

*An Exploration in the Efficacy of Acupuncture in the Relief of
Phantom Limb Pain in Amputees*

Presented By

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Background: Phantom limb pain (PLP) is the perceived pain of part of the body that is no longer present, and is a condition that affects up to 80% of amputees. Western medicine approaches humans as biochemical in nature and primarily treats disease with pharmaceuticals, as in the case of PLP, with treatments lacking consistency and long-term pain relief. These treatment failures do not consider the presence of our subtle energy bodies and the influence disruptions in these fields may have on the physical body. The following will review the pain processing pathways of the brain, the existence of subtle energy and its relations to Traditional Chinese Medicine, and the use of acupuncture as a method of treatment for phantom limb pain.

Methods: Relevant sources were searched from PubMed, MEDLINE, Ebsco, Cochrane Central Registrar of Controlled Trials, Google Scholar, and Science Direct. The combined number of studies found were 6, 231 for all search terms. After exclusions, 67 studies were included in this literature review. Search terms included *phantom limb pain, amputation, cortical reorganization, acupuncture, meridians, scalp acupuncture, sensorimotor cortex, cerebral cortex, energy medicine*. The years of publication were limited to the previous 25 years.

Results: Low quality evidence suggests acupuncture may confer a benefit to amputees suffering from phantom limb pain. Current research for acupuncture for phantom limb pain lacks controlled trials. Therefore, case studies were presented with various styles of acupuncture - body, scalp and auricular. Higher quality studies were included to investigate the relationship of cortical reorganization of phantom limb pain and acupuncture's effect on similar neuropathic conditions including CRPS and stroke. Supplementary studies of the energetic mechanisms of acupuncture defined the presence of meridian pathways and the therapeutic functions of acupuncture stimulation. Acupuncture points were shown through neuroimaging to influence the same brain structures affected by phantom limb pain. Acupuncture was also shown to have modulating effects on comorbid factors of phantom limb pain such as anxiety and depression, but the quality of studies was not adequate to confirm results across a generalized population.

Conclusion: Acupuncture combines its energetic properties with physical stimulation that can be linked to physical structures in the brain and systems throughout the body. It has shown to be beneficial for both western and eastern diseases; however, the efficacy of acupuncture for PLP in this review is inconclusive. Compelling case studies warrant further investigation into the benefits of this ancient medicine. Clinical trials are essential in understanding the complex nature of phantom limb pain and additional research could provide for an energy-based model supported by scientific evidence that would pave the way for a more integrated approach between eastern and western medicine.

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Chapter I: INTRODUCTION

Globally, more than one million limb amputations take place every year, with more than 80% of amputees experiencing phantom limb pain. Phantom limb pain (PLP) is the pain perceived by a region of the body that is no longer physically present. This pain has been described by sufferers as shooting, stabbing, boring, squeezing, throbbing, burning, twisting, or can feel like the phantom limb is being forced into an uncomfortable position. The pain is unique to each patient, can be intermittent or continuous, and can be triggered by external factors or bodily functions such as urination. The causal mechanisms of PLP have been theorized as psychogenic pertaining to symptoms of post-traumatic stress disorder (PTSD) after amputation, peripheral in relating to the stump and neuroma hyperactivity, and central neural with mechanisms involving desensitization and cortical reorganization, which may lead to maladaptive plasticity, the latter being the most cited theory to date. Phantom limb pain is not to be confused with phantom limb sensations (PLS) or residual limb pain (RLP), also known as stump pain (SP). PLS includes any feeling in the phantom limb that is not pain while RLP describes perceived pain experienced in the remaining stump of the amputated limb.

Patients with both planned and traumatic amputations have reported instances of PLP along with those having congenitally missing limbs.¹ About 2 million people are living with limb loss in the United States, and it is projected that this number will more than double by the year 2050 if the leading causes of amputation, dysvascular conditions such as diabetes mellitus, are not properly addressed.² Western medicine treatments include pharmacotherapy and invasive procedures, such as nerve blocking and stump revision, as a last resort. The efficacy of pharmaceuticals is well recognized in laboratory settings; however long-term observations have yet to be made.³ Currently, there is no pharmacological drug treatment protocol for phantom limb pain, so a process of trial and error dictates the course of treatment. A review of 38 therapies for PLP concluded no decisions could be made for the first-line management of PLP.⁴ Many doctors have turned their focus on preventing PLP with aggressive treatments for pre-amputation and immediate post-amputation pain. However, studies have shown this approach yields no effect for PLP.⁴

The mechanism of phantom limb pain has yet to be agreed upon in definite terms, which is perhaps why traditional treatment methods have not shown success in consistency among patients. PLP treatment failure rates have been recorded as high as 92% among amputees for up to 15 years after amputation⁵. In the same study, up to 65% of amputees had RLP at some point and 63% of those were failures of treatment. In a double blind, randomized, placebo-controlled trial, amputees with post-amputation pain reported a decrease in the intensity of post-amputation pain with the use of oral morphine, but was associated with a higher rate of side effects.⁶ In addition, no improvements in self reported levels of overall functional activity and pain-related interference in daily activities were reported. Furthermore, the U.S. Department of Health & Human Services declared the opioid epidemic a public health emergency in 2017. Secretary Thomas E. Price, M.D. outlined a 5-point plan to combat this crisis, and one of those points was to advance better practices for pain management. It's estimated that over 42,000 people died from overdosing on opioids and 11.4 million people misused opioid prescriptions in 2016.⁷ According to the Mayo Clinic, doctors usually begin with medications and then may add noninvasive therapies to supplement.⁸ The most recent studies have shifted focus to adaptive cortical reorganization with modalities like mental imaging and myoelectric prostheses.

The psychogenic view of pain, which has been dismissed as a cause of PLP, held that peripheral inputs, such as injury, were solely responsible for this imagined pain. In the absence of physical signs of organic disease, a patient was sent to a psychiatrist for further evaluation. The gate control theory proposed in 1965 by Ronald Melzack and Patrick Wall emphasized the importance of psychological factors such as attention, past experiences, and the meaning of the situation to influence pain processing and perception. This new theory did not dismiss these psychological factors as mere 'reactions to pain' as did the psychogenic view; they were now seen as integral components of pain processing by the brain and central nervous system. This new concept highlighted the brain's capabilities of filtering, selecting, and modulating inputs as an essential part of the pain process. It gave structures of the CNS, like the dorsal horn, that were previously thought to have passive transmissions, dynamic qualities that modulate activities such as inhibition and excitation. The gate control theory is now widely accepted as a mechanism of pain processing and underlies the cortical reorganization experienced by PLP sufferers. Although

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this theory has shed some light on pain-related structures and processes, conventional methods of treatment continue to lack consistency and long-term treatment alternatives.

The gap between eastern and western medicine lies in the empirical differences in culture, philosophy, and lack of scientific information surrounding the treatment mechanisms of acupuncture compared to the traditional western model of disease. The therapeutic methods and instruments utilized in TCM are not well developed for scientific investigation and data collection. New technologies are now allowing researchers to prove the existence of subtle energies, meridian pathways, and how they correlate with physical pain syndromes. Limited research has been done with acupuncture in relation to PLP, and it is commonly used as an adjuvant therapy alongside pharmacological treatments, making it difficult to examine its unilateral results.

Dr. Eric Leskowitz MD, whose medical research focuses on the human biofield, suggests that energy's key role in health and illness is acknowledged by TCM, which believes that an impaired flow of *qi* leads to low energy and disease, i.e. pain, while the free flow of *qi* leads to abundant energy and radiant health.⁹ The characteristics of PLP unable to be explained by western medicine, such as the vividness in its projections, are accounted for in energy-based explanatory models. In these models, the memories of traumatic experiences are attached to the subtle body and continue to cause imbalances to the physical body through the disruption of the flow of *qi*. In theory, once the health of the subtle body is addressed, the physical and psychological symptoms experienced will begin to dissipate.

One of our subtle energies, referred to as *qi* in eastern philosophies or *prana* in Ayurveda, can be thought of as a vital life force present not only in our bodies, but throughout the universe that gives spirit to all living things. Energy presents itself as the missing link between mind and body. TCM considers energy's essential role in the form of *qi*, "Blood follows the *qi*, mind directs the *qi*." The body responds to thoughts, emotions, and beliefs, which can enhance or hinder the flow of *qi* throughout the body. The following will review the pain processing pathways of the brain, the existence of subtle energy and its relations to Traditional Chinese Medicine, and the use of acupuncture as a method of treatment for phantom limb pain.

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Acupuncture has been demonstrated to have analgesic effects, but its mechanism of healing remains a mystery to the scientific community. This review will research the question of the relationship between acupuncture and phantom limb pain. Considering the high incidence of PLP post amputation, this information is both relevant and necessary to further research in this field of medicine. It could also lay the groundwork for treatments of neuropathic pain syndromes with mechanisms similar to those of PLP. The hypothesis for this review is as follows: The nature of phantom limb pain as a disruption of *qi* in the meridian pathways designates acupuncture as an effective course of treatment for amputees.

