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FEATURES OF SKELETAL REMAINS FORENSIC EXAMINATION

Abstract. Bone examination plays a crucial role in forensic medicine and criminology. It not only allows for the identification of individuals and determination of the cause of death but also provides important information for understanding the circumstances leading to death. This information is critically important for ensuring justice in criminal investigations and civil cases. This article analyzes contemporary literature from domestic and international scientific communities, describing the main methods and their features in the examination of skeletal remains. The aim of the study is to analyze scientific literature on the features of the examination of skeletal remains and their significance in the work of a forensic expert. During the search for information on the features of skeletal remains examination, various combinations of keywords were used: "forensic anthropology," "thanatology," "skeletal remains," "charred," "time since death," "postmortem interval estimation," and others. The review covers the past 10 years. After reviewing the annotations and full texts of over 78 articles, 33 sources of domestic and foreign literature were selected for review. In the process, a bibliosemantic method was used to determine the state of the outlined issues, as well as to study and analyze the results of scientific research presented in literary sources and electronic resources. As a result, it was found that modern scientific trends show that the examination of skeletal remains is a dynamic field that is constantly evolving. Despite significant progress, many problems remain that require further research and methodological improvement. The introduction of new technologies and methods will enhance the accuracy and efficiency of experts' work, ensuring reliable results for legal and scientific purposes. Therefore, it is important not only to implement new technologies and examination methods in the future but also to improve existing research methods.

Keywords: forensic anthropology, thanatology, skeletal remains, charred, postmortem interval, postmortem interval estimation.

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ОСОБЛИВОСТІ СУДОВО-МЕДИЧНОЇ ЕКСПЕРТИЗИ СКЕЛЕТОВАНИХ ТРУПІВ

Анотація. Кісткова експертиза відіграє одну з ключових ролей у судовій медицині і криміналістиці. Вона дозволяє не тільки ідентифікувати особу і встановити причину смерті, але й надає важливу інформацію для розуміння обставин, що призвели до смерті. Ця інформація є критично важливою для забезпечення справедливості, як у випадках кримінальних розслідувань, так і у випадках розгляду цивільних справ. В даній статті проведено аналіз сучасної літератури вітчизняної та світової наукової спільноти, в яких описані основні методи та їх особливості експертизи скелетованих трупів. Мета дослідження – провести аналіз наукових літературних джерел з питань особливостей експертизи скелетованих трупів, їх значення у роботі судово-медичного експерта. Під час пошуку інформації з питань особливостей експертизи скелетованих трупів було застосовано різні комбінації таких ключових слів: "судова антропологія", "танатологія", "скелетовані останки", "обвуглені", "давність настання смерті", "оцінювання посмертного інтервалу" тощо. Огляд проведений на глибину 16 років. Після ознайомлення з анотаціями та повним текстом понад 78 статей було відібрано 33 джерела вітчизняної та зарубіжної літератури для підготовки огляду. У процесі роботи було застосовано бібліосемантичний метод для визначення стану окреслених питань, а також для вивчення та аналізу результатів наукових досліджень, представлених у літературних джерелах та електронних ресурсах. Як наслідок встановлено, що сучасні наукові тенденції показують, що експертиза скелетованих трупів є динамічною галуззю, яка постійно розвивається. Незважаючи на значний прогрес, залишається багато проблем, які потребують подальших досліджень і вдосконалення методик. Впровадження нових технологій та методів дозволить підвищити точність і ефективність роботи експертів, забезпечуючи надійні результати для юридичних і наукових цілей. Тому в подальшому є важливим не тільки запровадження новітніх технологій і методів експертизи, а й удосконалення вже наявних методів дослідження.

Ключові слова: судова антропологія, танатологія, скелетовані останки, обвуглені, давність настання смерті, оцінювання посмертного інтервалу.

