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CHEMICAL COMPOSITION OF PELLETS AND THEIR IMPACT ON HUMAN HEALTH

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ХИМИЧЕСКИЙ СОСТАВ ПУЛЕЙ И ИХ ВЛИЯНИЕ НА ЗДОРОВЬЕ ЧЕЛОВЕКА

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Abstract

The increased use of pellet guns by various so-called law enforcement authorities around the globe necessitates an in-depth investigation into the nature of these pellets to grasp their potential impact on human health. This discourse provides a comprehensive assessment of the chemical ingredients found in these pellets and studies their biocompatibility, along with deriving implications for general health. A primary focus is cast upon recognizing which chemicals are utilized in pellet fabrication, thereby shedding light on any hazardous substances present with a propensity for negatively affecting health. Additionally, exploring how these compounds interact within our physiological systems when inflicted by a pellet strike hosts significant worth; this encompasses both immediate bodily response and prospective long-term complications. This article takes expertise from diversified fields such as chemistry, biomedical science, and public health to distinctly illuminate the complex interaction existing between pellet composition and its impact on human wellness.

***Keywords*:** Air guns, pellets, lead, chemical composition, biocompatibility, human health.

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Аннотация

Дүйнө жүзү боюнча түрдүү укук коргоо органдары тарабынан ок атуучу тапанчаларды колдонуу көбөйдү. Бул октордун адамдын ден соолугуна тийгизген таасирин түшүнүү үчүн алардын табиятын терен изилдөөнү талап кылат. Макалада октун курамындагы химиялык заттарга жана алардын биологиялык шайкештигине, жалпы ден соолукка тийгизген таасирине ар тараптуу баа берилет. Ок чыгарууда колдонулган кошулмалардын биздин физиологиялык системаларыбызда кандайча өз ара аракеттенишээрин изилдөөнүн чон маани бар, алар организмдин заматтагы реакциясын жана узак мөөнөттүү ооруларды алып келет. Макала химия, биомедицина жана коомдук саламаттыкты сактоо сыяктуу ар түрдүү тармактардагы билимдерге таянып, октун курамы менен адамдын ден соолугуна тийгизген таасиринин ортосундагы татаал байланышты ачык көрсөтөт.

Ачкыч сөздөр: Пневматикалык мылтыктар, ок, коргошун, химиялык курам, био шайкештик, адамдын ден соолугу.

ХИМИЧЕСКИЙ СОСТАВ ПУЛЕЙ И ИХ ВЛИЯНИЕ НА ЗДОРОВЬЕ ЧЕЛОВЕКА

Аннотация

Все более широкое использование пистолетов правоохранительными органами по всему миру обусловливает необходимость углубленного изучения природы этих пуль, чтобы понять их потенциальное воздействие на здоровье человека. В данной работе дается всесторонняя оценка химических веществ, содержащихся в этих пулях, и изучается их биологическая совместимость и влияние на общее состояние здоровья. Основное внимание уделяется выяснению того, какие химические вещества используются при изготовлении гранул, способные негативно влиять на здоровье. Кроме того, как эти соединения взаимодействуют в наших физиологических системах, когда они наносятся ударом гранулы, имеет значительную ценность, это включает в себя как немедленную реакцию организма, так и предполагаемые долгосрочные осложнения. В этой статье использованы знания из различных областей, таких как химия, биомедицина и общественное здравоохранение, чтобы четко осветить сложное взаимодействие, существующее между составом гранул и его влиянием на здоровье человека.

***Ключевые слова*:** Пневматическое оружие, пуля, свинец, химический состав, биологическая совместимость, здоровье человека

Introduction

A pellet gun, alternatively referred to as an air gun or air rifle, represents a specific category of firearm engineered to use compressed gas or air to discharge projectiles. These are typically miniature pellets composed of lead or alloy. Air guns gain popularity for their versatile applications such as recreational shooting, pest management, and in certain circumstances, hunting small game.

Fig. 1. General Design of Airguns

Pellet guns exhibit several designs like break-barrel models, CO2-powered variants, and pump-action versions. They constitute a popular choice for target practice exercises or plinking (informal target shooting). Generally perceived as lower in magnitude compared to traditional firearms, pellet guns prove ideal for backyard activities and training applications due to their tailored power output [1].

Pellets for airguns are typically crafted in the diabolo design, which takes its name from a traditional juggling activity. The term 'diabolo' originates from the Latin word 'Diabolus,' referring to a devil, fittingly incorporated due to the sport's early title as ‘devil on two sticks’ that involved manipulating a dual-headed bobbin using a string stretched between two rods.