CHAPTER II: LITERATURE REVIEW

INTRODUCTION

The first mention of phantom limb pain came in 1551 from French military surgeon Ambriose Paré, and later in 1872 by American physician, Silas Weir Mitchell, in his book *Injuries of Nerves and Their Consequences*, he conjectures, “Nearly every man who loses a limb carries about with him a constant or inconstant phantom of the missing member, a sensory ghost of that much of himself, and sometimes a most inconvenient presence, faintly felt at times, but ready to be called up to his perception by a blow, a touch, or a change of wind.”^{10(p342)}

As a result of exploring severe pains in the phantom bodies of paraplegics where the brain was completely disconnected from the spinal cord, Ronald Melzack developed four conclusions after his analysis of the phantom limb phenomenon:¹¹

1. Due to the vividness of the phantom limb, the neural processes in the brain are also responsible for physical body sensory normally activated by inputs, and can also act in their absence.
2. Because these neural processes act in the absence of inputs, the qualities of experience lie in the neural networks of the brain. Stimuli may trigger these sensory patterns, but do not produce them.
3. Distinct from other people and the surrounding world, the body is perceived as a whole, and identifies as the ‘self’, which is produced by central neural processes and cannot be derived from the peripheral nervous system or spinal cord.
4. The experience of unity is produced by central neural processes that are ‘built-in’ by genetic specification; although, this built-in component must be modified by experience.

He then introduced the theory of the ‘*body-self*’ *neuromatrix*, which expanded the scientific community’s understanding of pain. It explains the concept of pain as multi-dimensional with a

pattern- generating mechanism called the *neurosignature*. A widely distributed neural network, or the *neuromatrix*, consists of loops between the thalamus, cortex, and limbic system. Divergence of these loops allow for parallel processing in different areas and repeated convergence creates interactions between the sensory output products of processing. This cyclical processing and synthesis of neural impulses throughout the network forms a *neurosignature*. It's comprised of patterns of synaptic connections and is a continuous output stream from the *neuromatrix*. Various *neuromodules* process information such as temperature change, external stimulation, and injury related to major sensory events. These *neuromodules* impress their unique subsignatures on the greater *neurosignature*.

The brain is considered the *sentient neural hub* in which a chain of nerve impulses is transformed into a continually changing stream of awareness. In addition, these *neurosignature* patterns are capable of activating the *neuromatrix* to produce its own patterns of movement.¹¹ The *neuromatrix* is a template of the whole, and subserves the unique *neurosignature* pattern for the entire body. The Cartesian¹ 'psychosocial' link between injury and pain has been sustained in laboratory settings, where attention is focused on mildly to moderately painful stimuli. However, when the severity of the injury goes beyond moderate levels, as it often does in a natural environment, Melzack's theory of the *neuromatrix* surpasses the Cartesian model, as in the case of phantom limb pain.¹¹

METHODOLOGY

The databases used to find relevant clinical studies were PubMed, EBSCO, Medscape, Google Scholar, MEDLINE, Science Direct and the Cochrane Central Registrar of Controlled Trials. Search terms included *phantom limb pain, amputation, cortical reorganization, acupuncture, meridians, scalp acupuncture, sensorimotor cortex, cerebral cortex, energy medicine*. The years of publication were limited to the previous 25 years. Study types included in the search were

¹ René Descartes, in his 1664 *Treatise of Man*, theorized that body was more similar to that of a machine, and pain was a disturbance that passed down along nerve fibers until it reached the brain. He proposed his theory by presenting an image of a man's hand being struck by a hammer.

systematic reviews, randomized controlled trials (RCT), cross sectional studies, exploratory studies, cohort studies, case series, case reports, literature reviews, and scholarly articles. Inclusion criteria was set with interventions of acupuncture. Study designs with and without controls were included due to the limited research in this field. Exclusion criteria of adjunct therapies will be set with transcutaneous electrical nerve stimulation (TENS), massage, acupressure, acupuncture injections, cupping, and herbal therapies. It is assumed that all respondents have answered survey questions honestly and to the best of their abilities in accordance with standardized scales in each category of interest, such as the numeric rating scale (NRS) and the visual analog scale (VAS).

The results of the search strategy are summarized in Figure 1 flow diagram. The literature search resulted in 6,231 articles. An additional 3 articles were identified through references of eligible articles. Initial screening excluded 4,697 records due to duplication, not relating to topic, and non-human studies. Title and abstract screening was performed on 1,534 records leaving 111 articles eligible to be assessed for inclusion. Remaining articles were assessed for eligibility by reading the full text for relation to phantom limb pain and/or acupuncture mechanisms. In this phase, 44 articles were excluded due to adjunct treatment methods, treatment approaches, such as prevention of PLP, and proper distinction of PLP from PLS/RLP. After completed evaluation, 67 articles were selected for inclusion.

BACKGROUND

Albert Einstein showed that matter and energy are interchangeable ($e = mc^2$) with matter being the densest of states. The same would apply to the physical body relative to subtler, less dense energies surrounding, and all being of the same consciousness at different levels. The interdependence of these systems would assume a disruption in one, whether at the physical or subtle level, would synergistically affect the system as a whole. The nature of phantom limb pain aligns with this explanatory model of subtle energies influencing physical symptoms.

All of the cells in our bodies create tiny electrical charges forming an electromagnetic field (EMF). Every human has a magnetic field that is generally shaped like a torus with a central core that consists of an upward spiral of energy currents and a simultaneously descending spiral of energy currents. This is called the human 'biofield' because it is generated by a biological system that has unique dynamic qualities. These ascending and descending currents intersect at 7 points, or chakras, along the spine, similar to the Caduceus symbol of 2 snakes used in medicine. The chakra system comprises 7 main energy centers aligned vertically throughout the body. Chakra is derived from the Sanskrit word meaning 'wheel,' and describes these wheels of energy starting from the base of the spine to the crown of the head, which correspond to bundles of nerves and major organs as well as psychological, emotional, and spiritual states of being. This energy extends outward with increasing vibrational frequency and decreasing density.

Through the use of SQUID technologies (superconductive quantum interference device), tiny biomagnetic fields associated with physiological activities occurring in the body can now be measured. Photoluminescent bioceramic (PLB) material releases energy in the form of light and measures electromagnetic radiation of matter, allowing researchers to track meridians and point locations.¹² Stimulation of these biofields can facilitate healing through methods such as acupuncture, repetitive transcranial magnetic stimulation (rTMS), and transcranial direct current stimulation (tDCS), sound therapy, biofeedback, and therapeutic touch. Devices with lower level frequencies stimulate growth and repair of nerves, bones, blood capillaries, ligaments, connective tissues, and skin. Orthopedic surgeons utilize magnetometers to induce bone healing in non-union fractures while rTMS is being used to stimulate brain plasticity for depressive and pain conditions. Therapeutic touch (TT) is similar to Reiki or *pranic* healing, and is a way to balance energy systems of the body without physical contact with the patient. The energy field of the patient is 'smoothed' out by slow sweeping motions made by the hands of the practitioner. This essentially clears out the obstructions in that area of the biofield.

The biofield is commonly referred to as the aura, and assuming that the phantom limb is part of the aura, it should be detectable using electronic instrumentation. However, this theory has its controversies in defining the aura or *qi* as the equivalent of the human EMF, as the EMF is understood to originate from the electrical activity of the nerve impulses and muscle contractions

taking place in the physical body. Some say the more subtle energies are an after effect of the EMF itself and imagery of this field is not an accurate representation of the human biofield.⁹

Kirlian photography is a technique used to capture the peripheral EMF of living tissue by measuring electrostatic corona discharge patterns. (See Figure 7) The ‘glowing halos’ seen around these objects are purported to indicate the strength of the underlying EMF. Reference to phantom limbs occurred through the ‘Phantom Leaf Effect’ when electrostatic discharges were shown to exist around the tip of a leaf even after the tip had been cut away. This effect proves the Kirlian field is not dependent on biological structures. Though, the image effects of this photography have their limitations, one being that the object must fit in between the 2 electrode plates in a 1cm wide space. Previous attempts to image phantom fingers have been unsuccessful, likely due to the large discharge voltage needed that overrode any EMF that may have been associated with the finger.⁹ Polycontrast interference photography (PIP) was developed as a technique to image the entire biofield by British researcher Harry Oldfield. Light reflected off the human body is recorded by optical phase contrast filters that produce Moiré patterns. (See Figure 8) Oldfield was hopeful this technology would be able to detect phantom limbs, but no evidence was seen of a phantom limb past the edge of the amputation.⁹

The Five Element Theory in Chinese medicine holds that all phenomena in the universe correspond in nature to wood, fire, earth, metal, or water, and that these are in a state of constant motion and change.^{13(p20)} Each element is associated with certain organs, emotions, symptoms, seasons, foods, colors, etc. reinforcing the holistic point of view and the idea that everything in the universe is connected in nature. This can account for the holistic benefits of acupuncture having a wide range of therapeutic utility in addition to pain with respect to sleep, mood, energy, and digestion; as the body functions synergistically to form a whole, one area of improvement tends to positively affect other areas of imbalance. Many patients with PLP tend to suffer from various symptoms of PTSD, and acupuncture allows for the opportunity to address these issues in the same course of treatment with PLP.

A paradigm shift has been emerging over the past few decades that has been reshaping the idea that we are not just biochemical beings, but that humans are bioenergetic in nature, which allows

for a more holistic approach to healing, bringing us back to the roots of the eastern philosophies of medicine that have been around thousands of years. The National Center for Complementary and Alternative Medicine, part of the National Institute of Health describes acupuncture as a safe method of treatment citing few reported complications.¹⁴ Complications that can arise include those from the use of non-sterile needles and improper delivery of treatment, which can cause serious adverse effects including infections, punctured organs, collapsed lungs, and injury to the central nervous system. As a therapeutic tool, it is utilized to assist in the regulation of *qi* by providing a specific stimulus to body points that lie along meridian pathways to remove any blockages that may be causing imbalances, i.e. pain.

