Noise-induced hearing loss in humans as a function of serum Mg concentration

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Zusammenfassung

Bei 24 lärmexponierten Piloten der israelischen Luftwaffe bestand eine enge Korrelation zwischen dem lärmbedingten Hörverlust und der Serum Mg-Konzentration. Der Korrelationskoeffizient betrug $r = -0{,}61$, $p < 0{,}001$

Summary

In 24 noise-exposed Israeli Air Force pilots, there was a strong correlation between noise-induced hearing loss and serum Mg concentration. The correlation coefficient r was -0.61, $p < 0.001$.

Résumé

Chez 24 pilotes de l'armée de l'air israélienne exposés au bruit, la corrélation était très étroite entre la perte auditive due au bruit et la concentration sérique de Mg.
Le coefficient de corrélation r était de $-0{,}61$, $p < 0{,}001$.

Introduction

Noise-induced hearing loss (NIHL) is a frequent defect in noiseexposed persons. However, there is a high variance in individual susceptibility in NIHL.
In preceding experiments with guinea pigs [4] and rats [5], we found Mg deficiency and injection of catecholamines [6] to enhance NIHL.
With Mg-deficient animals, there was a negative correlation between serum Mg and NIHL. As these parameters are simple to measure we have examined whether the same relationship of serum Mg and NIHL is applicable to humans.

Methods

Blood was taken from 24 pilots of the Israeli Air Force aged 21 to 47 years who are frequently exposed to noise levels above 90 dB (A) and the hearing threshold of these persons was measured using a pure tone audiometer in the frequency range between 250 Hz and 8 kHz.
Blood was taken by means of evacuated glass tubes containing lithium-heparin. Serum and erythrocytes were separated by centrifugation. The erythrocytes were washed two times in 10.8 % sucrose and freeze-dried. The freeze-dried powdered erythrocytes were ashed in the plasma processor E 500 (Technics, Munich, FRG) and the ash was dissolved in 0.1 N HCl.
In serum and ashed erythrocytes, Na, K, Ca and Mg were measured by atomic absorption spectrophotometry.
For determination of noise-induced hearing loss, the hearing thresholds at 3; 4 and 6 kHz were averaged, i. e. frequencies at which noise-induced hearing loss in man is maximal (C^5-dip). As there was a wide variation of age, an age-depending hearing loss was subtracted from the measured hearing loss in the frequency range mentioned according to the values of Tab. 1.

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Results

Table 2 shows age, uncorrected hearing loss (HL), serum Mg and erythrocyte Mg for the 24 pilots. In Fig. 1, the age-corrected hearing loss (NIHL) has been plotted as a function of serum Mg (SMg). The correlation coefficient r between these two parameters had a value of -0.61 ($n = 24$, $p < 0.001$). No correlation was found between NIHL and erythrocyte Mg (EMg), nor was there a correlation between K, Na and Ca content in serum or erythrocytes and NIHL of the pilots (data not shown).

Discussion

From the 24 individuals examined, only one was hypomagnesemic judging by the normal range of SMg from 0.7 to 1.1 mM. Nevertheless, also within the range of normal SMg, there was a correlation to NIHL. This correlation may represent a causal mechanism because in the experi-

Tab. 1: Mean age-dependent hearing loss for the frequencies 3, 4 and 6 kHz, according to [10]

Age (years)	Hearing loss (dB)
25 – 29	1
30 – 34	4
35 – 39	7
40 – 44	11
45 – 49	16

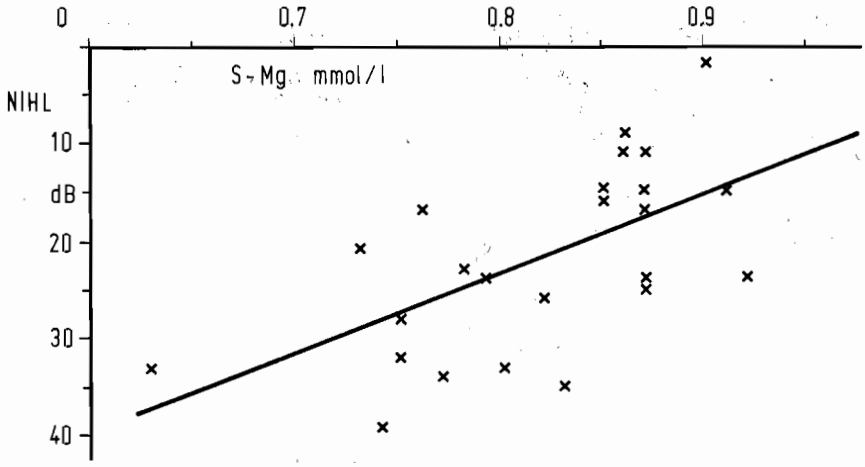

Fig. 1: Age corrected hearing loss (NIHL) of 24 pilots of the Israeli Air force as a function of serum Mg concentration (SMg)

ments with Mg-deficient rats and guinea pigs the same correlation was found.

When in the hearing process, the hair bundle is deflected, transduction channels are opened and K^+ enter the hair cells. The depolarization evoked by this transduction current activates voltage-gated Ca^{2+} channels and Ca^{2+} influx. The rise in the intracellular free Ca^{2+} concentration induces a Ca^{2+}-sensitive K^+ efflux and repolarization of the cell membrane [3].

When under conditions of experimental Mg deficiency, serum Mg is drastically decreased, cell membrane permeability and energydependent turnover of Na^+, K^+ and Ca^{2+} are enhanced [2]. Thus, ion fluxes and energy-dependent ion-pumping involved in the hearing process, may be enhanced in Mg deficiency, so that a reduction of serum Mg may favour energy exhaustion and damage of hair cells. Energy exhaustion is suggested to be the general mechanism of NIHL [9].

Moreover, in Mg deficiency, the release of catecholamines [1] and prostaglandins, particularly thromboxane B_2 (TX B_2) [8], was enhanced.

Injection of catecholamines increased NIHL in normomagnesemic rats [6], and in the lateral cochlear wall of guinea pigs with NIHL, TXB_2 was enhanced, whereas 6-keto $PGF_{1\alpha}$ was reduced [7]. Thus, increased release of catecholamines and prostaglandins may be a second mechanism of Mg-deficiency-induced NIHL. As the job of the pilots is connected with high psycho-mental stress, increased release of catecholamines with rather small reductions of serum Mg may offer an explanation of the correlation between NIHL and serum Mg.

Tab. 2: Age, hearing loss (HL), serum Mg (SMg) and erythrocyte Mg (EMg) of noise-exposed pilots

Age (years)	HL (dB)	SMg (mmol/l)	EMg (mmol/kg d.w.)
21	15	0,91	5,62
23	23	0,78	4,80
24	15	0,85	4,41
24	21	0,73	4,77
25	12	0,86	5,07
26	25	0,87	5,71
27	33	0,75	4,85
27	40	0,74	4,60
27	27	0,82	4,92
28	35	0,74	5,42
31	32	0,75	5,07
31	37	0,80	4,68
33	15	0,87	5,17
33	28	0,79	5,47
35	42	0,83	5,13
39	24	0,87	6,03
39	22	0,87	6,11
40	19	0,86	4,94
43	36	0,87	5,74
45	31	0,87	5,97
47	33	0,76	5,25
47	18	0,90	4,37
—	24	0,92	5,85
—	33	0,63	4,56

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