Lead Exposure among Sport Shooters

Health effects

BPSA
Machelen
December 8th 2019

Paul Kollmann, MD

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Blood lead: reference values

– General population

- **Adults : < 100 µg/L (or 10 mg%)**
  –> median 25 µg/L ; P95 73 µg/L
  moderate toxicity : 100-400 µg/L
  severe toxicity : > 400 µg/L

- **Children 1-6 years-old : < 50 µg/L**
  –> median 14,8 µg/L ; P95 34,5 µg/L

– Exposed workers

- specific monitoring
  – from 100 µg/L (F) or 200 µg/L (M)
  moderate toxicity : 300-400 µg/L
  severe toxicity : 400-990 µg/L

- limit value
  – 300 µg/L (F), 400 µg/L (M)

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Lead Absorption

- Airways
- Digestive
- Skin
  - Notable only for organic derivatives (lead naphthenate or lead acetate)
- Adults, absorption of
  - 30–40% of inhaled lead
  - 10–15% of ingested lead

(Markowitz, 2000)

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Airways (Inhalation)

- Much more efficient route of absorption than ingestion

Toxicol Res (Camb). 2013 March 1; 2(2): 99–114.

- The emissions produced by firearms are ejected into the shooter's breathing zone

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- lead can be deposited in the respiratory tract dependent upon
  - the age of the person exposed
  - pre-existing conditions (i.e., asthma, COPD)
  - breathing patterns (i.e., nose or mouth breathing)
  - Airway makeup
  - Air-stream velocity within the respiratory tract
- Lead absorption is also influenced by
  - particle size
    - 50 à 70 % of lead is absorbed if particle size < 1µ. (Ellenhorn, 1988)
    - Particles <1 µm penetrate to alveoli and are subsequently absorbed by phagocytosis.
    - Particles >2.5 µm are deposited in the upper airways and can be cleared *via* mucociliary clearance.
    - Particles cleared by mucociliary clearance can be subsequently ingested, contributing to Pb exposure *via* ingestion.

Toxicol Res (Camb). 2013 March 1; 2(2): 95–114. doi:10.1039/C2TX20064C.

  - solubility

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Digestive

- Lead particles on the hands and secondly to the mouth
- For most professional exposure, lead absorption is mainly digestive
- Lead absorption after ingestion
  - *Much higher in pregnant woman and children*
    - (70 % of lead ingested vs adults 20 %).
  - Higher for small particle lead
- Increased by
  - fasting
  - Fat enriched diet
  - Iron deficiency
  - Diets low in calcium, in magnesium, in iron or in zinc.

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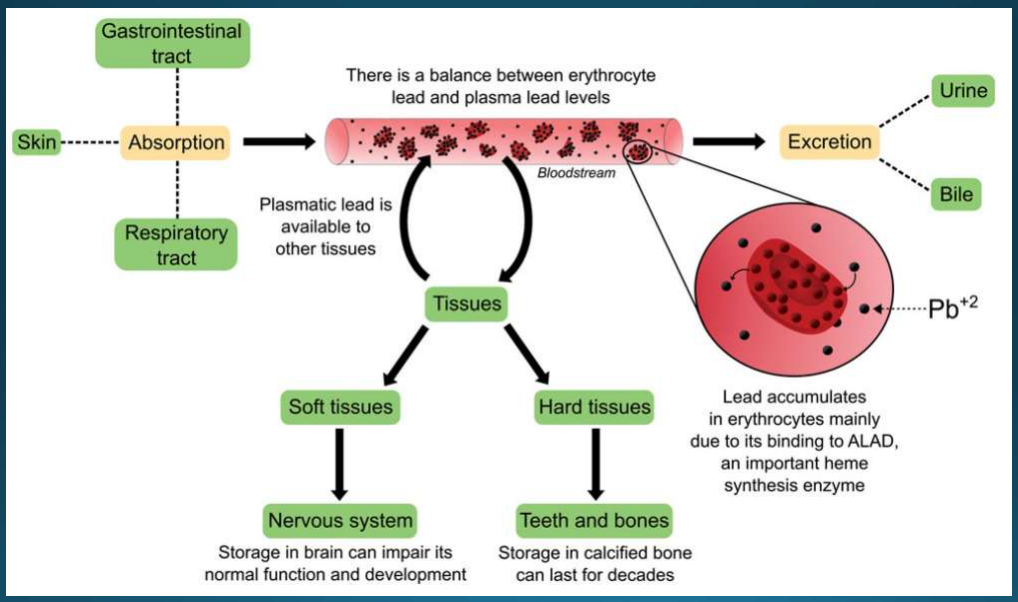