Qi is also present in the organs and in more specific systems of the body, and is referenced as such in Chinese medical diagnosis. *De qi* is the excitation of that energy through stimulation of an acupuncture needle along a meridian, or energetic pathway. Sensations of *de qi* may feel intense and accompanied by pressure, numbness, soreness, heaviness, distention, warmth, coolness, dull pain, or sharp pain. If a sharp pain persists after a few seconds, the practitioner adjusts the needle to achieve a less intense response. Elicitation of *de qi* is a key component to the effectiveness of this medicine as it is a reflection of connecting with the meridian pathway of the acupuncture point.^{13(p345)} This comes from the *Huangdi Neijing*, Yellow Emperor's Classic of Medicine, an ancient Chinese medical treatise on health and disease said to be written by *Huangdi*, a famous Chinese emperor from around 2600 B.C. whom some regard as a semi-mythical figure. This book is based on Taoist philosophy, which provides the key to a long healthy life is to follow the Tao, the natural way of the universe.¹⁵

The system of meridians includes 12 main meridians, 8 extra meridians, 15 collaterals, 12 divergent meridians, 12 muscle regions and 12 cutaneous regions.^{13(p60)} The meridians run longitudinally and interiorly within the body, and represent the main trunks of the body. Collaterals run transversely and superficially from the meridians and constitute branches of the meridians. A stagnation of *qi* in one channel causes an excess and/or a deficiency in multiple meridians. To rectify the imbalance, the channels must be strengthened, (tonified) or calmed (sedated). In acupuncture, this can be done through point selection, needle stimulation, technique, direction, and breathing.^{13(p347)}

The 12 main meridians are used to transport *qi* and *blood* (physical essence) throughout the body and are associated with 12 *zang-fu* organs², which is a term designating the nature of the organs referencing their functionality.^{13(p27)} The 6 *zang* organs are Heart (HT), Lung (LU), Spleen (SP), Liver (LV), Kidney (KD), Pericardium (PC), and the 6 *yang* organs are Gallbladder (GB), Stomach (ST), Small Intestine (SI), Large Intestine (LI), Bladder (BL) and the Triple Energizer (TE) meridian. (See Figure 9) They pertain to the organs interiorly and extend over the body following acupuncture point locations along the external body. The twelve main meridians are interconnected and create one continuous loop, which takes *qi* 28 minutes to complete a full cycle, where one channel ends, another begins. This forms a network connecting tissues and organs of the body into an organic whole.

The meridians are classified by their location on the body with given names such as *Hand-Shaoyin* for the Heart channel. The internal pathway of the Heart *Hand-Shaoyin* meridian starts at the center of the heart and permeates the heart system, i.e. the aorta and major blood vessels entering and exiting the heart, then descends through the diaphragm. The ascending portion of the meridian envelops the throat and follows the carotid artery up to the eye system. The main branch goes to the lung and emerges at the axilla at point HT1 *Jiquan*, or ‘Highest Spring.’^{13(p69)} The external acupuncture point pathway of the Heart *Hand-Shaoyin* meridian begins at the axilla (HT1 *Jiquan*) and ends on the radial side of the fifth finger. This meridian is associated with speech and mental disturbances as well as cardiac issues due to the location of the internal pathway, not the physical location of the external meridian. Although, local points on external pathways are commonly used to address specific issues such as muscle tightness. It’s important to note, in TCM theory, diagnoses are only associated with the *qi* pathways of that particular organ and don’t necessarily reflect derangements in the functionality of the organs themselves.

Acupuncture points are categorized by the meridians in which they are located and in ascending numerical order. The points also have Chinese names that generally reflect the therapeutic properties of the individual points. Heart 7 (HT7 *Shenmen*) translates into ‘Spirit Gate’. In TCM theory, *shen* is our spirit or soul, which is associated with the Heart *Hand-Shaoyin* meridian. This

² The primary physiological functions of the *zang* organs are to produce and store essential substances including *jing* (vital essence), *qi*, *blood*, and body fluid. The main functions of the *fu* organs are to receive and digest food, and transmit and excrete the wastes.

point is used for calming the spirit, pacifying the heart, and clearing the channel. Western conditions addressed by HT7 *Shenmen* are cardiac pain, irritability, palpitation, hysteria, amnesia, insomnia, mania, epilepsy, dementia, pain in the hypochondriac region, feverish sensation in the palm, and yellowish sclera.^{13(p166)}

Practitioners are able to use proximal and distal points along the meridian pathway to treat disease. For example, LI4 *Hegu*, located between the first and second metacarpal bones on the dorsum of the hand, is an empirical point to promote *qi*, a command point for issues of the face and mouth, and is commonly needled for headaches and pain.^{13(p140)} The Large Intestine (*Hand-Yangming*) point pathway starts on the radial side of the index finger, LI1 *Shangyang*, and ends in the nasolabial groove at LI20 *Yingxiang*. Once the point is needled in the hand, TCM theory propagates that the stimulation of the needle in that specific point will direct the flow of *qi* upward, clearing stagnation in the pathway, resulting in the return of the free flow of *qi*, and in theory relieving pain.¹⁶

DISCUSSION & EVALUATION

THE PATHWAYS OF PAIN PROCESSING

There is a consensus among experts that multiple mechanisms play a role in producing phantom limb pain. One is the peripheral mechanism due to the trauma that occurs at the site of amputation involving nerves and surrounding tissues.¹⁷ The proximal nerve endings begin to sprout neuromas, and the nerve excitability increases resulting in spontaneous discharges. Damage to these nerves disrupts afferent and efferent signals involving the missing limb in a process called deafferentation. The second is central sensitization where the receptive fields in the spinal cord become hypersensitive to increased neuronal activity. Increased N-methyl-D-aspartate (NMDA) activity in the dorsal horn of the spinal cord results in an upregulation of

receptors in that area and can cause descending inhibitory fibers to lose their target sites.¹⁷ This is also known as the wind-up phenomenon, which leads to non-responsive or chronic intractable pain.¹⁷ The third and most widely accepted pain mechanism of PLP comes from the maladaptive plasticity model referring to cortical reorganization (CR) of the somatotopic regions of the brain associated with the missing limb. A somatotopic map of the brain designates which areas in the cortex are associated with each part of the body. When deafferentation occurs, signals from the missing limb are no longer received by the brain in the somatosensory cortex (S1) and primary motor cortex (M1) due to a disruption of neuronal connections. This results in adjacent zones of the brain taking over the area representative of the missing limb, or reorganization. (See Figure 10) The experience of phantom pain designates this plasticity as maladaptive. These three mechanisms are not mutually exclusive and all are thought to contribute to PLP in varying degrees. However, still remains is the missing link of the underlying cause of the phantom pain.

The physical representation of PLP has shown links to CR in both S1 and M1. The sensorimotor cortex (S1/M1) comprises the precentral and postcentral gyri covering the primary sensory and motor areas of the brain. S1 receives and processes sensory information from the entire body involving touch, temperature, proprioception, i.e. the position of the body in space, and nociception, i.e. pain. M1 is located in the frontal lobe of the brain along the precentral gyrus and generates neural impulses that control the execution of movement. Sensory and motor representation is somatotopically arranged from the toe, at the top of the cerebral hemisphere, to the mouth, at the bottom of the hemisphere, along a fold in the cortex called the central sulcus which separates S1 and M1.

The activation of the lip and hand area representations in patients presenting with PLP has been proposed as the neural correlate of the pain.¹⁸ Functional MRI and MEG (magnetoencephalography) studies of upper limb amputees suffering from PLP showed evidence of cortical reorganization in the sensorimotor cortex (S1/M1) that expanded from the lip representation area to the missing hand area when subjects elicited lip pursing movements.¹⁹⁻²¹ In pain free amputees, lip representation was symmetrical in S1/M1, which would suggest correlation of displacement of the lip area representation with PLP.²⁰ During imagined movements of the missing hand in amputees, all patients showed higher activation of

contralateral S1/M1 than those of healthy controls. In addition, those with the most severe chronic pain showed the highest level of activity in S1/M1 missing hand cortices when performing phantom hand movements.¹⁹⁻²¹ (See Figure 11) During imagined movement of the phantom hand and executed movement of the intact hand, group maps demonstrated activation not only in contralateral S1/M1 hand and lip areas, but also ipsilateral to the movement side revealing a dual process of reorganization.¹⁹

Stochastic entanglement is an extension of the pain *neurosignature* theory that holds impaired sensorimotor circuitry as an alternative hypothesis for the genesis of PLP. The chaos and complexity theories of nonlinear dynamic systems are the basis of this mechanism where small variations in initial conditions can change in a sudden, unexpected, or irregular way.²² Post-amputation deafferentation would elicit such a response and begin a cascade of imbalances that yield abnormal outcomes. In a chaotic complex state of somatosensory and motor deprivation, stochastic entanglement can occur between networks of S1/M1 processing and perception of pain.

A review of pharmacological interventions for treating PLP examined randomized trials studying the effectiveness of pharmacologic agents compared with placebo, other active treatments, or no treatment at all.³ The review concluded that short and long-term effectiveness of opioids remains unclear. Morphine demonstrated favorable short-term analgesic efficacy compared to placebo. A double-blind crossover study used neuromagnetic source imaging to test the efficacy of oral morphine of 12 patients experiencing PLP.²³ Initial evidence displayed reduced cortical reorganization concurrent with a reduction in pain intensity. However, perception and pain thresholds were not significantly altered whereas attention to the pain was significantly lowered with morphine use.²³ The sedative actions of these drugs do not address the underlying processing of pain due to CR; their inhibitory effects cease reorganization which allows pain to return once the patient is no longer under this type of sedation.

