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Marksmanship and Adolescent Youth Lead Exposure

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Moderator: Marissa Hauptman, MD, MPH, FAAP
Acknowledgements

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1. Discuss potential sources of lead exposure at the firing range and how that translates to appropriate questions to ask the patient.

2. Describe personal protective and hygiene measures that reduce/prevent exposures from shooting.

3. Describe measures to control lead exposure in the firing range environment.

4. Discuss potential adverse health effects of lead exposure to adolescents.

5. Describe a strategy of medical surveillance that a health care provider could recommend.
Lead Exposures at Firing Ranges
Scenario #1

• A parent brings in 16 year old son who is a competitive marksman (shooter) because he heard there may be lead exposure at the shooting range
• What would be the sources of the exposure?
• What additional questions should I be asking?
• Should you get a blood lead level (?)
  • YES
  • NO
• If yes, what will I do with the results?
What is competitive marksmanship?

- Shooting guns for accuracy is known as “marksmanship”
- Recreational junior shooting clubs ages 8-10
- Competitive shooting teams high schools, colleges and national and junior Olympics programs
- Olympics have 9 different shooting events, pistols and rifles, 3 positions
- There are 16,000-18,000 indoor firing ranges in the U.S.  
  MMWR Morb Mortal Wkly Rep 63(16): 347-351
Where does lead come from?

- Discharge from the bullets (most leaded): pull trigger, firing pin causes the primer (lead styphnate) to start combustion of gunpowder -> burning-heat, creating pressure, propels bullet down the barrel to the target
- Lead vaporized at base of bullet, released at muzzle
Where does the lead come from?

- Second hand fume
- Dust on mats and surfaces
- Dry sweeping
- Retrieving bullets from targets
- Drinking, eating at range
- Cleaning firearm
- Take home dust clothes, shoes
Are there cases or studies showing lead exposure from firing ranges?

- Study of teen shooters in Central Alaska, 2004 (BLL 21-31 mcg/dL)
  MMWR Rep 2005; 54:577-579

  MMWR Rep 2014; 63:347-351

- S. Africa study: 4 shooting ranges Johannesburg and Pretoria, 67 adult shooters
  BLL 2-60 mcg/dL, mean 12.3, median 9.3
Are there cases or studies showing lead exposure from firing ranges?

  - Vancouver Rifle and Pistol Club, 2010 BLL tests, 20 youths BLL 0.6 mcg/dL-mean 9.29, 14 yo = 20 mcg/dL; contaminated surfaces, poor ventilation
  - Other examples of firing ranges, some run by volunteers, some in schools, poor maintenance, + surface contamination, inadequate ventilation
Potential health effects of lead exposure on adolescents
What are our concerns about lead exposure in adolescents?

- Maturation of adolescent brain—continued myelogenesis; lead effects myelin;
- Potential long terms effects even with BLL’s <10-20 mcg/dL
  - Renal-decrease function over time
  - Cardiac-increased risk for hypertension and cardiac events
  - Hematological, particularly with BLL’s > ~20 mcg/dL
  - Increased risks of long term neurological effects
- Storage of lead in bone, equilibrium with the blood, mobilization later (conditions increased bone turnover, like pregnancy/breast feeding)
Table 1.2: NTP conclusions on health effects of low-level Pb by major health effect areas

