

## ORIGINAL ARTICLE

# An Overview of Biofield Devices

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Content designated  
as open access

## Citation

Global Adv Health Med.  
2015;4(suppl):42-51.  
DOI: 10.7453/  
gahmj.2015.022.suppl

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## Key Words

Biofield, devices

## Disclosures

The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest and disclosed the following: Dr Muehsam is a consultant for Rio Grande Neurosciences. Dr Chevalier is a consultant for Psy-Tek Laboratory outside the submitted work. The other authors had no conflicts to disclose.

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## ABSTRACT

Advances in biophysics, biology, functional genomics, neuroscience, psychology, psychoneuroimmunology, and other fields suggest the existence of a subtle system of “biofield” interactions that organize biological processes from the subatomic, atomic, molecular, cellular, and organismic to the interpersonal and cosmic levels. Biofield interactions may bring about regulation of biochemical, cellular, and neurological processes through means related to electromagnetism, quantum fields, and perhaps other means of modulating biological activity and information flow. The biofield paradigm, in contrast to a reductionist, chemistry-centered viewpoint, emphasizes the informational content of biological processes; biofield interactions are thought to operate in part via low-energy or “subtle” processes such as weak, nonthermal electromagnetic fields (EMFs) or processes potentially related to consciousness and nonlocality. Biofield interactions may also operate through or be reflected in more well-understood informational processes found in electroencephalographic (EEG) and electrocardiographic (ECG) data. Recent advances have led to the development of a wide variety of therapeutic and diagnostic biofield devices, defined as physical instruments best understood from the viewpoint of a biofield paradigm. Here, we provide a broad overview of biofield devices, with emphasis on those devices for which solid, peer-reviewed evidence exists. A subset of these devices, such as those based upon EEG- and ECG-based heart rate variability, function via mechanisms that are well understood and are widely employed in clinical settings. Other device modalities, such as a gas discharge visualization and biophoton emission, appear to operate through incompletely understood mechanisms and have unclear clinical significance. Device modes of operation include EMF-light, EMF-heat, EMF-nonthermal, electrical current, vibration and sound, physical and mechanical, intentionality and nonlocality, gas and plasma, and other (mode of operation not well-understood).

Methodological issues in device development and interfaces for future interdisciplinary research are discussed. Devices play prominent cultural and scientific roles in our society, and it is likely that device technologies will be one of the most influential access points for the furthering of biofield research and the dissemination of biofield concepts. This developing field of study presents new areas of research that have many important implications for both basic science and clinical medicine.

## INTRODUCTION

Developments in several fields of research, including biophysics, biology, functional genomics, metabolomics, neuroscience, psychology, and psychoneuroimmunology have advanced our understanding of the interrelatedness of these disciplines from the level of basic biological processes to a dynamic systems or “biofield” level. These recent advances have also shown that emotional states, intention, stress, and other psychosocial factors can significantly affect biological function and health outcomes.<sup>1-7</sup> Molecular, cellular, and organismic function and regulation are thus interwoven with and can be influenced by emotion, cognition, and psychosocial factors, suggesting the existence of a “subtle”—ie, low-energy system of biofield—interactions connecting these activities.

Here, we define the term *biofield* as “an organizing principle for the dynamic information flow that regulates biological function and homeostasis.” Biofield interactions can organize spatiotemporal biological processes across hierarchical subtle and gross levels: from the subatomic, atomic, molecular, cellular, and organismic to the interpersonal and cosmic levels. As such, biofield interactions can influence and be influenced by a variety of biological pathways, including biochemical, cellular, and neurological processes related to electromagnetism, correlated quantum information flow, and perhaps other means for modulating activity and information flow across multiple levels of biology.

Biofield devices comprise physical instruments that may be most clearly understood from the viewpoint of a biofield paradigm, and a large and diverse number of devices have been developed to measure or manipulate biofield interactions. These include both diagnostic devices (to measure biofield properties) and therapeutic devices (to manipulate biofield interactions). The study of biofield devices is at a nascent stage of development, and much further research is needed to determine clinical efficacy and elucidate the underlying mechanisms of action for many of the devices mentioned here. Thus the purpose of this work is to provide an overview of those

devices that we judge to be promising enough to warrant further investigation rather than to provide a critical review. We believe a critical review is warranted but out of the scope of this paper.

