International Journal of Biomedical Science and Engineering
2025, Vol. 13, No. 3, pp. 52-56
https://doi.org/10.11648/j.ijbse.20251303.11

Research Article

Challenges in Electroacupuncture Research: An Indispensable and Valuable Perspective for Understanding Electroacupuncture Mechanisms

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Abstract

Electroacupuncture (EA) is a green therapy, including needle insertion and electrical stimulation, which has a long history, outstanding curative effect, and wide application. The electric current is brought into the acupoint body tissues through acupuncture needles, producing various bio-electrochemical or bio-electrophysical effects. The basis of these effects is the presence of bioelectricity in the human body. Examining these effects may offer many novel perspectives, ideas, and methods for studying EA, as opposed to molecular pathways. This seemingly tangible-yet-intangible phenomenon of bioelectricity may become a breakthrough in the study of acupuncture mechanism. However, research exploring EA from this perspective remains scarce, hindered by several challenges. The field demands high technical precision, interdisciplinary expertise (spanning biophysics, neurophysiology, and bioengineering), and prolonged experimental phases, which often result in preliminary findings failing to sustain long-term validation. Additionally, the rapid advancement of modern science and technology complicates consistent methodological frameworks, rendering some research directions obsolete prematurely. Despite these obstacles, a deeper investigation into bioelectrical mechanisms is indispensable for advancing EA research. Addressing these challenges will not only enrich our understanding of EA but also pave the way for innovative therapeutic strategies in integrative medicine.Therefore, we must first have a preliminary understanding of the current state of research on EA from the perspective of bio-electronics.

Keywords

Electroacupuncture, Challenges, Bioelectrical Effect

1. Introduction

Electrotherapy dates back to 46 CE when a physician of the Roman emperor Claudius found that standing on an electric eel by the seashore could relieve his pain after a period of numbness [1]. As a means of treatment, electricity has been well-known and controversial for centuries. Indiscriminate use and uncertain interpretation of the electricity's mode of action seem to be the two primary reasons that hinder electrotherapy development [2]. Electricity was first introduced into medicine in the 18th century but was not widely used until 19th century. Medical literature shows it was used to treat various diseases, usually chronic infectious diseases [3]. The emergence of electrotherapeutic equipment indicates the

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Received: 2 May 2025; **Accepted:** 17 July 2025; **Published:** 23 July 2025

ability to manipulate electric current into the body. However, the techniques for safely and precisely regulating local tissues or cells to address diseases and the fundamental biophysical and biochemical mechanisms remain unclear.

Wilhelmi Ten Rhyne, a Dutch doctor, was a key person in spreading acupuncture knowledge from China to Europe [4]. The idea of applying electricity to acupuncture needles began with a French physician in 1810. This pattern was initially employed as a therapy for neurological disorders by a French anatomist and physiologist approximately 100 years before its documentation in China in 1934. The mechanism of acupuncture treatment seems to be covered with a thick layer of yarn after introducing an electric current through the acupuncture needle. The principle of mechanical stimulation, encompassing twirling, lifting, thrusting, and rotating manipulations, has not been elucidated to date.

It is clear that essential physiological functions of the human body are intricately associated with electrical signals. Bioelectricity is any electrical phenomenon that is actively generated by cells or applied to cells to affect its phenotype [5]. An external electric current, such as electroacupuncture (EA), changes the electrical signals in the local tissues and stimulates the body to recover from an ailing state. Given its substantial analgesic properties, EA has been extensively utilized in surgical anesthesia and the treatment of various ailments. Studies on EA mainly focus on the clinical efficacy, safety evaluation, parameter optimization, and operation standardization. Nevertheless, research on the bioelectrical effects of electroacupuncture, which we should pursue by moving beyond the previous paradigm, is significantly lacking. The investigation of this aspect of void will inevitably precede other research efforts when using electrical stimulation as a therapeutic modality. This study retrieved relevant evidence from multiple databases in an attempt to establish a more robust theoretical foundation for our team's research on EA bioelectricity.

2. Literature Search for Bioelectrical Effects of EA

In addition to commonly used databases, such as PubMed, Web of Science, Embase, OVID, Scopus, and Cochrane Library, IEEE (Institute of Electrical and Electronics Engineers) was also used to locate pertinent literature. The Chinese databases included China National Knowledge Infrastructure (CNKI), China Biology Medicine Disc, China Science and Technology Journal Database, and Wanfang Database. No restrictions on time, subject category, article type, or language. The search strategy was as follows: (ampere density OR electric current density OR current density) OR (electrical resistivity OR resistance OR impedance) OR (electric current OR electricity OR electric field) AND ((bioelectricity OR electrophysiology) AND (electroacupuncture OR electricity needle OR electric acupuncture OR electric acupuncture apparatus)).