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Individual susceptibility and lead

- Diverse blood lead from a same exposure
- Different toxicity for a same blood lead

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Lead intoxication

- No threshold for lead
- Numerous clinical manifestations
- Type and intensity of symptoms depend on blood level of lead

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Acute Toxicity

- Rare
- Massive ingestion
  - Moderate and short duration digestive complains
  - Cytolytic hepatitis dosage-dependent
  - Moderate haemolyse dosage-dependent
  - Tubular nephropathy (rare)
  - Encephalopathy
  - Arthralgia
  - Blood lead always very high

–> > 1000 µg/L at day 2 ⇒ Severe Intoxication

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Chronic Toxicity

- Abdominal pain
- Encephalopathy
- Peripheric Neuropathy
- Other neurologic symptoms
- Renal disease
- High blood pressure
- Hyperuricemia
- Haematologics defects
  - Haem synthesis disorders
  - Anaemia
  - Red blood cells with basophilic granulations
- Cancer
- Reproduction
- Ophtalmologic

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Children and teenagers
Lead= toxic without threshold

Behaviour disorders

- Attention disorders (ADHD attention-deficit hyperactivity disorder)
  - Even for lead ***< 50 µg/L***

- Risk excess of criminal or/and antisocial behaviour in relationship with dosage of blood lead
  - ***–6-15 years-old***
  - ***– even lead < 100 µg/L***
  - ***– no threshold***

  Even after adjustments
  - » Socio-economic, cultural, etc.
  - » IQ

Cognitive changes

- Neurotoxic effects without any threshold
- Inverse correlation between blood lead and IQ
  - For a rise of blood lead of 100 µg/L, loss of 1-7 points of IQ
  - Children less than 10 year-old showed a 3,9 points IQ lowering as blood lead rises from 2,4 to 10 mg%. (Lanphear et al.)
  - Persistent cognitive deficit
    - From childhood to adulthood

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Children and teenagers

Delayed puberty

– Sufficient evidence even for low lead doses
  - Teste size, breast development, delayed menarche, …

Failure-to-thrive

– Sufficient evidence for low lead doses
– Inverse association between blood lead and
  - Height, head circumference, weight, thoracic circumference,…

– persistent effect for blood lead ***< 100 µg/L***

Hearing problems

- Sufficient evidence ***in children***
- ***no threshold***
- 2 dB hearing reduction for a blood lead increase of 60 to 180 µg/L

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Pregnancy

Mother

- Pregnancy-induced hypertension.
- Increased mobilization of skeletal lead during pregnancy and lactat
- Lead crosses the placental barrier
  - At birth, mother and child blood lead are similar.
- Lead excretion into breastmilk
  - Breastmilk lead concentration is 10-50 % of blood lead concentration

Foetus

- Lead accumulate in fetal bone
- Foetotoxicity correlated to blood lead :
  - Foetal growth retardation, decrease of cranial perimeter, delayed intellectual and psychomotor development
  - Increased risk of abortion, premature birth,
    - Sufficient evidence if lead ***> 250 µg/L***
    - Limited evidence if lead < 100 µg/L
  - Premature rupture of the placenta
  - Stillborn
- Intrauterine growth retardation if exposure to lead of the mother or the father

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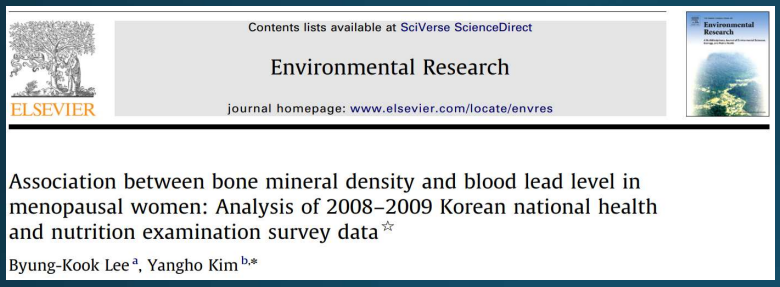
Menopause



Contents lists available at SciVerse ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Association between bone mineral density and blood lead level in menopausal women: Analysis of 2008–2009 Korean national health and nutrition examination survey data ☆

Byung-Kook Lee [a], Yangho Kim [b,*]

Postmenopausal bone mineral resorption is related to increased blood lead levels in menopausal women

- Premenopausal women had a geometric mean blood lead level of 2.000 mg/dL, compared with 2.274 mg/dL and 2.336 mg/dL for naturally and surgically menopausal women, respectively.