The biofield devices summarized here operate through a variety of modalities rather than a single mechanism. Some biofield devices function through well-understood mechanisms and are already widely used in clinical settings: for example, electroencephalography (EEG)- and electrocardiography (ECG)-based heart rate variability (HRV). Other devices appear to operate through mechanisms that are novel or incompletely understood. However, all of these devices share a common property: rather than functioning primarily in a reductionist, chemistry-centered manner, biofield devices function via the informational content of biological processes and can interact via low-energy or “subtle” processes, including those potentially related to consciousness and nonlocality.<sup>8,9</sup>

## BIOFIELD DEVICES

Here we provide a brief overview of the broad categories of biofield devices, with the goal being to stimulate further discussion and research. It is out of the scope of this overview to assess the efficacy of particular devices. Rather, we describe those devices for which we deemed that sufficient evidence exists to warrant mention. In order to manage this task in a manuscript of reasonable length, we chose to focus upon devices for which peer-reviewed scientific reports suggesting efficacy are available rather than conference proceedings or manufacturers’ white papers. However, in the few cases that specific devices with sufficient promise and relevance lacked a peer-reviewed basis, we have presented whatever evidence was available. Here, devices are organized according to mode of operation and these modalities include electromagnetic field (EMF)-light, EMF-heat, EMF-nonthermal, electrical current, vibration and sound, physical and mechanical, intentionality and nonlocality, gas and plasma, and other (mode of operation not well understood).

### Modalities Using Electromagnetic Fields: Light

One line of research that has yielded a large amount of information on biofield activity is the study of biophoton emission (BE), also called ultraweak photon emission. BE is the spontaneous emission of light which emanates from all living organisms, including humans.<sup>10</sup> Several studies have reported intercellular BE signaling,<sup>11</sup> and it has been suggested that such signaling by coherent biophotons could explain many regulatory functions,<sup>12</sup> including cellular orientation detection,<sup>13</sup> biophoton-regulation of neurotransmitter release,<sup>14</sup> leukocyte respiratory activity,<sup>15</sup> and enhanced seed germination.<sup>16</sup> A systematic review has suggested that detection of BE may be useful as a medical diagnostic approach and as a research tool.<sup>17</sup>

The body also exhibits sensitivity to exogenous light exposure, and numerous phototherapies use visi-

ble light to treat seasonal affective disorder,<sup>18</sup> vitamin D deficiency,<sup>19</sup> and a variety of skin conditions.<sup>20-24</sup> Infrared light has been used therapeutically for wound<sup>25</sup> and bone<sup>26</sup> repair. Laser therapy (LT) is another form of phototherapy that is now employed for a wide variety of clinical applications.<sup>27</sup> Low-level laser therapy (LLLT), which acts without ablating tissue, has been extensively studied, producing a growing body of systematic reviews supporting efficacy of LLLT for several pathologies<sup>27</sup> including skeletal muscle repair,<sup>28</sup> tendinopathy,<sup>29</sup> rheumatoid arthritis,<sup>30</sup> osteoarthritis,<sup>31</sup> neck pain,<sup>32</sup> chronic joint disorders,<sup>33</sup> and traumatic brain injury.<sup>34</sup> Nonthermal LLLT appears to involve cytochrome c oxidase as the photoacceptor,<sup>35</sup> further elucidating one instance in which the informational content of subtle low-energy light-signaling may be more important than the physical energy of the input signal.

### Modalities Using Electromagnetic Fields: Heat

Devices using infrared thermography (IRT), also called infrared thermal imaging, can detect small changes in temperature due to muscular and metabolic activity, subcutaneous blood flow, and patterns of perspiration in specific parts of the body.<sup>36</sup> Because of its high sensitivity, IRT can be used for a broad range of applications,<sup>37</sup> including assessment of fever, complex regional pain syndrome, Raynaud’s phenomenon, and cardiovascular disease. Although there is controversy regarding efficacy and clinical use, IRT has also been studied for the detection of temperature changes due to inflammatory diseases and a variety of other syndromes,<sup>38</sup> including breast cancer<sup>39,40</sup> and vascular dysfunction.<sup>41</sup> IRT can provide real-time clinical data on functional metabolism without the use of radioactive dyes to identify lymphatic congestion and lymph involvement in angiogenesis related to malignancies.<sup>42</sup> Other applications of IRT have been useful in relation to angiology, allergology, rheumatology, plastic surgery,<sup>43</sup> dermatology, orthopedics, diagnosis of circulatory abnormalities,<sup>44</sup> and veterinary medicine.<sup>37</sup> With respect to biofield and mind-body studies, IRT can be used as a tool to assess psychophysiological activity,<sup>45</sup> affective states in social situations,<sup>36,45</sup> and diagnostic techniques related to traditional Chinese medicine (TCM).<sup>46</sup> IRT may be viewed as both a subtle and gross measuring device.