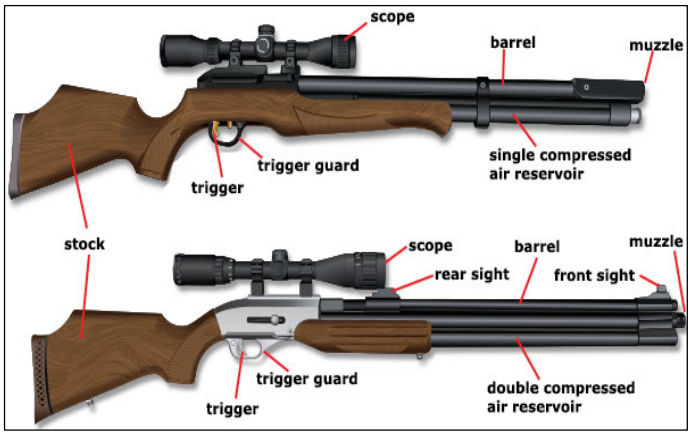

Fig 2. A range of "diabolo" pellets with various nose profiles

The construction of an airgun pellet mirrors this dual-headed bobbin structure featuring a solid head, broad skirt, and constricted waist. The skirt’s circumference meshes firmly with the internal rifling of the airgun barrel, generating significant spin resulting in a linear flight trajectory. A smaller diameter is maintained for the pellet's head than its skirt to minimize frictional

interaction with the inner firearm bore. Meanwhile, no contact occurs between the compressed medial zone termed waist and the gun bore.

Traditionally, airgun pellets have been produced using Lead (Pb - derived from the Latin term *'plumbum'*) or a combination of various lead alloys. Lead, being a soft and heavy metal that is also cost-effective, is less hard than steel - the material commonly used to make gun barrels. This peculiarity is relevant as it ensures that friction between the pellet and the barrel does not result in significant wear on the barrel's interior. This innate softness of lead becomes particularly crucial when an airgun pellet impacts its target - a vital factor in hunting or pest control activities. Upon impact with a surface, rather than maintaining its original form, an airgun pellet deforms - resulting in a larger wound thereby facilitating efficient and humane extermination efforts. Commonly found paired with antimony (Sb - originating from the Latin word 'stibium'), this semi-metallic element contributes to enhancing hardness levels within these combined lead alloy airgun pellets [2].

Recently, manufacturers have made pellets from alternative metals such as tin-bismuth alloys as well as versions containing compositions of iron, zinc, and tin. An existing trend worth noting illustrates the use of plastic in modern ammunition production [2].

Background

Pellets, while commonly employed for sport or leisure activities, have been controversially harnessed as instruments of "law enforcement" by authorities throughout the world. Acute instances of this can be observed in the tumultuous region of Kashmir where security forces employ pellet guns widely to disperse crowds during rallies and civil demonstrations. Despite the non-lethal nature attributed to pellets when utilized within a recreational context, their use as crowd control devices results in significant injuries.

A compelling study conducted at the Government Medical College (GMC), Srinagar, and documented by Kashmir Media Service presents scientific validation for concerns surrounding the potentially lethal properties of metallic pellet shotguns often deployed against demonstrators. This research encompassed 664 patients out of 1,066 admitted to SMHS Hospital in Srinagar from July 2016 through January 2018 who sustained eye injuries owing to these pellet shotguns (Figure 3) [3].

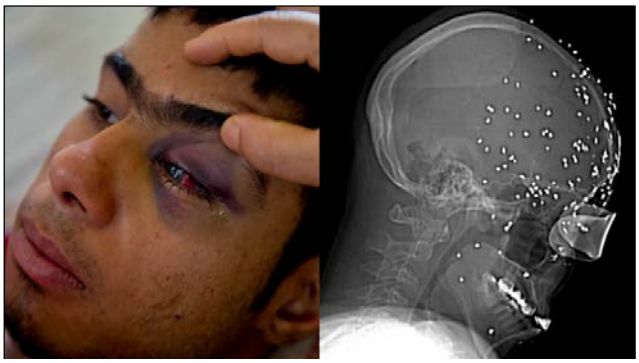

Fig.3. 19-year-old boy from Budgam Kashmir hit by pellets [Shuaib Masoodi/Al Jazeera]

Upon analysing the sampled eyes, researchers discovered that nearly three-fifths (59.3%) suffered visual impairment ranging across various degrees - a worrying fact underscored by data

indicating that nearly one-eleventh (10.8%) eyes were rendered entirely blind due to wounds inflicted by these weapons, involving a complete loss of light perception, signifying an inability on part of victims to discern even stark brightness upon exposure. In the examined cohort, a minimum of 32.1% had experienced closed globe injuries, encounters where the ocular wall remained intact. The balance faced open globe injuries, cases that encompassed penetrating trauma to one or more layers of the eye structure [3].

