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Short communication

Occupational exposure to airborne lead in Brazilian police officers

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ABSTRACT

Shooting with lead-containing ammunition in indoor firing ranges is a known source of lead exposure in adults. Police officers may be at risk of lead intoxication when regular training shooting exercises are yearly mandatory to law enforcement officers. Effects on health must be documented, even when low-level elemental (inorganic) lead exposure is detected. Forty police officers (nineteen cadets and twenty-one instructors) responded to a questionnaire about health, shooting habits, and potential lead exposure before a training curse. Blood samples were collected and analyzed for blood lead level (BLL) before and after a three days training curse. The mean BLL for the instructors' group was 5.5 μg/dL ± 0.6. The mean BLL for the cadets' group before the training was 3.3 μg/dL ± 0.15 and after the training the main BLL was 18.2 μg/dL ± 1.5. Samples were analyzed by Inductively Coupled Plasma Mass Spectrometer (ICP-MS). All the participants in the training curse had significantly increased BLL (mean increment about 15 μg/dL) after the three days indoor shooting season.

In conclusion, occupational lead exposure in indoor firing ranges is a source of lead exposure in Brazilian police officers, and appears to be a health risk, especially when heavy weapons with lead-containing ammunition are used in indoor environments during the firing training seasons.

Introduction

Exposure to lead from gunshot residues (GSR) originates from the combustion of lead-containing primer (primer is a highly explosive material that detonates on percussion), as well as from the shearing of lead particles as the bullet passes through the chambers and the barrel of the weapon (Schwoeble, 2000). Shooting in indoor firing ranges with lead-containing ammunition is a known source of lead exposure in adults (Diaz et al., 2012; Ozonoff, 1994; Svensson et al., 1992; Valway et al., 1989). This exposure can result in increases in blood lead level (BLL) from 1.5 to 2 times higher (Gulson et al., 2002) and is higher when non-jacketed pure lead bullets are used rather than jacketed bullets (Tripathi et al., 1990).

The Brazilian Legislation established the action level for occupationally exposed personnel in 60 μg/dL (Brasil, 1983), but there are concerns about the sub clinical BLLs (lower than 30 μg/dL) (Cordeiro and Lima-Filho, 1995; Gidlow, 2004; Kosnett et al., 2007).

Shooting exercises are mandatory in the police all around the world. In Brazil, some exercises imply the exposure in indoor environments to residues from several rounds with different weapons, in a short period of time. Changes in blood lead levels (BLL) during firearms instruction at indoor firing-ranges must be measured and determine their risk from lead exposure.

Materials and methods

20 police officers, ranged from 26 to 47 years old and 21 firing-range instructors aged between 34 and 77 years old, from military police in the city of Sao Paulo (Brazil) were invited to participate in the study prior to initiate the training curse "Self Protection and Life Preservation" based on the method developed by Nilson Giraldi, in which the officers have to use different weapons (Pistol, Portable Machine Gun and Pump Shotgun) and are submitted to several situations simulating real life situations. The training room was 20 m long, 15 m wide and 4 m height, the air exhaustion system was capable of approximately 20 exchanges per hour. Further environmental characteristics as airborne lead concentration were not available. The exercises implied hard physical strength and stress,

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Table 1
Type of weapons and ammunitions and rounds fired during the training curse.

	Weapon	Ammunition	# Shoots
Day 1	Pistola, Taurus, PT 24/7 e PT 640	.40 S&W EOPP	4225
Day 2	Submachine gun MT40	.40 S&W EOPP	3805
Day 3	Shotgun CBC 586.2	12-3T e 12-SG	1685

wearing a bullet protective clothes which simulates the real life situations of the policeman in day to day work in Sao Paulo City.

The participants assisted to conference where information about the exposure to GSR and health risks associated was shared, as well as the methodology and purposes of the present work. Additionally they were invited to respond to a questionnaire about current health, use of tobacco, present work tasks, occupational and recreational shooting habits as well as other potential sources of lead exposure. Incomplete questionnaires were accepted without further intervention, thus leaving incomplete data for some subjects. Informed consent was obtained from them, whereas one officer decided not to participate, while two others decided not to submit blood samples after the curse. In the case of the 21 firing-range instructors were collected samples of blood only before the curse. Two of them, those who participated in the curse, collected blood after the curse, so these two instructors were exposed to the same air during the curse.