### Modalities Using Electromagnetic Fields: Nonthermal

EMF interactions and electric currents, primarily created by ions within the body, are essential for a variety of critical biological functions, including regulation of ion transport, maintenance of membrane electrical potential, nervous system activity, cytoskeletal transport, coordination of cell migration, embryonic development, and wound healing.<sup>47,48</sup> Recent studies have also shown that processes regulating the dynamics of mitosis, meiosis, and a variety of other processes are governed by electric fields generated within the intracellular network of microtubules, centrosomes, chromosomes,<sup>48-50</sup> and nuclear chromatin.<sup>51</sup> Also, EMF

signaling in neuronal microtubules has been suggested as a substrate for cognition<sup>50</sup> and as a source of observed EEG correlates of consciousness,<sup>52</sup> suggesting the existence of a system of subtle signaling that relies on rhythm, resonance, and synchronization.<sup>53,54</sup>

In addition to these endogenous EMF interactions, biological systems appear to exhibit sensitivity to exogenous EMF exposures for most of the frequencies, field strengths, and amplitudes occurring in natural and man-made environments.<sup>46,47</sup> These observations have led to the development of a large number of therapeutic applications and clearance from the US Food and Drug Administration (FDA) and regulatory bodies worldwide for EMF treatment of pathologies such as bone repair, pain, and edema.<sup>55</sup>

Of particular relevance to biofield science, a large and rapidly growing body of data has demonstrated the existence of nonthermal EMF bioeffects, for which the molecular interaction energies are less than the average thermal energy of the target.<sup>56</sup> The existence of these extremely weak EMF effects suggests the possibility of bioinformation flow at extremely low energies and could foreshadow a paradigm shift away from the biochemical paradigm and towards an information-oriented model, wherein weak signaling (via EMF, light, or vibration) plays an essential role in biological regulation.

Pulsed electromagnetic field (PEMF) devices are the most common types of EMF therapy devices.<sup>57</sup> PEMF devices employ pulsed—ie, time-varying—waveforms that are generally transmitted to the body via antennae near the target tissue. Because of the extremely large body of literature on PEMF therapies, here we shall consider only those pathologies for which sufficient numbers of clinical studies have permitted literature reviews.

Treatment of nonunion bone fractures is one of the most widely adopted PEMF therapies cleared by the FDA.<sup>58</sup> Other PEMF devices have been cleared by the FDA for pain and inflammation.<sup>59</sup> PEMF treatment for osteoarthritis has been extensively studied, producing statistically significant results, but recent reviews have suggested that further research is needed to assess the clinical relevance of these findings.<sup>60-65</sup> PEMF “resonance” or “bioresonance” devices are designed to function via resonances at frequencies characteristic of EEG, ECG, or other endogenous EMF processes. Although the conceptual basis for bioresonance is unclear and efficacy has not been definitively demonstrated, bioeffects have been reported for some PEMF resonance devices.<sup>66-68</sup>

Transcranial magnetic stimulation (TMS) is a form of pulsed magnetic field therapy that uses a rapidly changing magnetic field to induce electric fields strong enough to stimulate cortical neurons and alter neuronal activity.<sup>69</sup> While TMS was initially used as an investigative tool in cognitive neuroscience,<sup>70</sup> further inquiry has led to its clinical use as an FDA-cleared treatment for treatment-resistant depression.<sup>71-74</sup> Now widely accepted as a noninvasive, low-cost method for brain stimulation, TMS has been reported to produce benefits for a wide variety of psychiatric conditions such as depres-

sion, acute mania, bipolar disorders, panic, hallucinations, obsessions/compulsions, schizophrenia, catatonia, posttraumatic stress disorder, and drug craving.<sup>75</sup> TMS has also been studied as a treatment for neurological conditions such as Parkinson’s disease, dystonia, tics, stuttering, tinnitus, spasticity, epilepsy, stroke-related aphasia, and motor dysfunction and pain syndromes such as neuropathic pain, visceral pain, or migraine.<sup>75</sup> Several clinical studies are underway to evaluate the clinical utility of TMS for these indications,<sup>69,75-77</sup> and a recent review has set forth evidence-based guidelines for TMS therapy and listed specific conditions for which current evidence is sufficient or insufficient to recommend treatment.<sup>78</sup>