Motor activity has shown to alleviate PLP through normalization of affected cortical areas. Phantom Motor Execution (PME) is proposed to reactivate the original central and peripheral circuitry involved in motor control of the absent limb in addition to increasing dexterity of the

residual limb muscles.²² The foundation of PME asserts that training of phantom movements induces gradual neuroplastic changes similar to those of perfecting a motor skill, and these intentionally induced neural changes attempt to normalize pain processing circuitry.²² Continued training and motor activity has shown to normalize cortical reorganization in the sensorimotor cortex (S1/M1) back to its pre-amputation area representation when limb movements were performed during an fMRI.²⁴ This suggests that PLP is mainly caused by cortical reorganization in S1/M1, and there is likely a relationship between persistent peripheral inputs pertaining to the missing limb representation and chronic PLP. This form of treatment has been supported by multiple studies correlating reduced cortical reorganization to a decrease or elimination of PLP after use of a myoelectric prosthesis.²⁵⁻²⁷

Brain activity was recorded during unilateral muscle contractions of the hip, knee and ankle from a long jump Paralympic gold medalist with a unilateral amputation below the knee.²⁸ Functional MRIs were compared to that of a healthy long jumper and non-athletes with the same type of amputation. The researchers confirmed with a biomechanical study that take-off of the amputee long jumper was mechanically efficient with precise control of the knee joint. Analyses revealed that brain activity of ipsilateral M1 to the movement side in the amputee long jumper was significantly greater than that of the healthy long jumper during take-off. In addition, the contralateral planum temporale, thalamus, and cerebellum displayed greater activation in the amputee long jumper. However, no other significant differences were observed during the other 5 movements, including knee movement of the non take-off leg. These results indicate greater activity in ipsilateral M1 of the prosthetic leg side during take-off when compared to the other 2 controls.²⁸ Considering these findings, limb amputation and intensive, long-term motor training that involves the use of a prosthesis would be likely to induce profound cortical plasticity in M1. The amputee long jumper in this study was not experiencing PLP, which suggests the amount of motor activity with a sensory feedback prosthesis is positively correlated with the degree of adaptive cortical reorganization in S1/M1.

With reference to PLP, a *neurosignature* pattern is formed in the absence of modulating inputs from the limbs or body. Melzack hypothesized that high frequency, bursting patterns that typically follow deafferentation is transduced in the brain into a hot or burning sensation. The

cramping pain was due to input from the 'action-neuro module' to move muscles in order to produce movement in the limbs. Parallels can be made between this hypothesis and cortical reorganization that occurs in the sensorimotor cortex (S1/M1).¹¹

Results have shown evidence of remapping of motor representations for the missing limb closer to their original locations, attempting to normalize cortical expression after targeted reinnervation (TR).²⁹ TR restores a direct neuronal connection from amputated sensorimotor nerves to peripheral locations, such as muscle, to restore function to the motor cortex.²⁹ This is a technique that improves artificial limb function for amputees and assists in regaining both motor and sensory functions related to the missing limb. With this procedure, residual sensorimotor nerves are surgically re-routed to alternative denervated muscle groups and skin areas over the chest or residual limb. In a few months, new connections will have been made between the nerves, muscles, and skin, and efferent motor command signals would be amplified by the reinnervated muscles. Surface electromyographic (EMG) signals provide control signals for an amputee to operate a motorized, myoelectric prosthesis.²⁹ Sensations of touch, pressure, vibration, and temperature are also returned by TR to the skin overlying reinnervated nerve muscles. Afferent and efferent neural traffic is restored for parts of the limb completely lost since amputation. High-density electroencephalography (EEG) has been used to localize cortical activity to motor tasks performed by the missing and intact limb. In a case series of 3 upper limb amputees, TR was performed at least 6 months post amputation.²⁹ All subjects used prosthetics, one using cosmetic and the other 2 using mainly myoelectric prostheses. All amputees performed a subset of proximal and distal motor tasks with both sides of the body. In general, the motor representations for distal parts of the missing limb were displaced from their expected locations on the cortex after an amputation. However, following TR, the distal limb motor representations were mostly remapped closer to their expected pre-amputation locations. The results confirm the existence of cortical normalization in M1 after amputation, therefore, allowing remapping of motor cortices after TR.

Multiple studies have shown that frequent and extensive use of a myoelectric prosthesis had negative correlation with cortical reorganization and with PLP.^{20,27,30} Comparatively, it had a positive correlation with the reduction in PLP over time suggesting continued stimulation,

muscular training of the residual limb and visual feedback from the prosthesis may have had a beneficial effect on both cortical reorganization and PLP.^{20,26} The experience of stronger PLP has been associated with less prosthesis use compared to those with less intense pain. Structural neural plasticity in parts of the cortex that belong to the dorsal and ventral visual streams was also displayed.³⁰ This indicates plasticity results from the extensive use of a functional prosthesis which is related to increased visual feedback to control the artificial limb.³⁰ Furthermore, more frequent use of the prosthesis by patients with stronger PLP directly correlated with the decrease in volume of the posterior parietal cortex.³⁰ The parietal cortex interacts with sensory processing areas of the brain to select and enhance behaviorally relevant information for the planning and execution of physical movement. This data shows a relationship between prosthesis use and cortical plasticity of the visual stream.³⁰

The utilization of electromagnetic stimulation of M1 has also demonstrated benefits in relieving chronic pain symptoms. TMS (transcranial magnetic stimulation) and rTMS (repetitive transcranial magnetic stimulation) use a figure-eight wire coil over the scalp to map brain activity and induce excitability changes in the motor cortex by generating a magnetic field that passes through the scalp indirectly and noninvasively. Studies show the use of rTMS can stimulate plasticity in the brain with lasting effects. A double-blinded, randomized, sham-controlled trial was conducted using rTMS for phantom limb pain in 54 subjects.³¹ Amputees of land mine explosions received stimulation to M1 contralateral to the amputated leg with the coil positioned peripherally on the scalp. The control group used a sham coil that did not produce a magnetic pulse within the cortex. Treatments were administered with 10 Hz for 10 days and results showed significantly reduced pain for up to 15 days after treatments. Although the main outcome was a clinically significant pain reduction, other non-painful phenomena such as PLS, phantom limb awareness, and telescoping could have been confounding factors in the evaluation of rTMS results. Despite this, results continue to support a clinically significant reduction in PLP induced with rTMS after traumatic amputation. No adverse effects were reported with the treatments.

Transcranial direct current stimulation (tDCS) is a non-invasive therapy that increases the excitability of the motor cortex (M1) by means of anodal electrical brain stimulation. A case

report demonstrated tDCS was able to modulate neuroplasticity and effectively reduce PLP.³² A 60 year old male underwent below-the-knee amputation and had been experiencing PLP and RLP for 9 months since surgery while taking anticonvulsant, analgesic, and proton inhibitor pump drugs. The patient had 2 weeks of tDCS treatment, each with 5 daily consecutive sessions. The sham tDCS was used the first week, followed by the active stimulation in week 2. The effects of the 5-day treatment with contralateral anodal tDCS of M1 reduced and eventually completely relieved the patient of both PLP and RLP, pain measured with VAS. Non-painful phantom sensations were not affected by tDCS stimulation in M1. No effect was found for the sham stimulation. The relief of PLP and RLP remained stable for up to 2 months with the patient still showing a significant benefit. Conversely, a single session of tDCS on M1 induced a short-lasting relief from PLP that diminished after 90 minutes. Motor excitability is upregulated by anodal tDCS and may modulate PLP through indirect stimulation of brain activity in areas involved in pain processing. Of significance in this study is that stimulation of the motor cortex corresponded to the first dorsal interosseous muscle of the hand contralateral to pain instead of the area corresponding to the absent lower limb. This part of the hand is congruent with the location of acupuncture point LI4 *Hegu*, which is a frequently used point for pain in TCM. Previous studies have shown neuropathic pain relief after stimulation to this hand muscle area with chronic types of pain of different anatomical origin, as was corroborated with this study.³³

The vast majority of congenital amputees do not report the presence of a phantom limb, and when TMS was applied over M1 contralateral to the missing limb, contractions in stump muscles were evoked without the presence of any phantom movement sensations.³⁴ Conversely, traumatic amputees were able to feel phantom sensations with applied TMS. These opposing results suggest the phantom sensations reported by congenital amputees are mostly driven by vision and not through motor excitability of the missing limb within S1/M1.³⁴ Therefore, pre-wired motor representations of a limb need the previous experience of movement to be expressed within M1.³⁴ This implies the existence of a neuronal pathway associated with motor activity prior to amputation enables CR of M1 post amputation and displays the brain's ability of adaptive plasticity after loss of a limb.

Mental imagery has also been shown to promote reversibility of neuroplastic changes. Using fMRI, 13 upper limb amputees with PLP were studied during hand and lip movements before and after intensive 6-week training in mental imagery.¹⁹ Prior to training, evidence of cortical reorganization of S1/M1 displayed expansion of the lip area to the hand area representation, which also corresponded with severity of pain. Post training, subjects reported a significant reduction in intensity and unpleasantness of constant pain and exacerbations along with corresponding elimination of cortical reorganization. A reduction of activation in contralateral M1 and S1 hand area, induced by lip pursing movements correlated with a decrease in constant pain scores. Reductions of ipsilateral activations of S1/M1 hand areas were associated with a decrease in contemporaneous and constant pain intensity, and unpleasantness of exacerbations. Additional analyses showed that the intensity of constant pain, but not exacerbations, correlated with reduction of cortical reorganization. Since reorganization and reduction of the lip area activation in contralateral S1/M1 primarily affected the intensity of the constant pain, ipsilateral activation seems to be associated more with the exacerbations. Mental imagery can be viewed as a core component of cortical normalization that should be utilized in conjunction with other forms of treatment involving movement to address the exacerbations and ipsilateral activations.