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How does the shooter absorb lead ?

- Inhalation
- Swallowing

→ Ratio ?

- Varies following
  - Range
    - Indoor
      - Adequate ventilation ?
    - Outdoor
  - Shooter's habits
    - Hands' washing
    - …

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Lead exposure by the shooter

- Primer
  - -> *lead vapours*
- Bullet
  - Handling of bullets (shooting, reloading) -> *lead dust*
  - Lead from the Barrell
    - Scratches on the bullet from the barrel grooves (tearing of the bullet's walls)
    - Lead vapour from the bullet base (except TMJ)
    - Lead vapour from the action of gazes on the bullet's wall (non jacketed bullet, …)
  - Lead from the impact of the bullet-> *lead dust*
  - Making of bullets-> *lead vapours*
- Powder
  - "The propellant is considered to contribute minimally to blood lead because of its very low concentration of ~2 ppm Pb "

B.L. Gulson et al. /The Science of the Total Environment 293 (2002) 143–150

- Lead on the range
  - Dust lead on the floor, the walls

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« Classic » primer

- lead styphnate and tetrazine
  - sensitive explosive ingredients
- barium nitrate
  - provides additional oxygen to increase the temperature of the flame
- antimony sulfide
  - fuel to prolong the burning time
- Aluminum, and occasionally magnesium
  - mainly in the higher powered magnum pistol or rifle calibers
  - produce a shower of white-hot particles to aid propellant ignition
- Powdered glass
  - often added to the mixture to increase the friction and assist detonation

Primer, composed of approximately 35% lead styphnate and lead peroxide

Laidlaw et al. Environmental Health (2017) 16:34

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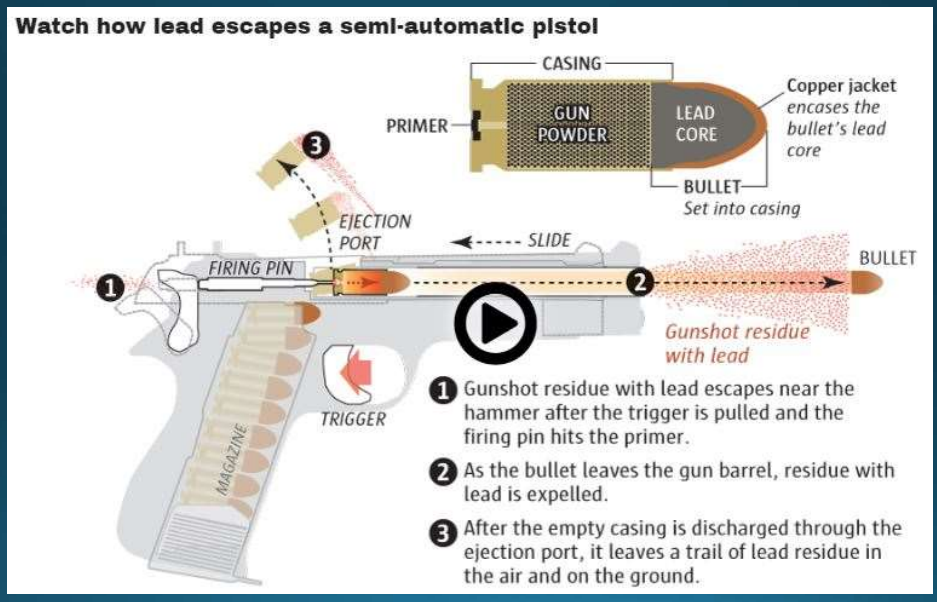

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Unprotected by clothes
- Face
- Hands and forearms