### Static Magnetic Field Therapies

A wide variety of health claims have been made for static magnetic field (SMF) therapies, and a large number of manufacturers currently sell magnets intended for therapeutic purposes.<sup>79,80</sup> Most SMF therapies use ceramic or neodymium permanent magnets placed on the skin surface or very near to the body. Although the quality of published research varies greatly, blinded *in vivo* studies have reported a variety of clinical benefits for SMF exposures, including improvements related to postsuction lipectomy edema and pain<sup>81</sup>; fibromyalgia pain and sleep disorders<sup>82,83</sup>; chronic pelvic pain<sup>84</sup>; pain, numbness, and tingling due to diabetic peripheral neuropathy<sup>85</sup>; postpolio pain<sup>86</sup>; and musculoskeletal pain.<sup>87</sup> Other trials reported both positive short-term and negative long-term results on osteoarthritis knee pain<sup>88</sup> and no effect on foot<sup>89,90</sup> and chronic back pain<sup>91</sup> (although the latter 2 trials employed magnets in bipolar configuration, resulting in lower amplitude inside the target as compared to unipolar configuration). Reviews have produced ambivalent conclusions for analgesia<sup>92</sup> and microcirculation<sup>93</sup> and have reported that more research is needed to determine clinical efficacy for bone, tendon, and skin healing.<sup>94</sup>

### Modalities Using Electric Currents, Voltages, or Potentials

All living organisms produce electric currents and potentials. This endogenous bioelectricity is a crucial component of biology, as it serves as a substrate for membrane potential, all nervous system activity, and many other vital biological processes.<sup>47,48</sup> Pivotal advances in medicine have resulted from the ability to measure and manipulate bioelectricity,<sup>95</sup> and here we provide examples of devices that measure or manipulate bioelectricity and have been employed for research in biofield science. Even though their underlying mechanisms are understood well, EEG and ECG are included as biofield devices. These approaches are sensitive measures of distributed information flow required for cellular regulation and function, which although well understood in terms of biophysical substrates, also represent important examples of biofield

interactions according to the above definition.

EEG is a noninvasive technique that uses electrodes on the scalp to produce quantitative information about the functional state of the brain. The frequencies present in EEG data are indicative of particular brain states and brain function on a cellular level. EEG is used to identify epileptic seizure activity and has been employed as a research tool to measure changes in brain state related to biofield therapies.<sup>96</sup>

ECG, using skin surface electrodes in a manner similar in principle to EEG, is a diagnostic tool for detecting the electrical activity of the heart. ECG is sometimes used for the diagnosis of heart-related conditions, including myocardial infarction, syncope, and pulmonary embolism.<sup>97</sup> ECG data can also be used to measure changes in HRV<sup>98-102</sup> that have been linked to a variety of biofield practices, though further studies are needed.<sup>103-105</sup>

Electrodermal activity measured by skin conductance and galvanic skin response (GSR) reflects autonomic sympathetic arousal associated with emotional and cognitive states.<sup>106</sup> GSR measurements are also employed by several devices claiming diagnostic abilities, but the veracity of these claims has not been clearly demonstrated. Also, the use of GSR for diagnosis is controversial: while the FDA classifies GSR measurement as a Class II medical device to be used only for the measurement of skin conductance and permitted for use in biofeedback,<sup>107</sup> a number of manufacturers of devices intended for a broader range of diagnoses via GSR have obtained FDA labeling under this more narrow designation. Another device employing electrodermal measurement is the apparatus for meridian identification (AMI), which measures electrical characteristics of the skin at acupuncture points located at the base of fingers and toes called Jing-Well points.<sup>108</sup> Based on the theory that the “energy” or “strength” of the acupuncture meridians (or energy channels) is reflected by electrodermal characteristics, conductance, capacitance, and polarization, measurements from Jing-Well points are analyzed in order to diagnose a variety of pathologies, as well as to assess overall wellbeing.<sup>109</sup> In a controlled study of claustrophobia therapy, increase in AMI-measured pre-polarization current at Jing-Well points correlated with a significant reduction in anxiety.<sup>110</sup> Similarly, statistically significant differences between electric potential measurements obtained on and off acupoints and between external focus and healing states have been reported in “energy healing” practitioners.<sup>111</sup>

In addition to these diagnostic uses of bioelectricity, electrical stimulation is rapidly emerging as an important new domain in medicine. Stimulation technologies, such as vagus nerve stimulation (VNS), deep brain stimulation (DBS), and transcranial direct current stimulation (tDCS), are currently practiced clinically and are under investigation for several new indications, in particular for diseases and conditions that are unresponsive to pharmacological therapy.