There has been further evidence for post-amputation cortical reorganization in the affected motor cortex, which suggests that cortical reorganization of M1 is seen mainly in patients with PLP, but not correlated with the intensity of PLP. A review found that M1 could be a clinical target for treatment of PLP.²⁴ Amputees were indexed by TMS cortical mapping of M1, showing its relationship to PLP. All studies evidenced correlation between PLP intensity and cortical changes. However, results showed no correlation between M1 reorganization and level of pain.²⁴ These findings support that consistent upregulation of motor excitability, whether by movement through use of a prosthesis, mental imagery, rTMS, or tDCS, facilitates adaptive cortical plasticity. The length of time performing these therapies to experience relief may also correlate with the severity of cortical reorganization. Functional MRI studies have demonstrated bilateral activation of S1/M1 missing limb and the lip area representations during imagined phantom hand movements, revealing a two-way process of reorganization.¹⁹ Further research is necessary to investigate this dual reorganization to determine if there is a link with the visual stream and motor excitability in addition to the reorganization occurring in S1.

Understanding how the processes of the limbic system are affected by PLP may assist clinicians in finding appropriate therapies for their patients. There has been clinical evidence reflecting a functional reorganization of the limbic system and emotional-related network in patients with PLP.³⁵ Findings suggest greater preoperative anxiety was significantly associated with greater ratings of average PLP.³⁶ The loss of white matter integrity has been shown to be significantly correlated with PLP, so it's reasonable to assume that chronic pain induces changes in white matter.³⁵ Diffusion tensor imaging (DTI) has been utilized to evaluate the cerebral white matter changes in patients with unilateral arm amputation with PLP.³⁵ Cerebral blood volume (CBV) in the anterior cingulate cortex (ACC) and the orbitofrontal cortex (OFC) of both hemispheres was increased. These regions are part of the cognitive prefrontal cortex and the limbic system, the emotional domain of the pain processing *neuromodule* responsible for reacting to pain associated with negative emotional events and memories. Avoidance of painful emotions is often the motivating force in negative behaviors such as substance abuse and suicide, and is taken as a maladaptive approach to control, avoid or regulate these painful emotions.³⁷

This evidence coincides with Melzack's theory that virtually every structure of the limbic system, which surrounds and is intimately connected with the hypothalamus, has been shown to play a critical role in aversive pain behavior.¹¹ Inactivation of the cingular bundle, a white matter nerve tract involved in appraisal of pain and reinforcement of behavior that reduces it, results in substantial long lasting pain relief. This can be done by means of anesthetic blocks or electrical stimulation such as rTMS or tDCS.¹¹ Melzack proposed several slowly conducting pathways make up the 'medial ascending system.'¹¹ This operates concurrently with a more rapidly moving lateral projecting system that sends information to the brain. This is consistent with the Kidney *Foot-Shaoyin* meridian, on the medial aspect of the leg and associated with the emotion of fear in the Five Element Theory.^{13(p73)} Stress, anxiety, and panic attacks are associated with this meridian and the Liver *Foot-Jueyin* meridian, both located on the medial leg, and can be seen as comorbid factors when analyzing chronic pain with PTSD.

Melzack concluded that at the thalamic level, escape behavior associated with responses to fear have been triggered through stimulation to areas in the 'medial ascending pathway.' Lesions of the medial thalamus have provided substantial relief from chronic pain.¹¹ An fMRI study showed

the absence of thalamic activity when PLP was present.¹⁹ Virtual lesions, such as those from rTMS or tDCS, induce a disturbance in the standing wave pattern, or *neurosignature*, reactivating the original pain processing pathways, thus providing relief of PLP. The *neuromodules* process information related to major sensory events, such as injury or acupuncture needling, and are continually sending nerve impulses to the brain where they are transformed into a constantly changing stream of awareness. These *neurosignature* patterns are also capable of activating the *neuromatrix* to produce its own patterns of movement, which could be considered an underlying factor of PLP.

Studies have shown not only a high incidence of PLP post-amputation, but that it is intractable, or unrelenting in its intensity without regard for time. This can be seen in the case of a 72 year old patient that had been experiencing PLP since his upper limb amputation 48 years prior due to a traumatic injury.²⁶ The patient reported living with constant burning pain of an intensity of 3 numerical rating scale (NRS) with episodes that escalated up to the maximum intensity, which he described as excruciating, approximately every hour for a few minutes at time. The patient was also normally woken up at night due to intense bouts of pain. This observation supports the theory that long-lasting pain is not only produced by peripheral sensory input during the discomfort, but can persist through brain processes without continued external stimulation.²⁶ This can be seen as an example of Melzack's disrupted *neurosignature* pattern activating the *neuromatrix* to produce its own patterns of movement. The absence of input does not stop the neuronal networks from generating messages about the lost limb, which would require a passively receiving brain to do such.¹¹ The phantoms of people born with congenital limb loss support this assumption. The brain generates the experience of the '*body-self*' with sensory inputs merely modulating that experience, not directly causing it.¹¹

ENERGETICS OF ACUPUNCTURE

The four fundamental forces of nature - gravity, electromagnetism, strong, and weak forces - govern how objects or particles interact and every force of nature can be linked to one of these

fundamentals. However, the endogenous energy fields that play such a distinct role in energy-based medicine, such as acupuncture, have yet to be fully understood by any of these concepts. A pool of research observing these interactions allows the underlying mechanisms of these therapies to be evidenced through causal relationships.

Three dimensional meridian pathways are unique standing wave patterns established within the human body through structures of different densities.³⁸ The function of the resonance frequencies is to promote blood flow into specific organs and the microvascular bed.³⁹ Varied harmonic frequencies of the pulse wave originate from the heartbeat, and the vibrations are propagated through the arterial vessels in the human body.³⁸ When a pulse reaches the fork between the aorta and common iliac arteries, a portion of the pulse waves rebound and travels backward to the aorta. As a result, the wave produces interference patterns of the same harmonic frequency to create resonance with standing wave formation in the aorta. This patterning also occurs in other smaller arteries. Standing waves can be shown by oscillating a string on a violin to produce a specific mapping of nodes, or stationary points, on salt particles put on the surface of a violin. The constant vibration of interference produces an effect on the interstitial fluid channels at stationary nodes, or acupuncture points, and assists in regulating fluid motion (homeostasis), forming the TCM meridians. Standing waves, by nature, increase the movement and fluidity of cells, thus improving cell metabolism, and effectively enhancing the human biofield.³⁸

The fundamental concept of pulse wave analysis has shown that different harmonic frequencies of the heartbeat produce coupled oscillations in different internal organs and have shown relationships to meridians in TCM theory.³⁹ Harmonics represent the components of a repetitive signal, and the resonance of organs with the heartbeat implies that each harmonic is tuned to an organ and its corresponding meridian.³⁹ This suggests the presence of a resonance pattern between specific organs and vasculature. The Five Element theory in Chinese medicine assigns fire, wood, water, earth and metal elements to the 12 primary meridian organs. Personalized characteristics of the human existence, both physical and psychological, are reflected in variations of the average weight of a specific harmonic frequency when this theory is combined with resonance patterns. Since harmonic pressure waves have large wavelengths, resonance conditions of related organs can be detected to determine health conditions. Large wavelengths

also enable the patient to move, bend, and twist without significantly hindering the propagation of the wave. Harmonic frequencies are 'in range' (1.2Hz - 13.2Hz) when the heartbeat remains constant at 72 beats per minute. Researchers were able to identify the harmonics of the heartbeat through human pulse pressure readings; liver (1st), kidney (2nd), spleen (3rd), lungs (4th), stomach (5th), gallbladder (6th), urinary bladder (7th), large intestine (8th), triple energizer (9th), small intestine (10th), heart (11th), and pericardium (12th).³⁹ The frequency matching of the organ with a harmonic mode of the heart affects pressure components all the way down to the peripheral arteries. If the resonance characteristics of the organ deviate from its normal value (1.2Hz-13.2Hz) due to illness, or if the resistance of the organ increases, a significant change will present itself in the spectrum of the pressure pulse of the entire artery, which will also reduce the efficiency of blood distribution into particular organs.³⁹ These harmonic frequencies are single frequency resonance channels and function to compensate for the low mechanical energy consumption of the heartbeat which helps to achieve blood perfusion of specific organs with unique resonance patterns of different micro-vascular networks.³⁸

Photoluminescence is governed by the law of interaction between electromagnetic radiation and matter. Photoluminescent BIOCERAMIC (PLB) material absorbs a portion of the electromagnetic spectrum and emits lower energy wavelengths, providing a usable visible light source. This type of material facilitates the breakup of large clusters of water molecules by weakening hydrogen bonds, which allows water molecules to act in various ways under different conditions. A meridian is a pathway of interstitial fluid without an external wall. Vibrations along these channels have been termed 'Propagated Sensation along Meridians' (PSM) and occur when a sensation moves along meridians during stimulation of an acupuncture point. PSM is a process of volume transmission in peripheral tissue along the meridian channels.⁴⁰ This concept was used to detect meridian channels through the physical theory of pulse sound and cardiovascular physiology.³⁸ Researchers were able to detect vibrations within human tissue that elicited PSM along TCM meridian channels.⁴⁰ The locations of PSM allow for the creation of a map of corresponding TCM meridian pathways. Through meridian point irradiation, its effects on the meridian current flow can be detected by the alteration of liquid characteristics in the meridian channels to show if a specific meridian channel current is indirectly affected by another that has been treated with PLB irradiation. Because the meridian channels and their

corresponding acupuncture points are located in distinct locations, typical light energy irradiation should not be able to affect the electrical resistance of the skin or other meridian channels if no interconnecting network exists.³⁸ Irradiation on different acupuncture points induced effects on the corresponding electrical conductivity measurements.³⁸ Clinical observations were made of various chief complaints of subjects in which sensation was induced along specific meridian channels.³⁸ *Ashi* acupuncture points, or trigger points, caused by ischemia were shown to be a result of imbalances in the harmonic resonance of standing waves.³⁸ This scientific evidence explains how meridians possess wave-induced flow characteristics and could be developed as a diagnostic tool for clinicians in the future.