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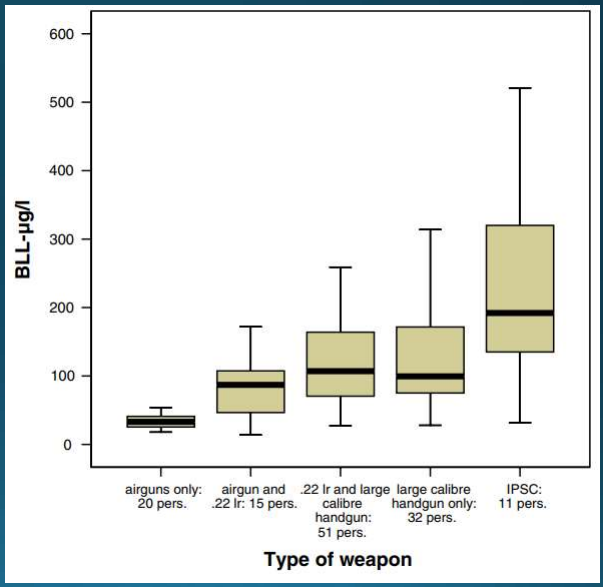
Int Arch Occup Environ Health (2009) 82:539–542
DOI 10.1007/s00420-008-0348-7

SHORT COMMUNICATION

High blood lead levels in recreational indoor-shooters

Matthias Demmeler · Dennis Nowak · Rudolf Schierl

- 129 shooters (120 male)
- 11 clubs
- In the surveys of 1998 the blood lead data of 3,974 Germans (age 25–69 years) have been measured and revealed a median BLL 33 µg/l
- Marksmen had exceptional BLLs but **in particular the IPSC-shooters**, since they are the ones who use up a lot of rounds per training session and move around on the range while shooting



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Annual mean lead concentrations in 2016

µg/m³ ≤ 0.02 0.02-0.10 0.10-0.50 0.50-1.00 > 1.00

No data

Countries/regions not included in the data exchange process

Table 1.1 Air quality standards for the protection of health, as given in the EU Ambient Air Quality Directives

Pollutant	Averaging period	Legal nature and concentration	Comments
PM_{10}	1 day	Limit value: 50 µg/m³	Not to be exceeded on more than 35 days per year
	Calendar year	Limit value: 40 µg/m³	
$PM_{2.5}$	Calendar year	Limit value: 25 µg/m³	
		Exposure concentration obligation: 20 µg/m³	Average Exposure Indicator (AEI) (a) in 2015 (2013-2015 average)
		National Exposure reduction target: 0-20 % reduction in exposure	AEI (a) in 2020, the percentage reduction depends on the initial AEI
O_3	Maximum daily 8-hour mean	Target value: 120 µg/m³	Not to be exceeded on more than 25 days/year, averaged over 3 years (b)
		Long-term objective: 120 µg/m³	
	1 hour	Information threshold: 180 µg/m³	
		Alert threshold: 240 µg/m³	
NO_2	1 hour	Limit value: 200 µg/m³	Not to be exceeded on more than 18 hours per year
		Alert threshold: 400 µg/m³	To be measured over 3 consecutive hours over 100 km² or an entire zone
	Calendar year	Limit value: 40 µg/m³	
BaP	Calendar year	Target value: 1 ng/m³	Measured as content in PM_{10}
SO_2	1 hour	Limit value: 350 µg/m³	Not to be exceeded on more than 24 hours per year
		Alert threshold: 500 µg/m³	To be measured over 3 consecutive hours over 100 km² or an entire zone
	1 day	Limit value: 125 µg/m³	Not to be exceeded on more than 3 days per year
CO	Maximum daily 8-hour mean	Limit value: 10 mg/m³	
C_6H_6	Calendar year	Limit value: 5 µg/m³	
Pb	Calendar year	Limit value: 0.5 µg/m³	Measured as content in PM_{10}
As	Calendar year	Target value: 6 ng/m³	Measured as content in PM_{10}
Cd	Calendar year	Target value: 5 ng/m³	Measured as content in PM_{10}
Ni	Calendar year	Target value: 20 ng/m³	Measured as content in PM_{10}

Notes: (a) AEI: based upon measurements in urban background locations established for this purpose by the Member States, assessed as a 3-year running annual mean.

(b) In the context of this report, only the maximum daily 8-hour means in 2016 are considered, so no average over the period 2014-2016 is presented.

Sources: EU, 2004, 2008.

