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Analysis of bioelements in the hair of adolescents in Mongolia

Tsolmontuya Dambasanjaa[1], Selenge Erdenechimeg[2]

[1]Sports Theory and Methodology Department, School of Physical Education, Mongolian National University of Education, Ulaanbaatar, Mongolia, tsolmontuya@msue.edu.mn
[2]Graduate school, Mongolian University of Pharmaceutical Sciences, Ulaanbaatar, Mongolia, selenge.e@monos.mn

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ABSTRACT
This study aimed to determine the content of 23 bioelements in the hair of 110 adolescents aged 13-17 years in Ulaanbaatar, the capital of Mongolia. The bioelements were categorized into macroelements (MaE), microelements (MiE), and ultramicroelements (UMiE). Participants, including birth parents, guardians, and teachers of Mongolian high schools from 2000 to 2003, were involved with consent from the school administration. A total of 111 individuals were enrolled in the study, with 110 providing hair samples. Hair analysis was employed as a convenient, non-invasive, and painless method to evaluate the concentrations of bioelements and toxic metals in adolescents. Micronutrients were classified as essential or toxic. Statistical analysis was conducted using mean values, t-tests, standard deviations, and comparative methods.

KEYWORDS
Adolescents, Bioelement, Microelement, Ultramicroelement

1. INTRODUCTION

Although Mongolia has made efforts to develop and implement science-based policies focused on children's health and development, there remain significant concerns about the lack of observable progress in achieving tangible results [1]. The average life expectancy of a population is directly related to the health of its adolescents [2]. The growth and development of adolescents are heavily influenced by various factors, including geographic location, environmental conditions, pollution levels, the prevalence of infectious and non-infectious diseases, and nutritional status [3]. Evidence suggests that the growth metrics of adolescents lag behind those in other regions, highlighting the need for creating healthier and safer environmental conditions for teenagers [4]. Moreover, negative factors such as inadequate food supply and air pollution have been shown to severely affect children's growth and development [5].

Inorganic pollutants, such as lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), and chromium (Cr), have a significant impact on the environment and pose health risks to vulnerable populations, including children [6] [7] [8]. Specific deficiencies, like iron deficiency, are known to cause conditions such as hair loss [9]. Exposure to certain elements, such as beryllium, is regulated due to its potential health effects, with exposure limits set at 2.0 $\mu g/m^3$ over an 8-hour period, affecting a small percentage of those exposed [10].

Research has demonstrated elevated levels of lead in the hair of adolescents living in both rural and urban areas in Taiwan [11]. Comparisons of lead and zinc concentrations in hair samples have also been made among students from various cities, indicating the influence of local environmental factors on bioelement accumulation [12] [13] [14] [15]. Additionally, the levels of trace elements such as calcium (Ca), magnesium (Mg), and strontium (Sr) in hair can vary due to factors like water composition [16] [17]. The concentration of zinc and lead in hair has also been found to depend on age and gender, with zinc levels decreasing with age until peaking in the pubertal group (15-19 years) [18].

Given these factors, this study aims to analyze the content of bio elements in the hair of Mongolian adolescents to better understand the influences of environmental and nutritional conditions on their development.

2. OBJECTIVES

The research used a high school-based, descriptive research design. It will be delivered to the chemistry department of the Geology Laboratory of Mongolia, and it will be performed by semi-quantitative analysis of the optical-emission spectrum, which simultaneously determines 44 hair chemical elements. The sensitivity of the analysis is indicated in the table for each method. Microelements (0.002-20 mg/kg) are determined in the concentration range by chemical pre-concentration.

3. SCOPE AND METHODOLOGY

Hair samples were collected from the side of the skin surface by cutting hair with scissors from six parts of the head. Starting from the tip of the hair, 3-5 cm long hair was taken from the nape of the head, the nape of the head, and the nape of the head, and put it in a paper bag. The name, surname, and address were coded and analyzed. A total of hair collected from one individual was weighed and analyzed with a variation of up to 0.3. 0.5 g of hair washed with acetone and washed three times with deionized water with acetone. After cleaning the hair, dry it to a constant mass at 105oC. The dried samples were weighed and a mixture of nitric and chloric acids was used (5:1 ratio). Determination of copper solution was performed by atomic absorption spectrometer using AAS-3 spectrometer.