Photoluminescent BIOCERAMIC (PLB) material and bioceramic resonance (BR) devices are able to produce weak force fields throughout the body that are objectively measurable, allowing for scientific integration of TCM concepts in reflexology, meridian channel, and biofield therapy. A BR device is applied to the surface of the skin of the anterior chest wall enabling the emission from PLB material to interact with rhythmic sound frequencies to provoke hydrogen bond weakening to achieve resonance with the tissues of the whole human body. This method weakens hydrogen bond strength in the fluid resulting in an enhancement of microcirculation, which resonates with harmonic frequencies of the individual's heartbeat.⁴⁰ BR produced effective coherent vibrations, or PSM, within human tissue along TCM meridian lines in 13 subjects with various chronic and acute illnesses that severely affected their sleep patterns and quality of life.⁴⁰ Tissues of interstitial fluid channels that fail to resonate with harmonic frequencies of the heartbeat are modulated by the bioceramic effect and enhance mast cell degranulation and histamine release along the specific meridian pathways.⁴⁰ These findings suggest the basis for PSM provoked by BR is a chain reaction of nerve impulses with effects including capillary dilation, increased blood circulation, and neuromodulation through simultaneous continuous neuronal signals to regulate the nervous system.⁴⁰ Furthermore, informational transmission between adjacent and distant acupoints has been shown to cross spinal segments along meridian pathways.⁴⁰

A clinical trial of 45 patients with chronic sleep disorders showed sleep quality improvement with BR therapy.⁴¹ All participants completed a sleep pattern and quality of life questionnaire to

assess causes of sleep disturbance. Functional MRI was used on 8 patients to demonstrate BR effect. Sleep quality improved in all 36 treated patients during the first 3 days. Significant improvements were seen especially in those with psychological reasons for sleep disorders which accounted for 33 patients, 91.7%. The fMRI results showed corresponding cerebral and cerebellar areas of activation and deactivation. These findings support the notion that BR effectively regulated the biofield through sound rhythm frequency modulation, affecting the psychological disturbances, such as insomnia, manifesting in the physical body.

BR has also been able to detect changes in electric current on a Urinary Bladder reflex point on the subject's hands during stimulation of the auricular Urinary Bladder point.⁴² Based on the concept that BIOCERAMIC material produces a biological effect when transmitted via sound waves propagation, 10 areas of the ventral hand were chosen based on reflexology charts and attached to metallic electric current detection sensors. As defined by the researchers in this experiment, reflexology is identified as a hologram as it points to the interconnecting of different parts of the whole body and internal organs to the ventral feet, ventral surface of the hands, and the lateral surface of both ears. Traditional reflexology uses manipulation of pressing or massaging specific parts or points on the same areas of the feet, hands, and ears to produce an effect on the corresponding body parts and internal organs. Pressure on any of these 3 body parts may send impulse signals to balance the nervous system or release chemicals such as endorphins to reduce stress and pain.⁴² Analysis found a significant change of skin current level referring to the bladder reflex point on the ventral hands during pinpoint stimulation of the ear under continuous BR treatment on the subject's feet. These findings indicate BR treatment enables the normalization, or homeostatic effect, of abnormal electric current on the skin's acupoints and virtual channels exist that connect points on the skin surface, which correspond to internal organs based on TCM concepts.⁴² In the next step of the experiment, BIOCERAMIC patches were placed on bilateral acupuncture points for examination. Based on the results, a causal relationship was found of the energy levels on the 5 different zones of corona discharge that represent organ systems. However, these results do not explain the nature of the mechanism of *qi* in its relation to reflexology. It can not be concluded how the energy levels of the 5 zones are related to the corresponding areas even though the relationship was observed.⁴²

Fritz-Albert Popp, a German scientist, and Chang-Lin Zhang, a Chinese biologist, developed the “Standing Wave Superposition Hypothesis” to explain meridian channels. They hypothesized the overall meridian system as a holographic image of the body that interconnects the feet, hands and ears.^{38,43} (See Figure 12) In reflexology and TCM, the feet, hands and ears are all microsystems of the entire body, meaning a practitioner can treat imbalances of the whole body by stimulating points in only those areas. The researchers also described the interconnectedness of the acupuncture points through a superimposition process, wherein two or more similar waves combine to form a third and more complex one. According to Yung KT, the meridian channel is equivalent to an electromagnetic transmission line and that *qi* is the electromagnetic standing wave riding on the line with acupuncture points as its stationary nodes.³⁸ The standing wave within each segment of the meridian channel separated by acupuncture points naturally oscillates until *de qi* effectively charges the body's capacitor through the transmission line.³⁸ Interference can occur when two waves start at the same point, but approach each other from different directions. When these two waves are in sync with each other, the result is constructive interference and the resulting wave is amplified. Destructive interference occurs when the waves are out of rhythm resulting in mutual cancellation. The act of acupuncture needling is utilized to create disturbances in the standing wave pattern and to modulate systems and enhance the biofield of the entire body.^{38,43}

The interference patterns produced by the standing waves draw parallels to Melzack's theory of *neurosignature* loops of convergence and divergence.¹¹ Convergence describes repeated synaptic connections between the sensory output products of pain processing that form a character pattern of the interactions. Divergence occurs to allow parallel processing in different components of the *neuromatrix*. Comparatively, these processes are unique to each frequency, or standing wave, and comprise the *neurosignature*. The patterned processes occurring in the smaller arteries can be equated with Melzack's subsignatures produced by *neuromodules*, which are impressed upon the greater *neurosignature*. The *neurosignature* is imparted on all nerve impulse patterns that flow through the *neuromatrix*.¹¹

Developments in research of ultra weak photon emission (UPE) and its relationship with dynamic metabolism have enabled technology to substantiate the fundamentals of eastern

medicine. UPE, also termed biophoton emission, is the spontaneous emission generated by all living systems mainly attributed to oxidation reactions without external excitation that can be measured using a photomultiplier tube. Research into UPE estimations from all types of biological organisms began with Russian scientists in the 1960s. Emission data was recorded demonstrating that photon emission depends on the presence of oxygen. UPE as a sensitive assay for oxidative radical reactions was created in the 1970s. By the 1980s, it was concluded that all organisms emit photons and that its intensity was correlated to stress and derived from oxygen radicals.³⁸ A broad part of the electromagnetic spectrum is covered by UPE as a result of these biochemical reactions.

Researchers at the Shandong College of Traditional Chinese Medicine and the Shanghai Institute of Traditional Chinese Medicine were the first to complete descriptive studies of UPE from the acupuncture points at the ends of meridian pathways mainly at the fingertips and toes.³⁸ Photomultiplier tubes were utilized with an approximately 1cm opening which were placed in a dark chamber in close proximity to the acupoint of interest. These studies included groups ranging in size between 10 and 100 subjects, controlled for sex and age, and statistically evaluated.³⁸ More than 30 studies were published in Chinese Scientific journals between 1979 and 1998. Recently, the Sino-Dutch Centre for Preventive and Personalized Medicine of Leiden University, the Netherlands have evaluated these studies, focused on UPE studies of humans, for independent repetition.⁴⁴ To summarize these results, human UPE has shown to increase with age and are reduced by acupuncture through measurable bioenergetic correlates that define diseased states.⁴⁴ The overall fingertip emissions of men and women were not statistically different until the age of 30 when UPE began to increase. The UPE of aging men increased more than that of aging women in the same age group. A seasonal pattern of photon emission was observed with significant increases in summer when compared to winter. In healthy subjects, the corresponding left and right fingertips behaved similarly. Unhealthy subjects often demonstrated a broken left-right symmetry and increased emission strengths. This asymmetry was observed for Chinese syndromes as well as Western diseases including hypertension, facial nerve paralysis, constipation, and cancer. (See Figure 13) Before acupuncture treatment, the overall unhealthy patient group had an increased UPE of 70% compared to the healthy control group. After acupuncture, the UPE of the unhealthy patient group was reduced to only 11% higher than that

of the healthy controls.⁴⁴ Another experiment was designed to measure UPE from the dorsum and palm of both hands of 45 healthy subjects that received magneto-acupuncture stimuli.⁴⁵ Results showed more emissions were seen after the acupuncture stimuli than from the control group. The trend in the average intensities of UPE before and after the acupuncture stimuli was more clearly discernible when comparing individual data rather than group data. This demonstrates the energy balancing mechanism of acupuncture, where needling has been shown to lower the UPE in unhealthy subjects and increase it in the healthy.