Blood samples were collected a day before the training curse and 12 h after the end of last training. Lead-free vacuum tubes containing EDTA were used by trained personnel at occupational health service center affiliated with the local police authorities. The samples were prepared following well-known methodologies (Mcshane et al., 2008; Smith et al., 2002). High purity de-ionized water (resistivity 18.2 $M\Omega\,cm^{-1}$) was used. All used reagents were analytical grade. All chemical solutions for Pb determination were stored in high-density polypropylene bottles. Blood samples were stored in 6 ml tubes at −20 °C. All tubes, plastic bottles, and glassware materials were previously cleaned by soaking in 10% v/v HNO_3 for 24 h, rinsing 6 times with Milli-Q water.

The samples were analyzed to ^{208}Pb isotope for BLL, using an Inductively Coupled Plasma Mass Spectrometer from Perkin Elmer model Elan DRC II. A Meinhard concentric nebulizer was used for sample introduction to a quartz torch, with peristaltic pumping and 2.0 μg/L of ^{193}Ir solution used as internal standard for quantification purposes.

To evaluate the accuracy of the measurements, SERONORM ™ whole blood Standard Reference Material and Blood Reference Materials produced by the New York State Department of Health as part of their Interlaboratory Program of Proficiency Testing were analyzed before and after 10 ordinary samples.

The total number of rounds, type of weapons and ammunition used in the three days curse are presented in Table 1. The differences in average BLL between the instructors group and the cadets before the curse and the cadets' samples before and after the curse were analyzed statistically via Graphpad Prism®.

Results

Two officers from the Instructors' group declared to have memory problems and weakness, one reported cardiac problems, one reported allergy, one reported renal insufficiency and one reported ulcerative colitis, three were regular smokers. Only one of the instructors reported recent firing range activity. The mean BLL for the instructors' group was 5.5 μg/dL and standard error 0.6; range 4.2–6.7 μg/dL (95% confidence). None of the cadets reported illness or symptoms related to lead intoxication. The cadets' mean BLL before the curse was 3.3 μg/dL and standard error 1.5; range 3.0–3.6 μg/dL (95% confidence). The means for these two groups were compared statistically (Unpaired *t*-test) and resulted significantly different ($P = 0.0019$) (see Fig. 1). After the curse the mean BLL in cadets' group increased to 18.4 μg/dL standard error 1.1; range 16–21 μg/dL (95% confidence). In all cases the BLL rose up (see Fig. 2). The means before and after the curse were compared statistically and showed significantly differences ($P < 0.0001$) in a paired *t*-test (see Fig. 3).

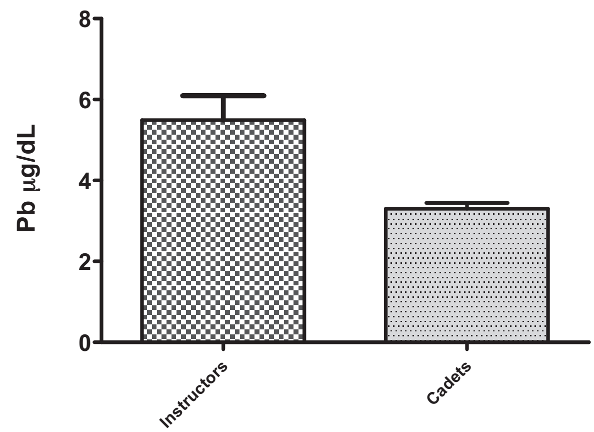

Fig. 1. Mean comparison between instructors' group ($n = 21$) and cadets' group ($n = 19$) before the training season.

The two instructors showed increments in BLL before and after the curse from 3.6 to 22.1 μg/dL in one case and 7.7 to 18.3 μg/dL in the second one.

Discussion

In this study occupational lead exposure in indoor firing ranges did not result in any case over passing the action limit (60 μg/dL) established in the Brazilian Legislation. Despite of this, these results indicate that the exposure to lead during firing training curses seems to constitute a health risk to Brazilian police officers, especially for those whose BLL increased up to more than 20 μg/dL (seven cases, including one instructor), incrementing risk of elevated blood pressure, adverse memory effects and kidney damage, especially for the instructors who are frequently exposed.