The Geological Laboratory under the Ministry of Mining and Heavy Industry received consent forms from the parents and teachers of 110 students in the chemical analysis department.

4. RESULT AND DISCUSSION

In the study, the following results were found in the study of 20 bioelements contained in the hair of teenagers. It includes in Table 1.

5. FINDINGS

This study on adolescent development in relation to environmental influences has provided several important insights:

1. Elemental Composition in Hair Samples: The analysis of hair samples from 110 healthy students from two schools in Ulaanbaatar, Mongolia, revealed significant levels of essential microelements necessary for life. Elements such as iron (Fe), copper (Cu), zinc (Zn), cobalt (Co), chromium (Cr), selenium (Se), manganese (Mn), and silicon (Si) were found at statistically significant levels (e.g., Fe: $t(108)=18.413,p<0.001t(108) = 18.413, p < 0.001t(108)=18.413,p<0.001$, Cu: $t(108)=11.189,p<0.001t(108) = 11.189, p < 0.001t(108)=11.189,p<0.001$). These findings highlight the critical presence of these nutrients, which are essential for various physiological functions during adolescence.
2. Essential Trace Elements: The study identified trace elements such as boron (B), nickel (Ni), and silicon (Si) as essential for human health. These elements were present at significant concentrations in the hair samples (e.g., Ni: $t(108)=39.882,p<0.001t(108) = 39.882, p < 0.001t(108)=39.882,p<0.001$), underscoring their importance in the biological and developmental processes of adolescents.
3. Toxic Trace Elements: Elevated levels of toxic trace elements, including aluminum (Al), cadmium (Cd), and phosphorus (P), were also detected in the hair samples (e.g., Al: $t(108)=18.019,p<0.001t(108) = 18.019, p < 0.001t(108)=18.019,p<0.001$; Cd: $t(108)=15.790,p<0.001t(108) = 15.790, p < 0.001t(108)=15.790,p<0.001$). The presence of these elements at such levels could indicate exposure to environmental pollutants, which are known to pose significant health risks, particularly in young populations.
4. Toxic Microelements: The detection of toxic microelements like lead (Pb) and tin (Sn) in the hair samples (e.g., Pb: $t(108)=11.090,p<0.001t(108) = 11.090, p < 0.001t(108)=11.090,p<0.001$; Sn: $t(108)=10.417,p<0.001t(108) = 10.417, p < 0.001t(108)=10.417,p<0.001$) further suggests environmental exposure. The accumulation of these toxic elements in the body can have detrimental effects on cognitive and physical health, especially during critical growth periods such as adolescence.
5. Psychological Impact of Hair Testing: Conducting non-invasive tests like hair analysis has a positive impact on adolescents' psychology. The method is painless and less intimidating than other biological sample collections, making it an ideal choice for studies involving children and adolescents.
6. Environmental and Health Implications: The high concentrations of both harmful and relatively harmful trace elements in the hair of adolescents appear to be associated with environmental factors, such as air pollution. Elements like zinc, chromium, silicon, nickel, arsenic, aluminum, lead, cadmium, and beryllium were present in high concentrations. The exposure to these elements can lead to a range of health issues, including cognitive impairments, cardiovascular problems, respiratory conditions, and an increased risk of cancer.
7. Health Risks of Low Bioelement Levels: Conversely, deficiencies in essential elements such as lithium, vanadium, cobalt, and copper may result in health problems like anemia, dizziness, and temporary loss of consciousness due to poor blood circulation. These deficiencies can cause irreversible changes in brain tissue, leading to severe and long-term health complications.
8. Need for Continued Research: This study highlights the urgent need for further research into the bioelement composition in the hair of adolescents in Mongolia. The lack of established reference ranges for bioelements in this population limits the ability to interpret these findings fully and develop appropriate public health interventions. Establishing these baselines would enable better comparisons and a deeper understanding of the

environmental and nutritional factors influencing adolescent health.

6. CONCLUSION

The findings of this study underscore the complex interplay between environmental exposure and adolescent health. Future research should focus on establishing normative data for bioelement levels in hair samples from different populations and developing strategies to mitigate the health risks associated with toxic element exposure.

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