Statement of the problem. The examination of skeletonized corpses is one of the most complex and multifaceted tasks of forensic medical practice, which requires experts to have deep knowledge and mastery of specialized methods for identifying the person and establishing the causes and time of death [1, 2]. This problem has gained special relevance in modern forensics, both at the world level and in Ukraine, which could be solved by various methods, in particular, anthropometric ones. The database of anthropometric parameters of Ukrainians still remains fragmented and incomplete [3, 4, 5]. Additionally, the issue is complicated in cases of mass burials associated with genocide, natural cataclysms [6] and disasters [7], as well as mass forced or illegal population migration, which further complicates the process of identifying the dead [8]. Such cases complicate the work of experts and require the use of the latest techniques to ensure the accuracy and reliability of the results.

DNA analysis. This is one of the most accurate methods that allows identifying a person even in cases where other methods cannot be used [9, 10]. DNA material is usually extracted from bones, teeth, or other well-preserved parts of a skeleton. However, this method has a number of limitations: DNA often degrades under the influence of external conditions (temperature, humidity, time), which can make identification difficult or impossible. In addition, the cost of conducting a DNA examination is high, which makes it unavailable in many cases.

Anthropological analysis. This method includes the assessment of morphological characteristics of the skeleton to determine gender, age, ethnicity and other characteristics [11]. One of the main disadvantages of anthropological analysis is its subjectivity and dependence on the expert's experience. In addition, the skeleton may be partially damaged, which makes it difficult to determine the necessary parameters.

Radiological methods (x-ray, CT, MRI). These methods make it possible to visualize the internal structures of bones and detect hidden damage or foreign objects [12]. Computed tomography (CT), which creates a three-dimensional image of the bones for detailed analysis, is particularly effective. However, these methods cannot always provide an accurate determination of the time of death, especially if the soft tissues have already completely decomposed. In addition, their use requires high-tech equipment and specialists [13].

Radioisotope analysis. Stable isotope ratio analysis is becoming a key tool for forensic investigators. It is particularly useful in missing person investigations, helping to identify unknowns through geolocation history reconstruction, determine the number of individuals involved, and separate or link remains from mixed groups [14]. However, radioisotope analysis is not accurate enough to determine the time of death and may also be limited by bone degradation under the influence of external factors.

The latest technologies (artificial intelligence [15], isotope analysis, virtual autopsy [16]). The involvement of artificial intelligence in the examination of skeletonized remains allows for automated analysis, including the determination of gender, age and ethnicity with high accuracy. Isotopic analysis helps estimate the diet and geographic origin of an individual. Virtual autopsy or virtual autopsy uses highly sensitive scanners to detect subtle pathological changes, but these methods are expensive and require specialized equipment, which limits their widespread use.

Despite significant progress in the development of methods of examination of skeletonized corpses, many of them have their shortcomings [17], which complicate the process of identification and determination of the time of death. Special attention needs to be paid to the integration of the latest technologies into the practice of forensic medical examination, which will increase the accuracy of the results and reduce the risk of errors. At the same time, it is necessary to improve existing methods to make them more accessible and effective in conditions of limited resources [18, 19]. The accumulated volume of literature on this topic needs to be summarized and systematized.

The purpose of the article – conducting an analysis of scientific literary sources on the specifics of examination of skeletonized corpses.

Research objects and methods. The scientometric databases Scopus, Web of Science, and Google Scholar were used to analyze literary sources. The criteria for including articles in the review were: publication in the period from 2008 to 2024; the presence of keywords such as "forensic anthropology", "thanatology", "skeletal remains", "charred", "time of death", "estimation of the post-mortem interval", etc.; open and accurate data on research materials and methods; a clear and homogeneous sample in sufficient quantity. After reviewing the abstracts and reading the full texts of 78 articles, 33 sources of domestic and foreign literature were selected for the preparation of the review.

In the course of the work, the bibliosemantic method was used to determine the status of the outlined issues, as well as to study and analyze the results of scientific research presented in literary sources and electronic resources.

Presentation of the main material.

Research results and their discussion.

