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Editorial

Physical biomedical science ☆

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Physical biomedical science emerges from profound understanding of the connection between life activities and physical principles [1]. Its research content mainly covers: (1) systematic analysis of the generation mechanisms and biological function of endogenous physical signals (such as light, electricity, force, magnetism, heat, etc.); (2) exploration of the regulatory effects of exogenous physical fields on biological systems from the molecular to the individual level. The rise of physical biomedical science means that physical techniques are no longer merely tools for observing biological processes, but have become important means for revealing the laws of life activities and intervening in life processes. By elucidating the essential connections and regulatory mechanisms between physical stimulation and biological functions, physical biomedical science provides a new paradigm for understanding disease mechanisms, developing non-invasive treatments, and designing novel medical diagnostic and therapeutic devices.

Nevertheless, physical biomedical science still faces a series of challenges ranging from the basic research to application. The precise correspondence between physical stimulation parameters and biological effects remains elusive, and the biological mechanisms of physical stimulation (from molecules to tissues and organs) need to be clarified urgently. These fundamental issues restrict the transformation of related therapies into clinical applications. Future research in physical biomedical science should focus on the following key directions: (1) the exploration of specific biological targets of physical stimulation and their signal transduction pathways; (2) the development of biophysical signal detection technologies with high temporal and spatial resolution; (3) the design and development of intelligent and miniaturized physical diagnostic and therapeutic devices.

The special issue of Physical Biomedical Science contains the latest research advancements and opinions in the field. Three research teams have focused on emerging physical treatment strategies for functional regulation of the nervous system. Wu et al. [2] integrated preclinical and clinical evidence to explain the mechanism by which repetitive transcranial magnetic stimulation (rTMS) treats post-traumatic stress disorder (PTSD) by regulating neuroplasticity and neuroinflammation. It also proposed innovative strategies such as precise targeting and closed-loop systems, aiming to promote rTMS as a transformative personalized PTSD treatment. In response to the treatment difficulties of refractory depression, Yao et al. [3] summarized the targets and mechanisms of new physical therapies such as music, light, cold therapy, electrical and magnetic stimulation, and pointed out that their development needs to move towards personalized strategies and more in-depth mechanism research. The perspective article by Wang et al. [4] discussed the breakthrough applications and transformative potential of terahertz wave technology as a refined approach to precisely regulate ligand-receptor interactions in regulating neuronal functions.

Two research teams discussed the effects of temperature regulation on immune responses and inflammation. The perspective paper by Liu et al. [5] focused on magnetic hyperthermia (MH) as an emerging cancer therapy that precisely regulated cell functions through nano-scale heat. They specifically paid attention to its mechanisms, advantages and clinical translation prospects in activating anti-tumor immune response and treating hepatocellular carcinoma. Li et al. [6] described the symptomatic improvement of different types of cryotherapy and thermotherapy as non-drug therapies for osteoarthritis (OA) and rheumatoid arthritis (RA). They also reviewed new cold and heat therapy devices and materials (e.g., wearable devices, nanomaterials) with the potential to treat OA and RA. These innovative technologies offered the prospect of more precise and convenient treatments.

Shi et al. [7] presented their unique viewpoints on the detection of physiological indicators using physical technology. They proposed a remote pulse diagnosis solution based on electrotactile stimulation. A wearable sensor captured the patient's pulse wave and converted it into electrical signal parameters. These parameters were used to control the electrical stimulation of fingertip electrodes, recreating a realistic pulse sensation for the physician. This technology successfully demonstrated the feasibility of remote, high-fidelity pulse diagnosis and provided a new technical approach to breaking the spatial limitations of traditional Chinese medicine diagnosis.

As guest editors of this special issue, we sincerely thank all the contributors for their insightful articles, the editorial board members for their professional guidance, and the reviewers for their valuable comments. Their collective efforts have made this special issue valuable and influential.

Declaration of competing interest

The authors declare that they have no conflicts of interest in this work.

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Author profile

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