All the data were arranged in Excel. The final data were obtained by manual repeated screening, including removal of duplicate articles and articles that did not meet the inclusion criteria. The results of the individual database searches are available in Table 1. There are 59 articles from eleven databases. Among them, 45 articles were in line with the theme idea. The internal relationship between EA and these discharges is not provided, and the majority of them employ EA to observe the discharge of neurons in a specific area or the effects of electrocardiogram and gastric electrical activity; rather, they describe the phenomenon and curative effect [6-10]. The rest are discussions or research on the skin electrical impedance of acupoints or meridians [11-13]. It is gratifying to note that three reviews have described the interesting connection between EA and bioelectricity from multiple perspectives [14-16]. A study involving animals prompted us to focus on the issue of current density at the needle's tip, while another clinical investigation offered initial insights into the direction of current during electroacupuncture [17, 18]. The primary research focus of acupuncture in electricity encompasses introducing bioelectricity knowledge, examining acupoint electrical characteristics, and advancing associated detection equipment. According to the search, in the 1970s, researchers focused on exploring the relationship between EA and electrophysiology. Indeed, the investigation into the efficacy of EA treatment for certain diseases is significant, as it can be augmented by bioelectricity research. It is essential to understand why EA can treat diseases and elucidate the relationship between ‘why’ and ‘how.’ Electricity is derived from both external input and endogenous sources. Consequently, this "how" must be elucidated in bioelectricity.

As illustrated in Figure 1, China and English-speaking nations have contributed substantially to research on EA and bioelectricity, with the majority of investigations being conducted via animal models. In contrast, non-speaking countries have demonstrated comparatively lower research output in this domain. Nevertheless, significant insights and innovative perspectives may often reside within these underrepresented studies, including review articles, observational analyses, comparative research, dissertations, and conference proceedings.

Table 1. *Statistics of relevant literature on EA bioelectricity research.*

Databases	Year	Quantity	EA Related	consistent with the theme	Article type	Language	Country
PubMed	1973-2024	52	31	30	Narrative Review/Animal Study/Clinical Trial/Randomized Controlled Trial	English/Chinese	America/Japan/China/Italy
Web of Science	1973-2024	32	9	4	Clinical Trial/Animal Study/Review	English/Korean	Japan/Korea
Embase	1974-2021	5	0	0	NA	NA	NA
OVID	1994-2022	6	5	3	Observational Study/Animal Study/Clinical Trial	English/Chinese	China
Cochrane Library	2002-2023	6	2	1	Protocol	Unknow	Unknow
IEEE	1973-2024	4	1	0	NA	NA	NA
CNKI	1978-2024	8	5	2	Conference article/Clinical Trial	Chinese	China
CBM	1994-2011	1	1	1	Animal Study	Chinese	China
CSTJ	1991-2017	6	0	0	NA	NA	NA
Wanfang	2006-2015	3	3	3	Dissertation (Animal Study)	Chinese	China
Scopus	2013-2018	2	2	1	Conference Paper	English	China