A review of 46 publications developed a descriptive level map of 18 acupuncture points located along 9 meridians using fMRI.⁴⁶ The activation/deactivation patterns of the acupuncture points of the same meridians displayed some similarities; however, the brain mapping of each specific acupuncture point differed significantly from each other. This reflects the therapeutic properties of the singular acupuncture points compared to others on the same meridian channel and interconnectedness of the energetic pathways between both individual points and associated meridians. Also of significance were changes seen in the visual areas of the brain not only points related to vision (GB37 *Guangming*, BL60 *Kunlun*) when needled, but in several non-vision specific points (LV2 *Xingjian*, LV3 *Taixi*, ST36 *Zusanli*). This correlates to TCM theory of the liver being associated with the eyes and is useful in those physiological and pathological conditions.^{13(p30)} Furthermore, the Liver *Foot-Jueyin* is a paired meridian with the Gallbladder *Foot-Shaoyang*, which means the acupuncture points on these channels are able to treat many of the same diseases.^{13(p48)} These findings suggest brain response to acupoint stimuli cover a vast network of areas in the somatosensory regions and those involving affective and cognitive processing. Included studies investigated only verum acupuncture or both verum and sham acupuncture by fMRI using imaging of the entire brain. Publications were structured according to research questions, i.e. the differences in brain activity associated with acupuncture stimuli between patient and healthy volunteers. Activation likelihood estimation³ (ALE) meta-analyses were used in conjunction with the reviewed literature to determine the convergence of information reported from different experiments. Some of the meta-analyses had to be performed

³ Activation likelihood estimation (ALE) is a technique for coordinate-based meta-analyses of neuroimaging data which determines the convergence of foci reported from different experiments; this type of analysis involves modelling these foci as probability distributions whose width is based on empirical estimates of the spatial uncertainty due to the between-subject and between-template variability of neuroimaging data.

multiple times due to variances in contrast for each group. Included studies were highly heterogeneous regarding their study designs, aims, and quality of reporting. Heterogeneity was due to acupuncture stimulation methods, controls, methods of acquisition and analyses of imaging data, the brain regions of interest, and statistical analyses. However, the researchers did not formally assess the quality of the publications and cite a narrative review including only high quality studies would have strengthened the reliability of all data. The authors noted the purpose of this review was to provide a broad overview of all publications currently available.

CO₂ emissions have been utilized to understand the energy metabolism distribution along the meridian channels and correlate the body surface points with TCM theory.⁴⁷ A specialized CO₂ instrument was used to measure the transcutaneous CO₂ emission at 13 points along the Pericardium *Hand-Jueyin* meridian. Twelve points were on the line, and one point beyond the line with 13 control points beside them. Results showed the distribution of transcutaneous CO₂ emission (TCE) is highly related to the position of the body with significantly higher emissions at PC7 *Dǎling* and PC3 *Qūzè* than the controls beside them. These 2 points have significance in TCM as a *Yuan-Primary Source*⁴ point and *He-Sea*⁵ point along this meridian, both having significant influence of *Qi* in the channel. The distribution of TCM is also gradually higher with points closer to the position of the lung, which may influence the TCE due to a higher concentration of CO₂ in the lung. The high correlation between the points on the meridian and the correlation of the control points indicates that TCE is related to position on the body. Furthermore, the PC *Hand-Jueyin* meridian did not lengthen beyond PC1 *Tiānchǐ* to the 13th point as researchers assumed it would. Only the points along the meridian channel had stronger correlation, and the 13th point beyond PC1 *Tiānchǐ* was far from the other points. Other TCE research has found the *Yuan-Primary Source* points on bilateral meridians had very strong correlativity.⁴⁷ These results exhibit the complex connection in the meridian and collateral network and support TCM theory of the interconnectedness of the pathways and its balancing mechanism.

⁴ Each of the 12 primary meridians has a *Yuan-Primary Source* point. This is where the *Yuan-Qi*, or primordial *Qi*, pools on that channel and are used to treat disorders of the *zang-fu* organs.

⁵ Each of the 12 primary meridians has a *He-Sea* point which is located at either the elbow or knee joint. It is where the *Qi* in that channel gathers to treat disorders of *zang-fu* organs.

A superconducting quantum interference device (SQUID) is a very sensitive magnetometer used to measure extremely subtle magnetic fields based on superconducting loops containing Josephson junctions.⁶ Sensors convert a magnetic flux, or a measure of magnetic intensity, into a voltage that can be recorded and has been used to measure brain magnetic fields evoked by needling acupuncture points. A study was conducted employing the use of SQUID technology to measure the brain's magnetic fields after stimulating LI4 *Hegu* using electro-acupuncture in 12 individuals.¹⁶ The aim was to explore the positional relationship between the projection of LI4 *Hegu* and that of the nerves of the jaw and face. LI4 *Hegu*, located between the first and second metacarpal bones on the dorsum of the hand, is an empirical point to promote *qi*, a command point for issues of the face and mouth, and is commonly needled for headaches and pain. The measuring points were located on the right hemisphere of the brain, contralateral to the stimulated hand. Anatomic physiological analysis on the position found that this projection area overlapped on the jaw and face projection area in the brain. In addition, the characteristics of MEGs of all 12 subjects were the same except for a few differences in latency and amplitude among different subjects. The results showed that excitation of the acupoint LI4 *Hegu* inhibited the action of the jaw and face projection area through the integration of the overlapped part and explains why stimulation of this point effectively eases dental pain.¹⁶ This effect had never been previously observed in the brain magnetic fields evoked by other methods of stimulation. This study suggests that acupuncture points designated to treat certain diseases and pain syndromes were those which had the overlapping projection areas with the organs involved. However, as shown with tDCS stimulation of this area in a case study of below-the-knee amputation, this point can be utilized for pain in other parts of the body, supporting the interconnectedness of the meridian pathways.³² This point is also known for promoting *qi*, which also implies its superior ability to facilitate the movement of *qi* anywhere in the body.^{13(p123)}

The therapeutic functions of acupuncture points have been linked to corresponding structures in the brain. A case series tested the stimulation of 3 randomly selected acupuncture points using fMRI in 12 subjects to study activation patterns related to acupoint functionality.⁴⁸ The points used were BL60 *Kunlun* for visual stimulation located on the lateral ankle, KD3 *Taixi* for

⁶ The Josephson effect is the phenomenon of supercurrent, a current that flows indefinitely long without any voltage applied, across a device known as a Josephson junction (JJ), which consists of a thin layer of a nonsuperconducting material between two layers of superconducting material.

auditory stimulation located on medial ankle. SP6 *Sanjinyao*, located 3-4 inches above KD3 *Taixi*, was used as the control point since its functions were related to digestion and the immune system, not visually or auditory. Only 2 points were needled at a time in each subject, and increased activation patterns were observed in the visual cortex for BL60 *Kunlun* and the auditory cortex for KD3 *Taixi*. The activations of the sham point SP6 *Sanyinjiao* did not result in either the visual or auditory cortices. Researchers did note that when the control point was stimulated, activity in the cerebellum and in the basal ganglia increased, which could be associated with digestive function or somatosensory stimulation.⁴⁸ The magnitudes of the activations were dissimilar in both cortices, which may be attributed to the level of stimulation by the practitioner. Some data from the study was discarded due to the motion effects synchronized with the placement of the needle in 3 subjects.

Acupuncture has shown the ability to exert a lasting influence on various neural networks even after needles have been removed from the body.⁴⁹ This suggests that acupuncture stimulation has a time-variant feature and may be specific to individual points. DU20 *Baihui* and HT7 *Shenmen* have shown to improve the memory in patients with vascular dementia.⁵⁰ DU20 *Baihui* was also found to be superior in improving apprehension, calculation, and adaptation to society while DU26 *Renzhong* benefited symptoms of lethargy, slowness in reaction, mental trance, and memory.⁵⁰

Studies have shown through fMRI of healthy controls the effect of acupuncture stimulation on the CNS and the human brain. The affected network has been termed the limbic-paralimbic-neocortical network (LPNN) and has been identified from patterns of responses during acupuncture stimulation. It includes the limbic system and somatosensory brain regions working closely with the default mode network (DMN) and the anti-correlated task positive network.³³ The task positive network comprises the S1/M1 along with other attention-related cortices and becomes activated during goal-driven tasks. A task negative network, such as the DMN, shows significant deactivation when a task demanding attention is being engaged. A disruption in the functioning of the DMN caused by pain will affect the patient's inner homeostasis and ability to adequately process internal experiences like body states, feelings, and emotions.⁵¹ This is especially true for chronic pain states.

The LPNN is similar to the default mode network (DMN) during attention-demanding tasks. When *de qi* is evoked during treatment, the limbic-paralimbic- neocortical network is deactivated.⁵² According to TCM theory, clinical efficacy of acupuncture needling is directly related to the unique physiological response of *de qi*.³³ Researchers have repeatedly found a hemodynamic response to acupuncture is dependent on the psychosomatic response.³³ This is further confirmed through the connection of the limbic system to both emotions and acupuncture.⁵² Studies have shown that 71% of acupuncture elicits *de qi*.^{33,53} Variances were found between acupuncture points, with LI4 *Hegu* showing the most profound response.^{33,53} Decreased blood flow during acupuncture were found in patients experiencing sensations of *de qi*, but were absent or markedly attenuated in patients experiencing sharp pain. Conversely, increases in the somatosensory cortices were found during both acupuncture and sensory control.^{33,52} Another observation of note was that the increased activation in S1 during acupuncture needling, an invasive procedure, was less than the increase seen during the control stimulation, or sham needling. Such effects indicate that deactivation of the DMN during acupuncture needling cannot be entirely explained by the ‘demand of attention’, which is commonly proposed in literature.^{33,53} Therefore, a patient’s response to acupuncture is not singularly related to the act of needling, or demanding attention to an external stimulus. There is an underlying mechanism that results in a therapeutic effect that is only achieved when the LPNN is deactivated through *de qi*. Furthermore, these results provide scientific evidence for the widely accepted notion that LI4 *Hegu* is an empirical acupuncture point in TCM for pain and is one of the most commonly used points in clinical practice.⁵⁴

Acupuncture has shown its influence on the functionality of the DMN through fMRI studies and seems to strongly connect the DMN and regions linked to the analgesic, affective, and memory aspects of pain processing.⁵¹ When acupuncture needling induced a sharp pain, imaging showed the deactivation of the DMN was reversed, or attenuated, in direction.^{33,51,53} This suggests that acupuncture may facilitate the task-positive networks of the brain to mediate its actions when *de qi* is not achieved, which is dependent on the patient’s psychosomatic response to acupuncture stimulation.^{33,53} An analysis of 201 acupuncture runs in 48 healthy subjects of 3 acupuncture points (LI4 *Hegu*, ST36 *Zusanli*, and LV3 *Taichong*) revealed clusters of decreased activity in the limbic-paralimbic-neocortical network regions along with increased activity in S1/M1 and

select paralimbic structures.⁵³ Whole brain imaging studies on acupuncture point ST36 *Zusanli* also showed coordinated decreased activation throughout the limbic system in conjunction with cerebro-cerebellar system when stimulation was applied.⁵³ Again, the hemodynamic response pattern depended on needle manipulation of *de qi* and the patient's psychosomatic response.