VNS, which entails the use of implanted elec-

trodes to stimulate the vagus nerve, is currently approved in the United States for treatment of epilepsy and depression and is being actively studied as treatment for osteoarthritis, tinnitus, anxiety, Alzheimer's disease, migraine, fibromyalgia, obesity, autism, sepsis, and inflammatory pathologies.<sup>112,113</sup> DBS involves the use of implanted electrodes to stimulate targeted regions of the brain.<sup>114</sup> DBS has been studied as a treatment for chronic pain, major depression, and Tourette syndrome<sup>115</sup> and is currently FDA-cleared for the treatment of tremor, Parkinson's disease, dystonia, and obsessive-compulsive disorder. It is also under consideration as a diagnostic/research tool.<sup>115</sup> During tDCS, electrodes are placed upon the scalp to noninvasively transmit electrical current across the brain. Research on tDCS is emerging and preliminary results suggest it may enhance cognitive performance.<sup>116</sup>

Earthing, also known as grounding, is a practice whereby individuals connect themselves electrostatically to the earth by walking barefoot outdoors or by using grounded conductive mats, bedsheets, or body bands when indoors. Based upon the notion that the earth's negative surface charge is a virtually limitless reservoir of free electrons constantly replenished by the global atmospheric electric circuit,<sup>117,118</sup> when earthed, the body uses these electrons as antioxidants for neutralizing excessive oxidative stress in the body.<sup>119,120</sup> Research published over the last decade reports a broad array of health-related results, including improved sleep, decreased pain, normalizing effect on cortisol, reduction and/or normalization of stress, diminished damage to muscles caused by delayed onset muscle soreness, reduction of primary indicators of osteoporosis, improved glucose regulation, and enhanced immune function.<sup>121</sup> While this simple technique holds promise as a therapy and method for enhancing overall wellbeing, more research is needed to determine the mechanisms and clinical significance of earthing.

Taken as a whole, these electric current technologies, which alleviate symptoms by delivering electrical current into a system that is experiencing dysfunction, produce systems-level effects and could be viewed as cutting-edge examples of biofield diagnostic and therapeutic devices. While still in the nascent stages of refinement and elucidation of mechanisms of action, the potential positive clinical impact of this class of devices is significant and likely to shed light upon several interrelated areas of biofield science.

### Modalities Using Vibration/Sound

A number of devices use sound, both within and outside of the audible range for humans. Infrasound is low-frequency sound with frequencies below 20 Hz, which is the limit of “normal” human hearing. Infrasound has been reported to be effective for increasing vitality, accelerating healing, and strengthening immune function.<sup>122</sup>

Transcranial ultrasound (TUS) is a noninvasive neuromodulatory technique that may be useful for the

treatment of mental health and neurological disorders.<sup>123,124</sup> While further work is needed to demonstrate the range of clinical applications,<sup>125,126</sup> recent clinical studies have reported improvement in mood in chronic pain patients, suggesting promise for TUS as a noninvasive treatment for pain management and perhaps depression.<sup>127</sup>

Several therapies using audible sound have been developed that could be considered biofield devices. Music therapy, the clinical and evidence-based use of musical sounds to meet therapeutic goals, has been shown to promote wellness, manage stress, alleviate pain, enhance emotional expression and memory, improve communication, and promote physical rehabilitation.<sup>128</sup> Neuroacoustic therapies use sound to modulate brain activity and are reported to affect sympathetic-parasympathetic balance and synchronize the activity of the right and left brain hemispheres.<sup>129</sup> Binaural beat neuroacoustic therapies employ combined tones of slightly differing frequencies and left–right channels, which are reported to induce altered states of consciousness,<sup>130</sup> modulate EEG activity and hypnotic susceptibility,<sup>131</sup> and affect vigilance and mood.<sup>132</sup>

