Electroneuromyographic findings in workers exposed to dioxins, furans and metal fumes (lead and cadmium) in a cable scrap smelter.

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Abstract

- Relevant clinical neurophysiological findings are mainly caused by physical working conditions and effects of lead and cadmium mediated by smoking of cigarettes at the work place. Nevertheless there are distinct effects of PCDD/F.
- Measurements show predominantly no additive effects of dioxins/furans and metals. Both lead to disturbances on different nerves and neuromuscular locations.
- The components of findings correlated to I-TEQ are separated by principal-components analysis in 4 factors.
- The results indicate the need of further epidemiological investigations with an extensive neurophysiological program.

Introduction

As part of an explorative health study 12 exposed male workers of a cable scrap smelter were examined by electroneuromyographic measurements. From 1980 until 1990 the workers were exposed to PCDD/F, lead and cadmium (Tab.1). There is conflicting evidence from epidemiologic studies regarding an association between neurophysiological results and human exposure to PCDD/F (1-7).

Methods

Electroneurographic (eng) measurements (latency = lat., motor conduction velocity = cv, sensory cv = scv, relative latency, i.e. cv including neuromuscular latency, quotient of proximal and distal cv = quot.) were done in Nn. ulnaris, medianus (mot./sens.), fibularis, tibialis, suralis. Electromyographic (emg) data were obtained from m. abductor digiti quinti and m. extensor digitorum brevis (duration of action potentials and phases, always mean value, standard deviation, screwness and excess of distributions). The eng measurements outside the normal range were scored (= engscore). - Statistical procedures comprised multiple steps of data reduction, SPEARMAN correlation coefficients and factor analysis (FA) with extraction of principal components. As covariables were included: age, alcohol uptake, smoking status, body mass index (BMI), body length, body weight, physical working conditions (heat, hand-arm strain, standing position, smelting, awkward posture, years of exposure to whole body vibration and heavy physical load).

Results and Discussion

Results of FA regarding engscore, exposure related biomonitoring and covariables (Tab.2): There are 3 components causing neurographic deviations; 1. Influences of lead and cadmium, obviously mediated by smoking of cigarettes during work (oral intake of contaminated dust). 2. Long time heavy physical load and 3. awkward posture. But in the factor 1 and 2 a differential effect of PCDD/F can not be neglected, PCDD/F my be increases as well as decreased nervous conduction ability. - The significant SPEARMAN correlation coefficients (Tab. 3-6) show among other relations of covariables different relations to exposure variables of lead, cadmium and dioxins/furans. It is noteworthy, that the eng-/emg-variables, which present relations to I-TEQ, do not relate to metal exposure. The final FA (Tab.7) after multiple steps of data reduction concerning effects of PCDD/F, demonstrates 4 factors. Factor 1 is structured only by physical covariables. PCDD/F effects are splitted to factors 2-4: 1. decreased cv of ulnar nerve, combined with increased conduction ability in tibial nerve; 2. decreasing of phase duration in the m. abduct.dig.V. and of the distal conduction ability of the n.tibialis, combined with opposite effects by whole body vibration; 3. once more decreased phase duration in the same muscle, but now combined with effects by hand-arm strain in the same direction. The results support the hypothesis of phasic reactions of the nervous conduction ability as observed also in other neurotoxic agents (8). The shortening of phase durations is similar to findings by myogenic and distal located neurogenic diseases. All these deviations of neurophysiological parameters are within normal range of variation, leaving the problem of clinical or prognostic relevance especially in view of long time effects open for discussion and further research.

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Tab.1: Exposure and biomonitoring

	mean	median	range
I-TEQ (1993) (pg/g bloodfat)	127,42	106,90	48,60 - 299,10
lead (1995) (µg/dl blood)	16,04	16,20	8,20 - 26,60
lead (1993) (µg/dl blood)	17,57	16,50	10,40 - 25,80
cadmium (1993) (µg/l blood)	1,21	0,80	0,20 - 2,80
EPP (1995) (µg/dl blood)	17,40	16,90	12,67 - 24,09
D_ALA (µmol/l urin)	21,05	21,89	5,33 - 52,31
exposure years (up to 1990)	24,5	28,5	6,00 - 39,0
age (life years)	51,8	55,5	32,0 - 68,0

Tab. 2: Factor analysis regarding clinical relevant eng-score (principal components extraction, VARIMAX-rotation)