<table>
<thead>
<tr>
<th>Health Area</th>
<th>Population or Exposure Window</th>
<th>NTP Conclusion</th>
<th>Principal Health Effects</th>
<th>Blood Pb Evidence</th>
<th>Bone Pb Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurological</td>
<td>Prenatal</td>
<td>Limited</td>
<td>Decrease in measures of cognitive function</td>
<td>Yes, &lt;5 µg/dL</td>
<td>No data</td>
</tr>
<tr>
<td>Children</td>
<td></td>
<td>Limited</td>
<td>Decreased IQ, increased incidence of attention-related and problem behaviors, decreased hearing</td>
<td>Yes, &lt;10 µg/dL</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sufficient</td>
<td>Decreased academic achievement, IQ, and specific cognitive measures; increased incidence of attention-related and problem behaviors</td>
<td>Yes, &lt;5 µg/dL</td>
<td>Tibia and dentin Pb are associated with attention, behavior, and cognition.</td>
</tr>
<tr>
<td>Adults</td>
<td></td>
<td>Sufficient</td>
<td>Decreased hearing</td>
<td>Yes, &lt;10 µg/dL</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limited</td>
<td>Increased incidence of essential tremor</td>
<td>Yes, &lt;10 µg/dL</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limited</td>
<td>Psychiatric effects, decreased hearing, decreased cognitive function, increased incidence of ALS</td>
<td>Yes, &lt;10 µg/dL</td>
<td>The association between bone Pb and cognitive decline is more consistent than blood.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limited</td>
<td>Increased incidence of essential tremor</td>
<td>Yes, &lt;5 µg/dL</td>
<td>No data</td>
</tr>
<tr>
<td>Immune</td>
<td>Children</td>
<td>Limited</td>
<td>Increased hypersensitivity/allergy by skin prick test to common allergens and IgE* (not a health outcome)</td>
<td>Yes, &lt;10 µg/dL</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td>Adults</td>
<td>Inadequate</td>
<td>Asthma, eczema</td>
<td>Unclear</td>
<td>No data</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Children</td>
<td>Inadequate</td>
<td>–</td>
<td>Unclear</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td>Adults</td>
<td>Inadequate</td>
<td>–</td>
<td>Unclear</td>
<td>No data</td>
</tr>
<tr>
<td>Renal</td>
<td>Children &lt;12 years old</td>
<td>Inadequate</td>
<td>–</td>
<td>Unclear</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td>Children ≥12 years old</td>
<td>Limited</td>
<td>Decreased glomerular filtration rate</td>
<td>Yes, &lt;5 µg/dL</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td>Adults</td>
<td>Sufficient</td>
<td>Decreased glomerular filtration rate</td>
<td>Yes, &lt;5 µg/dL</td>
<td>Yes, one study</td>
</tr>
<tr>
<td>Reproductive and Developmental</td>
<td>Prenatal</td>
<td>Limited</td>
<td>Reduced postnatal growth</td>
<td>Yes, &lt;10 µg/dL</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td>Children</td>
<td>Sufficient</td>
<td>Delayed puberty, reduced postnatal growth</td>
<td>Yes, &lt;10 µg/dL</td>
<td>One study does not support effects of bone Pb on growth.</td>
</tr>
<tr>
<td></td>
<td>Adults</td>
<td>Sufficient</td>
<td>Reduced fetal growth</td>
<td>Yes, &lt;10 µg/dL</td>
<td>Maternal tibia Pb is associated</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Limited</td>
<td>Increase in spontaneous abortion and preterm birth</td>
<td>Yes, &lt;10 µg/dL</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>Sufficient</td>
<td>Adverse changes in sperm parameters and increased time to pregnancy</td>
<td>Yes, ≥15-20 µg/dL</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td>Limited</td>
<td>Decreased fertility</td>
<td>Yes, ≥10 µg/dL</td>
<td>No data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limited</td>
<td>Increased spontaneous abortion</td>
<td>Yes, ≥31 µg/dL</td>
<td>No data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adults</td>
<td>Inadequate</td>
<td>Stillbirth, endocrine effects, birth defects</td>
<td>Unclear</td>
<td>No data</td>
</tr>
</tbody>
</table>
Preventive Strategies
Gun Marksmanship and Youth Lead Exposure: A Practice-Oriented Approach to Prevention

Rose Hannah Goldman, MD, MPH\textsuperscript{1,2,3,4}, Alan D. Woolf, MD, MPH\textsuperscript{2,4}, and Mateusz P. Karwowski, MD, MPH\textsuperscript{4}
<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Table 1. Personal Protective and Hygiene Measures.</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Use full protective outer shooting clothing, shooting shoes, and/or shoe covers.</td>
</tr>
<tr>
<td>2.</td>
<td>No eating, drinking, or smoking inside the firing range.</td>
</tr>
<tr>
<td>3.</td>
<td>Wash hands, forearms, and face before eating, drinking, or smoking. Soap and water may not fully remove lead dust. It is better to use lead decontamination wipes after shooting, handling spent cartridge cases, or cleaning the guns. NIOSH developed a decontamination towel that is commercially available, called &quot;Hygenall Decontamination Towels&quot; (wipes), which reportedly removes 98% of lead (<a href="http://www.cdc.gov/niosh/topics/lead/prevention.html">http://www.cdc.gov/niosh/topics/lead/prevention.html</a>).</td>
</tr>
<tr>
<td>4.</td>
<td>Avoid shooting in a prone position, when possible, and when doing it, place a piece of paper or other disposal material on the mat or floor. Clean any mat or knee pads after each use.</td>
</tr>
<tr>
<td>5.</td>
<td>Shooters should shower, whenever possible, after shooting and change into clean clothes and shoes, to avoid &quot;take home lead&quot; contamination of vehicles and homes. Put contaminated clothing in a bag and wash separately from other clothing.</td>
</tr>
<tr>
<td>6.</td>
<td>Consider use of non-lead-containing primers.</td>
</tr>
<tr>
<td>7.</td>
<td>Consider use of non-ledged or fully jacketed bullets. (This is not a complete solution if other shooters are still using leaded ammunition.)</td>
</tr>
<tr>
<td>8.</td>
<td>Do not make your own lead bullet &quot;slugs.&quot;</td>
</tr>
<tr>
<td>9.</td>
<td>Pregnant young adults should be advised about possible risks of lead exposure to their fetus, and consider avoidance of shooting and potential lead exposure during pregnancy.</td>
</tr>
<tr>
<td>10.</td>
<td>Use other recommended personal protective equipment, including eye protection and hearing protection.</td>
</tr>
</tbody>
</table>
Table 2. Measures to Control Lead at the Firing Ranges.