A comprehensive study recently disclosed in The Indian Journal of Ophthalmology substantiates that 80% of pellet-induced injury sufferers within Kashmir have endured partial or complete vision loss. The scholarly document, detailing the findings from 777 ocular surgical procedures performed during a specified time frame, conveys that for 80% of these casualties, the extent of their visual capacity is now restricted to elementary finger counting due to inflicted damage. Noted retina specialist and Mumbai-based surgeon Dr. S Natrajan, one of the key contributors to this research paper relayed in an ensuing report that despite targeted medical interventions, "…the unfortunate truth persists; patients consistently demonstrate poor prognoses for visual recovery post-injury"[4].

Results and Discussion

Lead, understandably characterized as a potent toxin, performs no necessary function within our bodies. Lead has been found to be present in lenses afflicted by cataracts. A cataract condition involves a clouding of the eye's crystalline lens, impairing light transmission to the retina. When traces of lead infiltrate this lens, it disrupts its redox equilibrium and induces structural changes in proteins, consequently diminishing lens transparency. Moreover, it has been observed that this hazardous metal interferes with metabolic glutathione processes present within the lens while increasing protein-bound levels of this antioxidant as well as cysteine; two essential substances for ocular health. Overexposure to lead can induce severe damage to an individual's visual system aspects potentially leading even to irreversible blindness. These effects fall under an encompassing category referred to as "optic atrophy"[5,6].

Its resemblance to calcium, an integral component of brain biochemistry, permits its entry into the otherwise secure fortress that is our brain. Subsequently, lead interferes with the transportation and retention of calcium within cells. This enhances cellular stress levels, which may result in neurodegeneration or premature destruction of other brain cells [5,6].

Moreover, Lead intentionally commandeers calcium's responsibilities within the cerebral realm, especially neuron communication. In normal conditions, upon neuronal activation, calcium permeates into neurons stimulating neurotransmitter release; chemicals responsible for carrying this activation signal from one neuron to another through small intervening gaps for signals to successfully reach their target. However, lead drastically alters this vital process by masquerading as Calcium - impacting how neurons relay these signals. Primarily competition arises between Lead and Calcium regarding their entrance into neurons - when lead is present fewer quantities of calcium can infiltrate neurons thereby leading to decreased neurotransmitter releases which results in weaker signal transmission between successive neurons. Secondly, unnecessary spontaneous discharges are initiated by non-activated neurons due to the excessive presence of Lead causing subsequent inappropriate signaling (Figure 4) [8].

Neurotransmitter signaling plays a pivotal role in abetting learning processes and preserving memory recall capabilities ultimately distressed under extensive exposure to lead

poisoning. The pernicious effect of lead on the fundamental interaction between neurons has been found to instigate cell mortality, causing an unalterable shift in developmental processes [8].

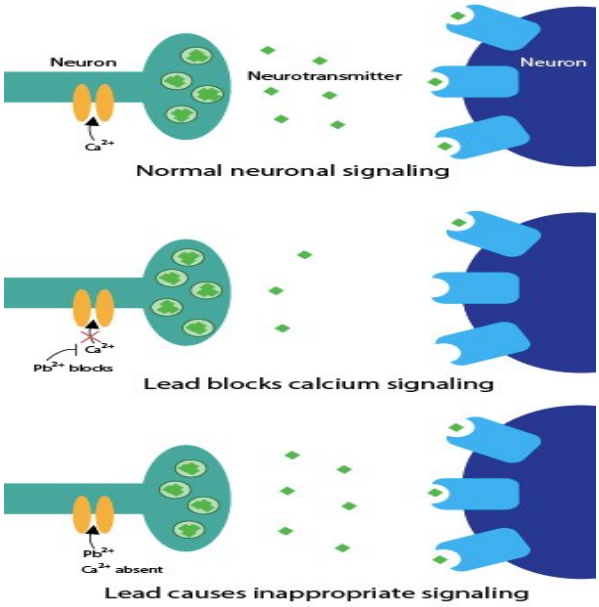

Fig.4. Lead alters neurotransmitter release

A comprehensive investigation undertaken by researchers aimed at understanding how exposure to lead variably influenced the overall size of the brain, as well as its distinct regions. Utilizing Magnetic Resonance Imaging (MRI) technology, it was discerned that heightened levels of lead exposure were correlated with a diminished prefrontal cortex in young adults. Brain scans were compiled/averaged from 157 subjects in the Cincinnati Lead Study and overlaid on a standard brain template. Red and yellow areas indicate regions of volume loss. The first row of images shows prefrontal cortex volume loss. (Figure 5) [8].