#### Modalities Based Upon Mechanical/Physical Interactions

TCM uses acupuncture as a technique for balancing the flow of a vital energy called *qi*, believed to move through the body's meridians.<sup>133</sup> TCM posits that disruption of energy flow is a root cause of many types of disease<sup>134</sup> and that one means to harmonize the flow of *qi* is to insert thin metal needles into particular acupuncture points on the skin, often followed by stimulation of the needles mechanically or electrically.<sup>135</sup> Acupuncture is commonly used to treat many symptoms and diseases, including chronic pain, osteoarthritis, side effects of chemotherapy, and fibromyalgia.<sup>136-139</sup> Although the anatomical nature of these meridians is unclear, it has been suggested that thread-like, nonlymphatic subcellular structures sometimes called Bonghan ducts or primo vascular structures may play a role<sup>140,141</sup>; several theories for mechanisms of action have been put forth, including local inflammatory responses, cytoskeletal remodeling, release of adenosine (antinociceptive effects), neuromodulation, endogenous opioid production, and alteration of autonomic nervous system tone.<sup>142-145</sup>

#### Modalities Based Upon Human Intention

A large and growing research literature has considered the role of human consciousness and intention in biology, psychology, and the physical sciences.<sup>8,9</sup> These human intentionality effects have been reported in a variety of living systems—for example EEG<sup>146</sup> and galvanic skin response<sup>147</sup>—suggesting that human intention may play a key role in biofield interactions.

Two large-scale projects are currently collecting data on human interactions with global events: (1) the Global Consciousness Project is collecting data on cor-

relations between statistics of continuously operating random event generators around the world and brief episodes of widespread mental and emotional reaction to major world events,<sup>148</sup> and (2) the Global Coherence Initiative is seeking to examine interactions of humans with EMFs of terrestrial, solar, and cosmic origin by installing a global network of 12 to 14 ultrasensitive magnetic field detectors around the planet and correlating EMF data with variables such as HRV.<sup>149</sup> While these global projects involve large numbers of participants around the world, the intention host device (IHD) is another type of device methodology based upon human intention focused more individually.<sup>150</sup> The IHD has been reported to broadcast imprinted human intention to condition a laboratory environment and to produce alterations in time-series measurements of temperature, pH, drosophila fitness and energy metabolism, in vitro enzyme activity, and molecular concentration variability.<sup>150,151</sup>

#### Modalities Using Gas or Plasma

Gas discharge visualization (GDV) is an important example of the use of plasma in biofield science. Based on the Kirlian effect, a high-frequency, high-voltage field is used to stimulate weak photon emission, followed by the application of modern optics, electronics, and computer processing to form images of the weak photon emission. Dating back to the 1930s,<sup>152</sup> this technique has been called electrography,<sup>153</sup> electrophotography,<sup>154</sup> corona discharge photography,<sup>155</sup> bioelectrography,<sup>152</sup> GDV,<sup>156</sup> electrophotonic imaging (EPI),<sup>157</sup> and Kirlianography.<sup>152</sup> GDV/EPI techniques are currently used diagnostically based upon the characteristics of images of the fingertips<sup>158</sup> and often with proprietary means of correlating these data with acupuncture systems or other means of assessing the biological state.<sup>159</sup> Nearly 1000 papers have been published (mostly in Russian) on GDV research and a few hundred more in the West. A recent review of GDV research applied to medicine and psychology can be found in the book *Electrophotonic Applications in Medicine: GDV Bioelectrography*.<sup>160</sup> One study reported significant differences in cancer patient GDV scans when compared with healthy participants, and after 6 weeks of treatment including surgery, chemotherapy, and radiation, a change trending toward healthy subject GDV profiles.<sup>161</sup> These intriguing data suggest that informatics based upon biofield measurement devices such as the GDV may be useful for gaining deeper understanding of disease states and guiding practitioners and their patients towards states of greater wellness.

#### Other Device Modalities

In light of observations of nonlocal effects,<sup>8,9</sup> which suggest that biofield interactions may involve means of information transfer that cannot be easily described via well-understood substrates (eg, EMFs), here we describe devices that do not fit easily into the categories listed above. Although a vast number of

other devices fall into this category, here we list 3 of the more well-known modalities: torsion fields, orgone energy, and scalar waves. These 3 modalities were chosen because of their prominent positions amongst devices purported to act upon the biofield. However, it should be noted that the biophysical substrates are either poorly understood or not generally accepted by the scientific community. Claims of effects and efficacy for these modalities have not been verified, and further research is needed to establish not only the veracity of the claims but also to fully confirm the existence of the specific effects reported.

### **Torsion Fields**

The notion of a torsion field is generally credited to the Russian professor N.P. Myshkin<sup>162</sup> and is based upon the theory that particles with spin are coupled via torsion fields.<sup>162</sup> A collection of relevant experiments is reviewed in a volume by Swanson.<sup>163</sup> Torsion fields are of interest to biofield science in that they could provide a theoretical framework for explaining non-EMF interactions and how these might interact with biological systems.