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Erhöhte Bleiaufnahme in geschlossenen Schießständen

P. Mühle, R. Schierl, D. Nowak

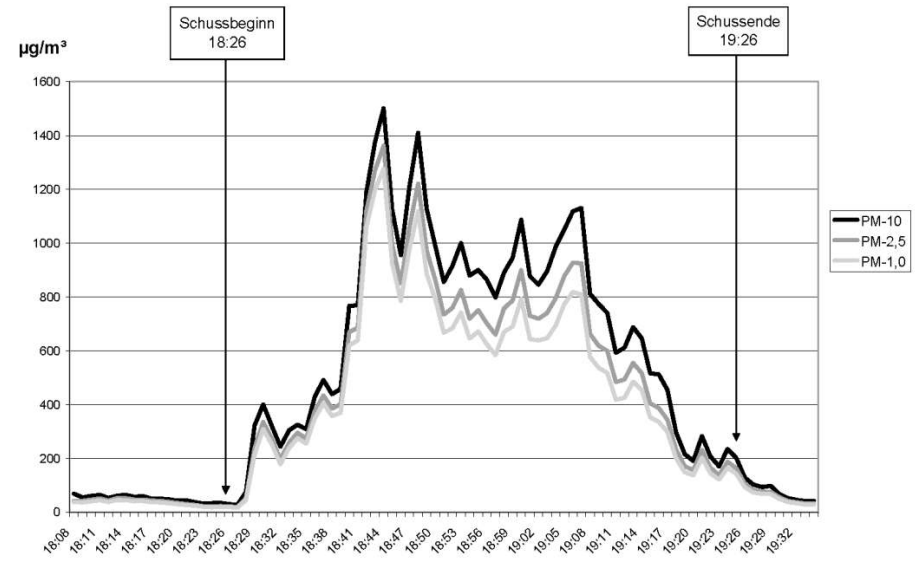

Bild 1. Zeitlicher Verlauf der Immission während des Probandenversuchs ohne FFP2-Masken.

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Prevention

- TMJ or FMJ ammo
- Lead-free primers
- On shooting prone, place a shield between the floor and the shooter
- Wearing (disposable) gloves during brass picking
- No drinking, eating or smoking on the range.
- Hygiene
  - Washing hands, forearms and face immediately after shooting, cleaning guns , picking brass, or reloading and before eating, drinking, smoking, contacting other people
  - Use of cold water(hot water opens cutaneous pores)
  - Use of soap (heavy metals specific ?)
- Blowing his nose after the shooting

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Prevention

- Change of clothes and shoes before quitting the range
- Wash separately shooting clothes (not with family clothes)
- No dry sweeping of the floor, never !
  - Wet cloth or HEPA vacuum
- An indoor shooting range must present an continuous airflow of at least 0,15 m/s, with a high air extraction (depression in the range)
  - Poor ventilation can increase hazards raising floor dusts and putting it back in the air circulating.
  - A range should show rigorous cleanliness with no shooting residue.
- Wearing of full protective cloth and mask with HEPA filters during maintenance operation
- Checking lead blood : 1-2 times/year
  - depending on last results.

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Methods That Can Reduce Exposure To Lead

- Range redesign, including installation of appropriate ventilation systems, showers, locker rooms, and eating areas separate from the range.
  - In particular, the shooting range heating, ventilating, and air conditioning systems can be designed to maintain negative pressure to adjacent non shooting areas.
  - Because all of these can be expensive to install, it is difficult to envision private ranges, such as rod and gun clubs, implementing these suggestions.
- However, all ranges can and should be cleaned regularly to avoid accumulation of lead-laden dust.
- The facility walls, structures, tables, chairs, and partitions should have washable surfaces to ameliorate cleaning operations
- Employees should be provided with annual training on lead exposure hazards, health effects of lead exposure, and protective measures to reduce lead exposure at the facility.

Kitty H. Gelberg PhD, MPH & Ronald DePersis BA (2009) Lead Exposure Among Target Shooters, Archives of Environmental & Occupational Health, 64:2, 115-120

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Some Conclusions

- Importance of primer's lead for lead blood levels
- Shooter breathes mainly its own shot's lead

→ use of lead free primer

- Importance of cleaning lead dust on the range
- Lead absorption by hands-mouth contact

→ use of gloves to collect cases
prevention by Ca intake ?