The differences among the cadets may be explained because of differences in physical strength and behaviors while breathing or breathing by mouth, as well as differences in the air intake during the training seasons. Increments up to 15 μg/dL in such a short period of time represents a risk to the health (ATSDR, 2007; Fewtrell et al., 2003; Kosnett et al., 2007).

In the group of firing-range instructors the mean values for the BLL (5.5 μg/dL) before the curse are comparable with the reported by Lofstedt et al. (1999) and NIOSH (2009) and the difference with the cadets group before the training season might indicate a risk concerning the occupational exposure in a less studied field when compared with exposures to lead in industry and might be related to the symptoms declared by the instructors.

The increment in BLL to the cadets and instructors, before and after the curse, is considered extremely significant taking into account the short period of time (3 days!) the personnel were exposed. They are higher (5–7 times) than those reported for other exposures (1.5–2 times) (Harlan, 1988; Nash et al., 2003; Pocock et al., 1988; Schwartz, 1988).

Considering all these facts is recommended that those whom BLL resulted in the range from 10 to 19 μg/dL (12 cases) must be informed about the risk, decrease the lead exposure, increase the biological monitoring and consider stopping the lead exposure if BLL does not decrease to less than 10 μg/dL. Those whom BLL are

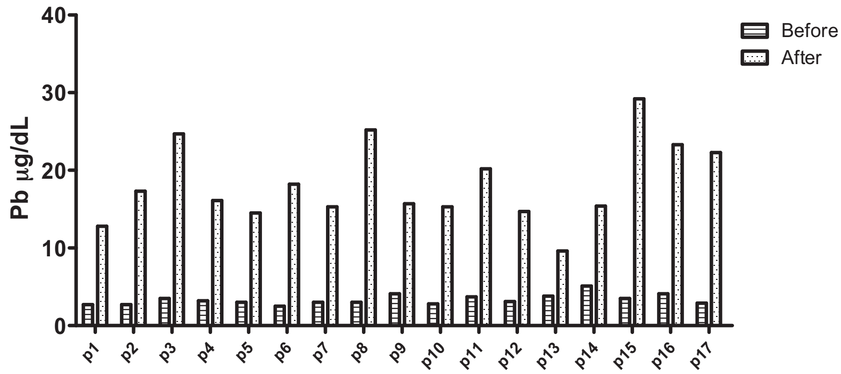

Fig. 2. Changes in cadets' BLL before and after the training season.

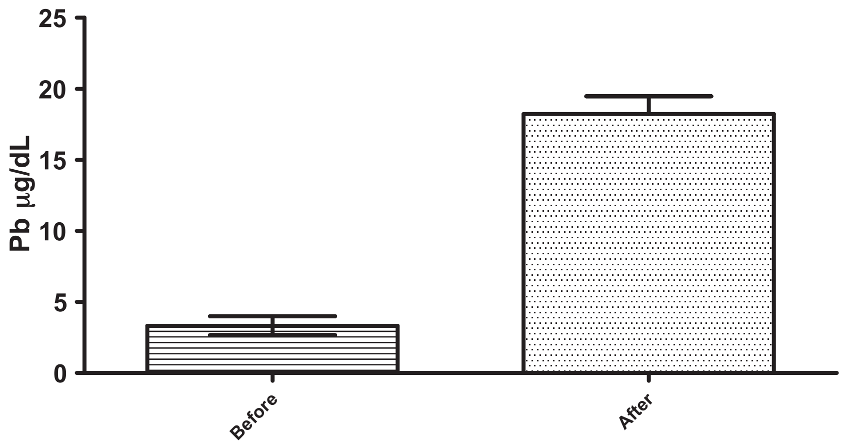

Fig. 3. Comparison between means before and after the training season in BLL from cadets (n = 17).

in the range from 20 to 29 µg/dL must be removed from exposure if repeated BLL in 4 weeks remains above or equal to 20 µg/dL (Kosnett et al., 2007). Others measures in order to minimize the GSR produced, as well as the optimization of the ventilation system must be priority.

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