### **Orgone Energy**

Orgone energy is a purported universal life force originally described in the 1930s by the Austrian psychoanalyst Wilhelm Reich.<sup>164-166</sup> Reich believed orgone energy to be a massless, omnipresent substance, closely associated with living energy but also present in inert matter. Orgone energy was thought to create organization on all scales using orgone particles called “bions,” from the microscopic to macroscopic levels within organisms, clouds, or even galaxies.<sup>165</sup> Reich designed and built special “orgone energy accumulators” to collect and store orgone energy from the environment and claimed these devices could be used for improvement of general health.<sup>164</sup>

### **Scalar Waves**

Scalar waves are said to be produced when 2 electromagnetic waves of the same frequency are exactly out of phase and cancel with each other.<sup>167</sup> Rather than the waves completely disappearing in the destructive interference, it is hypothesized that a transformation of energy into a scalar wave occurs, with the resulting scalar field “reverting back” to a vacuum state of potentiality.<sup>167</sup> Scalar waves are purported to explain homeopathy and lymphatic detoxification; treat diabetes, nearsightedness, kidney stones, Parkinson’s disease, strokes, arthritis, and cancer; and reverse the aging process.<sup>168</sup>

## **DISCUSSION**

Although the biofield devices described here operate through a great diversity of mechanisms, these devices all share the common quality of being most clearly understood within a biofield framework, wherein information flow or the capacity to create organiza-

tion acts across hierarchical levels to coordinate biological activity. Elements of this framework are already well accepted by the biomedical community and have been applied through several device modalities, including ECG, EEG, other electrophysiological techniques, some EMF therapies, ultrasound, thermal imaging, and techniques using light like LT. Extraordinary medical and scientific progress has occurred as a result of these modalities and the elucidation of their underlying principles. Further progress is likely to be informed by the recent demonstration of endogenous EMF regulation of a variety of biological processes and indications of quantum information processing in the cytoskeleton.<sup>48-52,54,169</sup> These recent results suggest a biophysical basis for biofield coordination of activities across the molecular, cellular, and organismic levels<sup>53</sup> and may provide testable hypotheses regarding biofield regulation of homeodynamics and mind-body interactions.

In contrast to this growing knowledge of biofield mechanisms, several biofield modalities appear to operate according to principles that are not currently well understood or accepted by mainstream medical science. Further study of those modalities for which there is strong experimental evidence—eg, BE, consciousness and nonlocal interactions, GDV, TCM—may substantially advance our understanding of biofield interactions and their biological and health implications.<sup>57</sup> The growing basic science data and existence of devices operating via consciousness or intention,<sup>8,9</sup> which may act through nonlocal quantum correlations, must be taken seriously. Despite long-lasting taboos proscribing study of these phenomena, researchers must have the courage and self-awareness necessary to assess the veracity, specific properties, and general significance of the large and important body of research in this area.

The large diversity of biofield device modalities presents several significant methodological issues not limited to the fact that biofield interactions appear to involve exceedingly complex systems. Attempts to reduce biofield interactions to reductionist substrates may be inadequate, underscoring the need for a more holistic “systems biology” approach.<sup>170</sup> Significantly, several of the modalities described here, such as BEs and extremely weak EMFs, operate at extremely low interaction energies, often below the apparent thermal threshold of Brownian motion.<sup>56</sup> Such low energies suggest the existence of weak-field information transfer or subtle signaling, for which the biological mechanisms are only now becoming elucidated. While the existence of extremely weak EMF effects is now beyond dispute,<sup>56</sup> understanding of the clinical relevance of specific nonthermal waveforms is still in its infancy, and a more comprehensive model of the resonant response of the body to particular weak EMF signaling is still needed. Furthermore, the significance of these EMF effects is unclear when juxtaposed with the variety of EMFs that many individuals are exposed to in the course of everyday life.

In order to determine which biological processes exhibit functional sensitivities to these subtle factors, researchers will have to carefully control for the influence of very weak EMFs and other low-energy subtle influences. Therein, specialized equipment and laboratories will be required, including the use of Faraday cages,  $\mu$ -metal enclosures, completely dark rooms, noise-proofing, and the development of instruments sensitive enough to measure biofield interactions or subtle low-energy nonthermal influences. Nearly all cell culture incubators produce a nonuniform EMF of bioactive strength, which must be taken into consideration.<sup>56</sup> Controlling for picotesla-nanotesla range sensitivities<sup>57</sup> presents further challenges, as shielding at these extremely low field strengths may be difficult or impossible in some situations. In the absence of a means to control for all potential subtle effectors, it may, in some instances, be necessary to adopt a new paradigm of research wherein naturally occurring EMF fluctuations due to solar/geomagnetic and other sources are an integral part of the experimental environment and are therein measured and accounted for in analyses. Similarly, circadian and other naturally occurring biological rhythms may influence very sensitive systems. These factors may be precursors of a shift towards an information-based model of low-energy interactions, wherein the informational content of a process may be much more relevant than the apparent energy of interaction.