The analysis of literary sources shows that the examination of skeletonized corpses remains one of the most difficult tasks of forensic medical practice, which requires the improvement of existing methods and the introduction of the latest technologies. Given that bodies are often found in a state of high decomposition, especially during military conflicts, mass burials [20] in occupied territories or mass disasters, determining the cause of death and identifying the person are critical aspects that determine the success of investigative actions and further legal proceedings.

One of the main methods used to identify skeletal remains is DNA analysis [21]. Comparison with the genetic material of possible relatives allows identification of a person even in the absence of other evidence. Determining the time of death is another important aspect. The stages of decomposition help determine the approximate time of death. Research methods include X-rays, scans and chemical analysis. Radiography helps to reveal the internal structures of bones, possible hidden fractures or foreign objects. Computed tomography (CT) creates a three-dimensional image for detailed analysis of bones and possible injuries [22]. Magnetic resonance imaging (MRI) is less commonly used for bone, but can be useful for analyzing soft tissue remnants.

Virtual anthropology is the use of anthropological methods to analyze 3D models of human remains. Despite the significant progress achieved over the last decade, there are still several unsolved questions regarding the reliability of these models and their correct application [23], and in many countries, in particular in Europe, there are no modern collections of skeletons, which complicates the development of forensic anthropological methods. Researchers are using computed tomography (CT) data as an alternative to create 3D models of bones. However, the accuracy of these models derived from clinical CT scans remains unknown. Although some studies have shown favorable results, they have used postmortem CT scans, which may result in better image quality. Linear measurements to assess accuracy can be distorted by observer error. Optical scanning, which provides an accuracy of 0.05 mm, can eliminate these errors. Comparison of 3D bone models created using CT with models obtained from optical scanning allows to objectively assess their accuracy [24]. Thus, there is a need for further research to determine the reliability of clinical CT scans as a data source for forensic anthropological studies.

Isotope analysis is a relatively new method in forensics, but it is already proving its effectiveness in application [25, 26]. Over the past decade, predictive models have been developed that allow comparison of isotopic values in tissues such as bones, teeth, hair, nails, using spatial data and isotopic maps (isoscapes). Isoscapes created for materials such as water or soil help narrow down regions of origin. In combination with biological data, isotopic analysis allows more accurate determination of a person's geographic origin [27].

All examination methods are directly dependent on the state of the biomaterial. The preservation of DNA in skeletal remains depends on many factors, including the age of the corpse, storage conditions, and exposure to the environment [28]. Degradation of DNA significantly complicates the identification of a person. Accuracy of identification: Reconstruction of anatomical features and reconstruction of the face from bone remains may be inaccurate due to partial loss or damage of bones.

The analysis of sources of scientific literature proves that traditional methods of determining the age of death are often not accurate when working with skeletonized remains [29]. The use of innovative approaches such as isotope analysis, spectroscopy and microscopic analysis, involving artificial intelligence [30] requires further research to improve accuracy. Detection of diseases or pathologies in bones is a difficult task, especially if decomposition has progressed too far [31]. New methods, such as virtual autopsy (virtpsy) and highly sensitive scanners, especially those that allow detection of various elements and residual components [32, 33], help to detect minor pathological changes, but their implementation is expensive and requires significant resources and time in everyday implementation. the work of a forensic expert.

Conclusions. The examination of skeletonized corpses remains a complex branch of forensic medicine, which requires the improvement of methods and the introduction of new technologies. Despite advances in DNA analysis, anthropological, radiological, and chemical methods, each has shortcomings that affect the accuracy of identification and determination of causes of death. The preservation of DNA and the availability of modern technologies such as computer tomography and artificial intelligence are important.

To date, the anthropological method of examination is one of the effective and efficient methods of examination of skeletonized corpses, which allows even in conditions of insufficient material support remains valuable due to its ability to provide key information about age, sex, ethnicity and physical characteristics, even in cases where other methods do not provide enough data.

Virtual autopsy and isotope analysis, which increase the accuracy of examinations, are promising for future implementation as a daily method of examination of skeletonized corpses, but currently their wide application is limited by high cost, imperfection of methods and insufficient research and description of methods in the world and domestic literature.

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