Given its pivotal role in attention management, intricate decision-making processes, and social behavior regulation, any discrepancies relating to size or function could rationalize cognitive complications and behavioral issues associated with lead contamination [8].

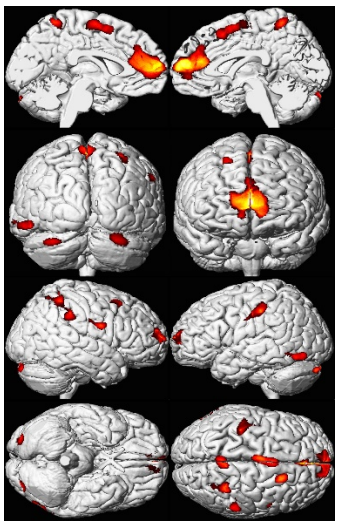

Fig. 5. Lead exposure is associated with decreased brain volume (Cecil et al., 2008, licensed under a Creative Commons Attribution License)

Lead has a significant impact on various physiological functions, particularly concerning the cardiovascular system. The cardiac and vascular implications of lead exposure may amplify an individual's susceptibility to developing hypertension, coronary artery disease, and stroke as they age.

Blood vessels serve functions beyond their primary role as conduits for blood circulation; they comprise muscle cells that enable adaptability to varying physiological conditions. For instance, during periods of dehydration, these muscles constrict effectively minimizing room for blood flow while simultaneously elevating your blood pressure, so you avoid syncope. Persistent high blood pressure adversely affects vessel health necessitating numerous intricate regulatory signals - a number of which are disrupted by lead exposure.

One familiar compound implicated in these lead-induced damages within our circulatory system is calcium. This element behaves similarly to what it does within our brain - lead mimics its function within our vascular cells often usurping several roles ordinarily performed by calcium. Within these vessels, calcium instigates vessel contraction to boost blood pressure - an action subsequently mirrored by lead inflicting long-term damage to vessel integrity over time. Moreover, exposure to lead amplifies stress levels within vascular muscle cells resulting in further hardening of arteries succeeding an elevation of one's overall blood pressure (Figure 6) [8].

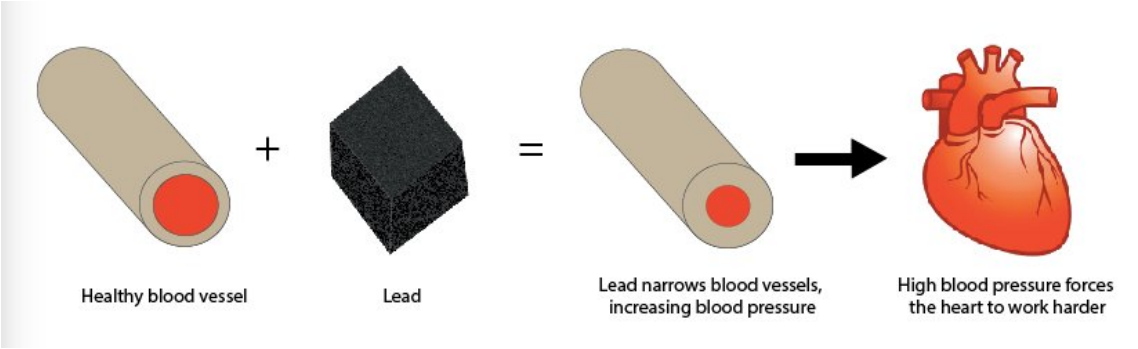

Fig.6. By mimicking calcium and increasing cell stress, lead causes vessels to constrict, limiting the space for blood to flow (compare the size of the red circles)

When the diameter of blood vessels decreases, it necessitates the heart to exert extra effort in circulating blood throughout the organism. To comprehend this strain more clearly, draw a parallel between consuming water through an average-sized straw and then via a reduced coffee stirrer. The action simulates how arduously your heart must pump under a significant reduction in vessel size. In its struggle to manage these heightened stresses over time, the cardiac muscle progressively debilitates. Consequently, protracted periods following primary exposure to lead can culminate in cardiac weakness and vascular impairment which could result in serious health crises such as myocardial infarctions or cerebrovascular accidents along with additional adverse complications [9, 10].

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