1. Shooting ranges should have well-designed and maintained ventilation systems that take lead fume and particles away from the shooter.\textsuperscript{6,13}
2. Ventilation systems should receive routine measurements of effectiveness (ideally every 3 months)\textsuperscript{13} unless there are automatic alert systems.
3. Air should be exhausted at or behind the bullet trap.
4. Ventilation system of the range should be separate from the rest of the building's general ventilation.
5. An air filtration system should be installed, and filters changed at recommended frequency.
6. Proper housekeeping avoids dry sweeping, and regular cleaning of horizontal surfaces with detergents, or if necessary a lead cleaning agent (such as Hygenall Leadoff Wipes).\textsuperscript{13}
7. Cleaning the floor should be performed by wet mopping or use of an explosion-proof high-efficiency particulate air (HEPA) vacuum cleaner.
8. Children and adolescents should not participate in range maintenance or clean up.\textsuperscript{5}
9. Shooters and workers should be provided with lockers and places to wash.
10. Use only properly set up shooting ranges for practices and competitions. Coaches should inspect the shooting ranges for proper ventilation, maintenance, and housekeeping.
What is the Role of the Practitioner?
Patient comes in inquiring about BLL after identifying concerns about lead exposures from shooting ranges

Youth comes in for a routine exam, and you learn that this person is on the shooting team (scenario #2)

- What questions to ask?
- What advice to give?
- Check BLL? Then what?
Questions to ask about personal use and hygiene

- Do you know that there is a risk of possible lead exposure from shooting guns? (scenario #2)
- Do you shoot pistols, or rifles, and about how often?
- Do you shoot in the standing or prone position? If so, do you clean the mat? [Note: prone has more risk of exposures]
- Do you eat or drink at the range? How do you clean your hands?
- What type of bullets do you use? Do you make your own leaded bullets?
- Do you use special shooting clothes? Do you wash these clothes separately from the usual?
- Do you ever help with clean up, or retrieval of bullets from the targets, or the target?
Questions to ask about the firing range

- Do you tend to shoot at the same ranges, or different ones?
- How do you perceive the control measures the ranges you go to:
  - Is there visible dust on surfaces (floor, tables, chairs)?
  - Is the ventilation system adequate? Air moving from behind the shooter to the target? Know anything about maintenance and effectiveness of the system?
  - What is the process for clean up-dry sweeping, wet mopping/wiping, use of special (hepa filter) vacuum?
Should I check a blood lead level?

YES, but….

- Check a venous blood lead rather than capillary given the risk for external contamination, and need for greater accuracy.
- Have a plan for what to do when you get the results.
- Risk and benefits balancing act: these are youths on a team who want to compete now vs increase in future risks (since most will not be symptomatic from mild elevations of lead now).
What are guides for medical surveillance actions for blood lead levels?

- None specifically directed to adolescents
- Occupational Safety and Health Administration (OSHA)
  - 1978 standard—out of date, directed to workers, allows for BLL $\leq 40$ mcg/dL
- Council of State and Territorial Epidemiologists (CSTE)
  - Remove workers from exposure with BLL of 30 mcg/dL, or 20 mcg/dL if persists for 1 month after attempts to control exposures
What are guides for medical surveillance actions for blood lead levels?

- **U.S. Dept of Defense (USDoD) Revision 2017:**
  - Remove military personnel with 1 BLL > 30 mcg/dL
  - Advise about reducing exposure for BLL’s <29 mcg/dL
  - Remove from exposure if follow up BLL of 20 mcg/dL
  - Return to lead exposures (with proper protective measures) if BLL is ≤ 15 mcg/dL

- **U.S. Dept of Health and Human Services:**
  - Given that NHANES geometric mean for U.S. adults is 1.2 mcg/dL
  - Case definition for an elevated BLL for adult is >5 mcg/dL
  - HHS recommends BLL for adults be reduced to <10 mcg/dL given potential for long term health effects
At what level do you think the marksman should be advised to stop shooting?

1. $\geq 5$

2. $\geq 10$

3. $\geq 15$
Our (PEHSU) current approach

- **BLL < 5 mcg/dL**: no action but continue to monitor periodically
- **BLL ≥ 5 to <10 mcg/dL**: review exposures, personal hygiene, firing ranges (may need to stop using dirty ones) - offer suggestions (see tables), implement changes. Retest BLL in ~1 month
- **BLL > 10 mcg/dL**: Temporarily stop shooting; review all controls and exposures measures and implement changes. Retest BLL in ~1 month, resume shooting when BLL < 10 mcg/dL
Be proactive: if you learn a patient is a competitive shooter, ask questions about personal shooting practices, hygiene, and condition of shooting ranges.

Educate about potential exposure to lead, health risks, and methods to control exposure.

Check BLL if patient and parents agreeable.

Take appropriate actions based upon the BLL level.

If involved at a school with a shooting team, advise about risks of lead exposure, control methods, and consideration of medical surveillance for team members and coaches.

Summary: Role of Practitioner
OTHER QUESTIONS???
Useful References

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