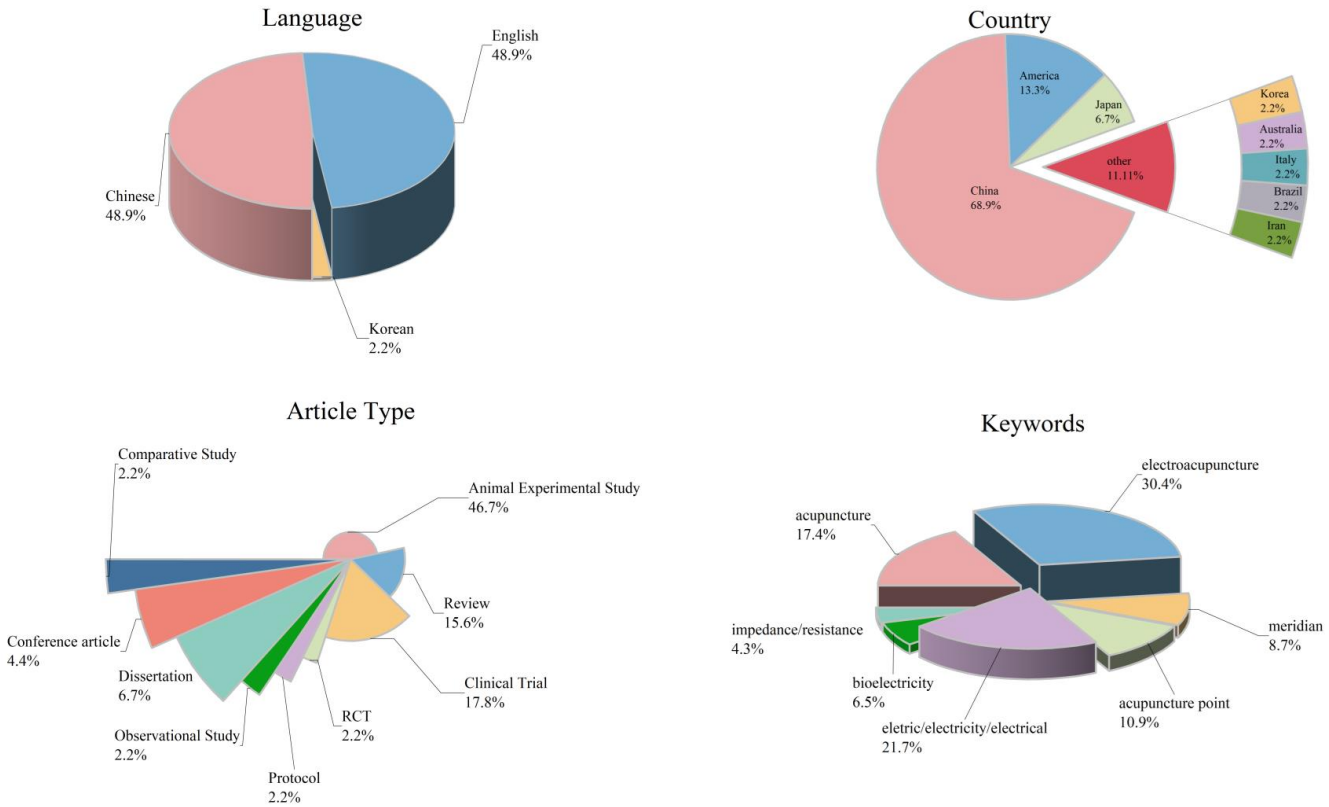

Figure 1. *The basic information of the pertinent literature.*

3. Present Challenge

Limited information is available about the EA bioelectricity. While it is understood that EA can alter neuronal firing activity, the specific frequency, waveform, and mechanisms of this alteration remain unknown. First, acupoints and meridians have electrical characteristics, as bioelectricity is the most direct external manifestation of normal life activities in the human body. Second, the external electricity, including electrical stimulation therapy and EA, can change or regulate the bioelectricity in the human body. Third, the electrical properties of acupoints can reflect the state of body organs. Consequently, based on this consensus, we should identify individuality within the commonality. In addition to solid knowledge of acupuncture, comprehension on biology, electrophysiology, physics, electrochemistry, computer, and mathematics is needed to find individuality.

Electricity is inherently intangible; therefore, to comprehend it, visualization becomes essential, particularly since tracing electricity within the human body poses significant challenges. The diagnostic information obtained from electrocardiograms (ECG), electroencephalograms (EEG), and electromyograms (EMG) is inherently limited. Labeling ions or membrane channels would be a sensible approach if bioelectricity generation in the human body results from ion exchange across the cell membrane. However, the demands placed on the experimenter and the laboratory are exceedingly high, regardless of whether employing patch clamp, optical imaging technology, bioimpedance measurement, or nuclear imaging technology. A critical point is that investigative approaches inevitably interfere with the EA procedure itself, thereby distorting the outcomes of in situ studies. In addition, the phototoxicity and spatial resolution of the bioluminescent indicators used in imaging technology must be considered. Nuclear imaging technology poses radiation risks, and labeling instability may arise in somatic cell tracing. Lastly, the cost issue cannot be ignored. Due to the intricacy of human bioelectrical activity and its varied associations with diseases, research in this domain necessitates extensive, long-term, and numerous repeated experiments.

4. New Opportunity and Challenge

It is unfortunate that most acupuncture researchers fail to recognize the significance of bioelectricity in EA study. Only a few researchers may realize this, yet not all possess the capability to execute experiments autonomously. This research gap is a conduit linking acupuncture with other fields and may have many needed answers. Currently in its second phase, the SPARC program in the United States presents both challenges and opportunities for acupuncture. The bioelectricity research of electroacupuncture may offer a significant chance of precision medicine within traditional Chinese medicine.

Abbreviations

EA	Electroacupuncture
TCM	Traditional Chinese Medicine
CE	Common Era
CNKI	Chinese Databases Included China National Knowledge Infrastructure
IEEE	Institute of Electrical and Electronic Engineers
CBM	China Biology Medicine Disc
CSTJ	China Science and Technology Journal Database
SPARC	Stimulating Peripheral Activity to Relieve Condition

Supplementary Material

The supplementary material can be accessed at https://doi.org/10.11648/j.ijbse.20251303.11

Funding

This work was supported by the National Natural Science Foundation of China (No. 81473759).

Conflicts of Interest

The authors declare that there is no conflict of interest.

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