### **Interfaces for Future Research**

Biofield studies are now evolving toward being an accepted discipline within mainstream science, and the existence of a community or several related groups focused on biofield research will greatly enhance the visibility and credibility of the field as a whole. To further the development of knowledge in the next decade, we propose the creation of an organization or community of researchers dedicated to furthering biofield studies and device development. Regular opportunities for interaction and critical assessment of progress and results will enhance the growth of knowledge related to this emerging field. A collaborative community will also enable the independent replication of key findings. This will be critical for achieving acceptance by the scientific community at large.

Another important goal will be to acquire funding for independent replications or concurrent experimental protocols in separate laboratories. Private sources of funding are necessary to perform research today, and this often results in conflicts of interest. For example, device manufacturers provide a substantial portion of the funding for research in EMF therapeutics. Research in this emerging and sometimes controversial field, which is moving toward advances in science, illustrates how such conflicts of interest could significantly hinder acceptance by the mainstream scientific community. Efforts could be made to form collaborations amongst device manufacturers to replicate findings and make distinctions between similar devices. Although this may appear to run contrary to the short-

term goals of individual companies, the long-term benefits may be substantial.

In order to further the progress of biofield research and device development, research must be coordinated across several levels. Further developments of diagnostic and therapeutic biofield device technologies will require interdisciplinary research joining clinical and preclinical studies with basic science efforts in physiology, biophysics, and the development of a theory of mind and nonlocal consciousness in the following areas.

### **Basic Science Foundations: Physiology, Biophysics, and Theory of Mind/Consciousness**

Interfaces among these 3 fields are crucial for the development and refinement of biofield device technologies. A better understanding of the physiology of biofield interactions (ie, biofield reception, generation, and function) will require interfaces with biophysics and new models for subtle biological influences such as extremely weak EMF effects or biophotonics. A more comprehensive theory of mind is required to understand nonlocal interactions and to further understand the biophysical bases for these effects. At this stage, models based upon quantum correlations appear promising,<sup>54,169</sup> but testable hypotheses are needed in order to develop a more detailed functional framework. Development of the interfaces between physiology, biophysics, and a testable nonlocal theory of the role of the mind will elucidate the specific ways in which devices can be developed for detection and manipulation of biofield interactions.

### **Preclinical Research**

Cell culture and animal models provide an essential interface for testing and implementation phases of device development. A large body of previous data has already been valuable for steering the device research described here.

### **Clinical Research**

Many of the devices reviewed here hold significant promise as low-cost, personalized diagnostic and therapeutic approaches. As such, rigorously designed clinical studies are a high priority for moving biofield device research and development forward. This will require interfaces among clinical, preclinical, and basic science researchers in order to assess the unique translational and methodological questions discussed above.

### **Cross-platform Validation**

An immediate goal will be to support the creation of laboratories that can design and carry out studies to test across multiple devices using gold-standard diagnostic and therapeutic medical approaches as comparators. The outcomes of these crossplatform validation studies could lead to the further development and implementation of noninvasive diagnostic medical assessments and therapeutic devices that are related to biofield science.

## CONCLUSIONS

The current existence of biofield devices is a demonstration of the clear, specific, and tangible knowledge that has been gained thus far in biofield science. Devices play prominent cultural and scientific roles in our society, and it is likely that device technologies will be one of the most influential access points for the furthering of biofield research and the dissemination of biofield concepts. Comprehensive study of biofield devices will require a concerted research effort, interdisciplinary collaborations, and sufficient funding. Systematic studies are needed to deepen our understanding of the nature of biofield interactions and to move biofield device development and experimentation forward. This developing field of study presents new areas of research that have many important implications for basic science, clinical medicine, and potentially, the forward progress and evolution of our species. The ever-growing understanding of biofield science holds promise to foster a more humane and personalized form of medicine and an expansion of our scientific viewpoint to include the importance of each individual's interconnectedness with communities, the immediate environment, the earth, and the cosmos.

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