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Shooting sport and lead issue

- Most studies published concern adults or children with environmental exposure to lead
  - « low » levels of exposure
  - Permanent exposure
  - Diffuse localization
- Most studies evaluating lead issues in shooting
  - Police, army, …
  - State shooting range
  - Old studies
- Practice of shooting sport
  - Known time of exposure
  - Limited duration of exposure
  - High level of exposure
  - High rounds count
  - Precise spot of exposure
  - Civilian shooting range

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Belgian sport shooters and lead

- Study in collaboration with Pr Haufroid, toxicology laboratory, of Cliniques Universitaires St Luc, Brussels
- Concern every sport shooter (and her/his family)
- Goal :
  - Better knowledge of lead hazards in sport shooter, especially IPSC shooter
  - Getting better shooting conditions (cleaning, …)
  - Sensibilization to lead hazards (young women, children !)
  - Usefulness preventing digestive absorption of lead by calcium intake in sport shooters?

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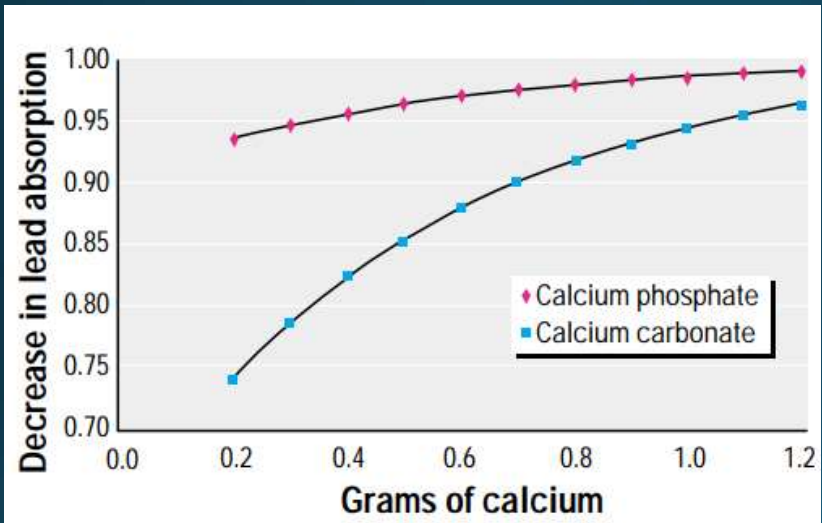

Figure 1. Decreases in lead absorption in the presence of calcium and phosphorus [data from Blake and Mann (*20*)].

***Environ Health Perspect* 109:283–288 (2001).**

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1st part

- Quick evaluation of general knowledge of lead hazards
- Presentation for sensibilization on lead hazards

- Written evaluation of shootings habits
- Blood lead dosage
  - Shooter
  - Family
- Medical questionnaire if joining the second part of the study with intake of calcium

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2nd part, a

- Selection and exclusion following risk profile

- 2 g Ca intake before every shooting session
  - Prevents digestive lead absorption
- Short written overview of every shooting session

- Blood test at 3, 6, 9 and 12 months
  - Lead at 6 and 12 months
  - Ca at 3, 6, 9 and 12 months

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2nd part, b

- For those not included or not willing to be included in the part of the study with calcium intake
  - Short written overview of every shooting session
  - Blood lead at 6 and 12 months

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- The participants assume on their own the cost of the calcium intake
  - Equivalent to the price of two 9 mm ammo per shooting session
- Blood samples must be sent to the laboratory of toxicology of UCL, Brussels
  - Known expertise in lead dosage
  - To allow accurate comparison between samples

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To join the study

- Send me
  - Last name, given name
  - national number
  - Address
  - E-mail
- I send you back
  - Informed consent form and explanation of the study
  - Short quiz on lead hazards
  - A retrospective questionnaire on your shooting habits
  - Blood test request
    - You can add your general practitioner on the request form if you want to.
  - Medical questionnaire (If you wish to enter the 2nd part with calcium intake)

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2ND PART

I send you

A)

- Medical prescription to buy calcium
- Short questionnaire on shooting sessions
- Blood request form
  - Months 3, 6, 9, 12
- Short final questionnaire on shooting habit changes

B)

- Short questionnaire on shooting sessions
- Blood request form
  - Months 12
- Short final questionnaire on shooting habit changes

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KOLLMANNPAUL@HOTMAIL.COM

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