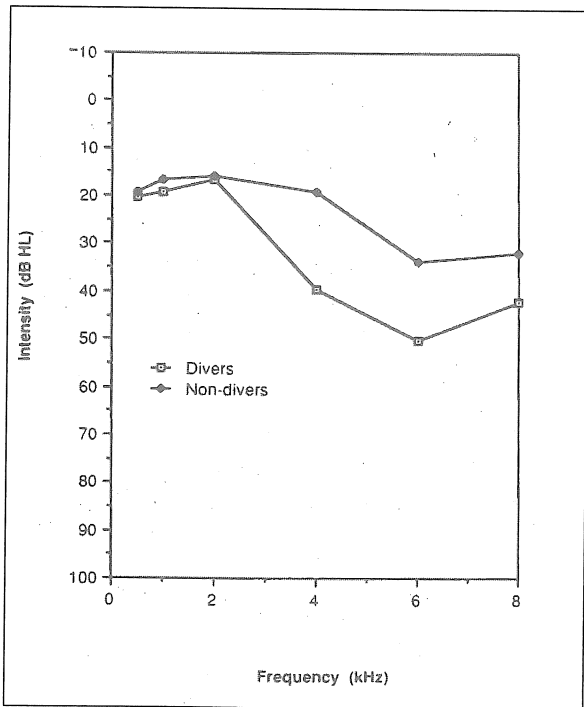


Fig. 5c: The mean hearing level of divers and non-divers of age group 30-34 years

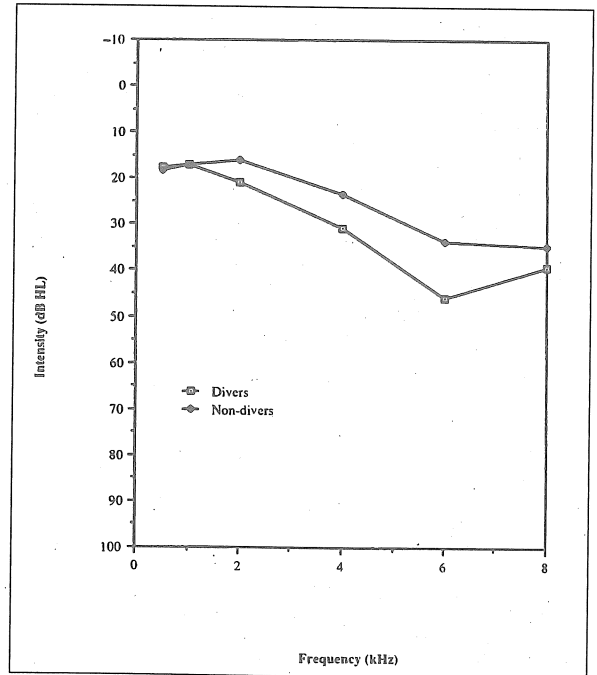


Fig. 5d: The mean hearing level of divers and non divers of age group more than 35 years

causing sudden hearing loss and vertigo has been well documented. Although, it results in permanent hearing loss and disability in a few patients but the majority resolves with treatment and resumes diving.

Our study has shown that apart from those resulting from obvious barotraumatic incidents, insidious development of high-tone sensorineural hearing loss may also be associated with diving. In the population of the present study, the divers and non divers were navy personnel, all of whom had exposure to noise environments and gunshot trauma during their training. Because of this, it is not surprising that the majority had high frequency hearing loss. However, when the mean hearing levels in the divers and non divers were compared, the divers seemed to have greater hearing loss than non divers at frequencies 4000 to 8000Hz. This is observed in both the left and right ears. Since subjects in the two groups were analogous in many respects, this poorer hearing acuity in the high frequencies in divers could be attributed to diving.

We also attempted to ascertain that this hearing loss in divers is not attributable to age by comparing the hearing levels of divers and non divers according to age groups. There was significantly greater hearing loss amongst the divers at frequencies 4000, 6000 and 8000Hz in the age groups 30-34 years and more than 35 years. In the age groups less than 30 years both divers and non divers have actual level of hearing loss at those frequencies. Accordingly, the hearing seemed to deteriorate faster in divers than in non divers.

There was no recent diving exposure to explain the deficits on the basis of a temporary threshold shift, and no evidence of middle ear barotrauma on otoscopy. Therefore, this observed hearing losses predominantly of sensorineural type in the high frequency, would be a result of insidious deterioration of the ear function that occurs from diving. This significant effect of diving on hearing deterioration was also found by Molvaer and Alberktsen in 1990<sup>2</sup>. They measured the hearing acuity in 116 professional divers and after 6 years they were retested. At most frequencies, the divers had higher hearing thresholds than otologically normal subjects at the same age, both at the first and final examination. The divers hearing deteriorated faster than that of the otologically normal subjects. Edmonds (1985) in an

audiometric survey on 28 professional abalone divers showed that over 60% of the divers had an unacceptable sensorineural high frequency deafness<sup>4</sup>. All these divers had experienced a great deal of exposure to dysbaric conditions.

The etiology of this insidious deterioration of the ear function that occurs from diving is debatable and most probably multifactorial. High noise levels are ubiquitous in the work environment of professional divers. This noise exposure is thought to be the cause of the high frequency hearing deterioration<sup>5</sup>, there is also evidence that diving is associated with an enhanced sensitivity to noise induced hearing loss. The high frequency hearing loss has also been described as a manifestation of decompression sickness<sup>6</sup>. In this condition, nitrogen or other inert gases dissolved in the body tissues will come out of solution and form bubbles that can cause cochlear damage when an ascent is too rapid.

Inner ear barotrauma, apart from causing acute, serious inner ear injury may also result in permanent minor residual damage which may be perceived as normal by the diver and attending physician<sup>7</sup>. As they continue diving this mechanism of inner ear injury will result in insidious deterioration of the hearing.

The evidence of an association of diving with internal ear injury has been further strengthened by experimental studies. Freeman and Edmonds (1972) showed that inner ear barotrauma may be less severe and unrecognised, in which the round window membrane ruptures and heals spontaneously but not before some damage beyond recovery is caused<sup>8</sup>. Wilkes *et al.* (1989) studied inner ear changes in minipigs and found that cochlear degeneration occurred in minipigs on a pressure schedule that is usually regarded as being safe for man<sup>3</sup>. With the above results we conclude that high frequency hearing loss should be regarded as an occupational disease of divers, and its incidence is significantly high. However, we believe our evidence are preliminary and require confirmation before definitive recommendations can be made.

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