	Factor 1	Factor 2	Factor 3
percent of variance	36.0	25.7	15.2
pb (blood)	**.871**	-.237	.153
cd (blood)	**.898**	.268	-.166
I-TEQ	.373	-.372	.019
cigarettes	**.951**	.066	.030
awkward post.	-.112	-.032	**.942**
expos. years	-.119	**.878**	-.039
heav.phy.load	.182	**.870**	.153
engscore	.364	.492	**.590**

Tab.4: SPEARMAN correlation coefficients regarding electroneurographic data, exposure and covariables: ENG of n.fibularis, n.tibialis, n.suralis

	n.fib. lat.dist.	n.tib. lat.dist.	n.tib. cv	n.sural. scv
alcohol			0,62***	
BMI		-0,60***		
EPP			-0,59***	
D_ALA				
exposure years up to 1990	-0,58***			-0,57**

*** $p \leq 0,05$ / ** $p \leq 0,1$

Tab.5: SPEARMAN correlation coefficients between electroneurographic data, exposure and covariables: ENG of n.ulnaris, n.medianus, n.radialis, n.fibularis, in cluding neuromuscular latency.

	n.uln. prox.	n.uln. dist.	n.med. dist.	n.rad. antebr.	n.fib. dist.	n.tib. prox.	n.tib. dist.
age	-0,60***						
alcohol						0,69***	
body length	0,58***						
I-TEQ	-0,50**			-0,50**	-0,72***		0,64***
pb (blood)			0,51**				
EPP		-0,55**				-0,59***	
DALS		-0,62***					

*** $p \leq 0,05$ / ** $p \leq 0,1$

Tab. 3: SPEARMAN correlation coefficients regarding electroneurographic data, exposure and covariables: ENG of n. ulnaris, n. medianus, n. radialis

	n.uln. dist. lat.	n.uln. cv	n. uln. dist. cv	n. uln. cv quot.	n. med. cv	n. med. cv quot.	n. med. sens. lat.	n. med. scv	n. rad. dist. lat.	n. rad. cv
age			-0,64***	0,69***	0,50**					
alcohol						-0,51**			-0,69***	
BMI										-0,53**
body length		0,56**	0,62***							
I-TEQ		-0,66***								
pb (blood)					-0,59***					
EPP							-0,57***	0,71***		
D_ALA	0,50**								0,61***	
cd (blood)							-0,50**	0,50**		
exposure years up to 1990										0,59***
cigaret./day							-0,64***	0,60***		

*** $p \leq 0,05$ / ** $p \leq 0,1$

Tab. 6: SPEARMAN correlation coefficients regarding electroneurographic data, exposure and covariables = EMG of m.abductor digit. V. and m.extensor. digit. brevis

	m.abd. durat. mean	m.abd. durat. SD	m.abd. durat. exc.	m.abd. phas. mean	m.ext. durat. mean	m.ext. durat. SD	m.ext. durat. scr.	m.ext. durat. exc.	m.ext. phas. SD	m.ext. phas. exc.
age						0,50**				
body weight						0,53**				
body length				0,50**						
I-TEQ				-0,79***						
pb (blood)							0,66***	0,71***	-0,74***	
EPP	0,51**	0,55**	0,60***			-0,57***	0,71***			
D_ALA								0,61***		
cd (blood)			0,57**		-0,65***		0,60***	0,75***		
exposure years up to 1990					-0,52**					0,59***
cigaret./day					-0,56**		0,87***	0,85**		

*** $p \leq 0,05$ / ** $p \leq 0,1$

Tab.7: Factor analysis regarding target parameters of PCDD/F exposure and covariables (principal components extraction, VARIMAX-rotation)

	Factor 1	Factor 2	Factor 3	Factor 4
percent of variance	49.2	14.9	11.2	10.1
I-TEQ	.014	**-.613**	**-.649**	**.408**
body length	**.689**	.461	.237	-.011
age	**-.887**	-.080	.101	.276
whole body vibration	**.704**	-.101	**.619**	.043
hand-arm strain	-.205	-.057	-.047	**.940**
n.uln.cv	.281	**.873**	.205	.022
m.abd.phas	.184	.282	**.591**	**-.594**
n.fib.rel.lat.dist.	.171	.246	**.871**	-.045
n.tib.rel.lat.dist.	-.103	**-.884**	-.116	.173
n.uln.rel.lat.cubit.	**.719**	.296	.310	-.212