While significant similarities exist in the brain's response to verum acupuncture and sham, such as activation of S1/M1 and deactivation of the DMN, important differences have also been found.⁵⁴ Acupuncture sensations correlated with activation in the sensorimotor and cognitive processing regions along with deactivation of the DMN.⁵⁴ Sham sensation was correlated with greater activation of the sensorimotor linked areas and deactivation of the DMN. Heightened connectivity between the DMN and other affective regions following acupuncture were correlated with decreased sympathetic and increased parasympathetic modulation.^{33,53} Acupuncture sensations were associated with greater activation in higher cognitive areas of emotional/interoceptive (anterior) and cognitive/evaluative (posterior) subregions of the DMN. This may explain the general feeling of relaxation and pain relief experienced with this kind of treatment; i.e. genuine acupuncture leads to stronger DMN deactivation than sham acupuncture.^{33,53}

Studies support the hypothesis that this effect goes beyond 'attention' of the DMN or the somatosensory stimulation of needling. In particular, the amygdala and hypothalamus show decreased activation during acupuncture stimulation that is not usually related with DMN activity.^{33,53} The amygdala is involved with emotions and behavior, particularly relating to fear. The hypothalamus plays a significant role in the endocrine system by stimulating or inhibiting many of the body's key processes in maintaining the body's internal balance of homeostasis. It can be inferred that acupuncture may help regulate homeostasis by modulating connectivity of DMN-related regions.⁵⁵ Acupuncture has been shown to evoke significant structural reorganization of the DMN network and may be a potential therapy target and mechanism where acupuncture improves motor and cognition.⁵⁶ These findings could be the key to understanding how the brain processes acupuncture sensations and how they lead to a therapeutic response.

ACUPUNCTURE IN PROCESS

Acupuncture is a key component of Traditional Chinese Medicine (TCM) that utilizes very thin sterile needles to puncture the skin at specified points and surrounding tissues for relief of pain and pathological disease. The length and thickness of the needles depend on the part of the body being needled and the intention of the practitioner. The needles are meant to direct *qi* along the meridian channels in a way that harmonizes imbalances in the system to facilitate healing. The style of acupuncture, the condition being treated, and the therapeutic functions of the points dictate which points will be utilized during a session. Current research lacks controlled trials to investigate acupuncture's therapeutic benefits for PLP. When the different systems of acupuncture are evaluated, assessing what constitutes an acupuncture point may become difficult. The insertion of needles into the body has a psychosomatic effect that may or may not have the potential to be replicated, i.e. the elicitation of *de qi* may not always occur. Therefore, the following will review reported case studies of acupuncture for PLP along with conditions of similar pathology and other forms of energetic healing. The effect of acupuncture on comorbid factors such as those from PTSD will also be explored.

David Bradbrook, a physiotherapist at the Royal National Orthopaedic Hospital in Stanmore, Middlesex, presented a case series of PLP.⁵⁷ Each patient experienced chronic PLP and was treated with body acupuncture using contralateral needling on the intact, asymptomatic limb. The points were chosen for their analgesic properties and their anatomical positions on the right leg, mirroring symptoms felt in the phantom legs.

Case 1

The patient was a 34 year old male that underwent a transtibial amputation after multiple surgeries failed to correct congenital talipes.⁵⁷ (See Figure 14) Symptoms were felt on the plantar surface of the phantom foot and were aggravated by sitting still. The patient reported the intensity of the PLP decreased when he wore a prosthesis, but returned upon its removal. This patient had received previous acupuncture treatments for hip pain with good results and was willing to try it again for his current symptoms. The patient experienced chronic PLP in his left

phantom limb since his surgery and described it as a cramping pain with pins and needles that felt like his toes were ‘bunching up’, visual analog scale (VAS) score was a 9. The practitioner used 5 acupuncture points (LV3 *Taichong*, SP6 *Sanyinjiao*, ST37 *Shangjuxu*, ST36 *Zusanli*, ST32 *Futu*) on the contralateral intact leg. The points were needled for 30 seconds each, stimulating each at 15 seconds to achieve *de qi*. During the initial session, the patient reported a tingling in his phantom toes with the insertion of the needle LV3 *Taichong* along with a *de qi* sensation at ST32 *Futu* which brought on a gradual relief of the cramping feeling in his phantom toes. Treatments were given weekly in 4 total sessions, and by the end of the fourth session, the patient reported a VAS score of zero for PLP and continued to remain pain free for the following 2 months.

Case 2

A 68 year old female underwent a hemi-pelvectomy 2 years prior following multiple unsuccessful operations to remove a myeloma.⁵⁷ The patient experienced recurrent wound infections, delayed healing, PLP post-surgery, and was not able to complete rehabilitation due to the exacerbation of pain from wearing a prosthesis. The pain was located on the anterior lateral aspect of the left thigh and was described as ‘cramp-like’ and constant while wearing the prosthesis. The phantom leg also felt like it was being constantly ‘twisted’, externally rotated 90 degrees throughout the day. The pain could be temporarily relieved by rubbing the residual limb, VAS score was a 7. Examination showed the scar of the residual limb was fully healed with normal power and ROM. The patient reported she had a low tolerance of exercise, fatigued very quickly, and walking was too exhausting post-surgery. This patient had never previously tried acupuncture and was enthusiastic at its prospects. The same five points were needled (LV3 *Taichong*, SP6 *Sanyinjiao*, ST37 *Shangjuxu*, ST36 *Zusanli*, ST32 *Futu*) and stimulated in the same manner as the first case. LV3 *Taichong* produced a feeling of *de qi* that the patient described as extreme relaxation with warmth and tingling around the needle site. As the rest of the needles were inserted, she reported an ‘un-clamping’, ‘diminishing’, and ‘reducing in length’. Upon insertion of the final needle at ST32 *Futu*, the patient reported a complete cessation of her PLP and feeling as if her leg had retracted into her body. After the first treatment, the VAS score was zero for PLP, and the patient required no further acupuncture sessions. She was also able to continue with her prosthetic rehabilitation pain free for its remainder.

Case 3

A 19 year old male with a right transfemoral amputation 2 months prior due to a road traffic accident had undergone multiple surgeries as a result of compromised blood flow.⁵⁷ However, the vascular compromise was more severe than initially thought, so the wound broke down and the femoral fracture failed to properly heal leading to eventual above-the-knee amputation. The accident left him with an ‘open book’ fractured right pelvis, a displaced fracture of the right femur requiring external fixation, and a comminuted fracture of the right tibia and fibula. The patient was not responding to conventional pain management medication including oral morphine. The PLP was described as an ‘electric shock’ pain down the back of his phantom leg and severe ‘cramping’ in the phantom toes with a feeling of them ‘crossing over’ one another. His pain was exacerbated by sitting still or being unoccupied. Upon examination, the residual leg scar was uneven and adherent, and the pelvis was extremely unstable along with a stiff lumbar spine. He had very poor balance and little objective and functional trunk stability. His PLP score was an 8 VAS, and he appeared to be skeptical about the ability of needling to relieve his pain. The same treatment as the previous 2 cases were given; five points (LV3 *Taichong*, SP6 *Sanyinjiao*, ST37 *Shangjuxu*, ST36 *Zusanli*, ST32 *Futu*) on the intact contralateral leg. The patient experienced a significant decrease in symptoms after the first session, PLP was a 3 VAS even though he did not experience *de qi*. This improvement in VAS scores was encouraging to the patient, and his belief in the treatment increased. The pain returned 2 hours after the first treatment, and there were no positive results in the next 3 subsequent sessions with the same treatment of acupuncture points, ending with a VAS score of 7 for PLP. The patient continued to remain extremely focused on his pain, dependent on his medications. However, he was able to complete prosthesis rehabilitation with full use of his limb and became fully independent.

These cases demonstrate the analgesic and reorganizational ability that acupuncture can have on the central nervous system. As seen with the third case, unsuccessful treatment may be related to multiple surgical traumas and stump revisions. It is possible that this type of body acupuncture may only be effective after a single trauma with less *qi* stagnation, and that cases of this type might respond differently to another technique such as scalp acupuncture. It can be debated whether the needles should have been retained for longer or stimulated more to achieve *de qi*, or whether more or different points may be more appropriate for an amputee with multiple

traumas.⁵⁷ Extensive injuries result in more *qi* stagnation and may increase cortical reorganization which could require a longer recovery period.

Scalp acupuncture (SA) is used to treat conditions of the CNS including central nerve damage, residual limb pain, complex regional limb pain, post-concussion syndrome, post traumatic stress disorder, and PLP.⁵⁹ SA utilizes western medicine's knowledge of representative regions of the cerebral cortex and combines it with a traditional needling technique. (See Figure 15) This style of acupuncture requires a specialized technique to achieve desired results and is not practiced by all acupuncturists. The location of scalp acupuncture (SA) regions are based on the Western medicine reflex somatotopic layout organized on the surface of the scalp. These areas do not relate to the meridian pathway theory in TCM and are a new type of concept integrating western brain mapping with eastern needle technique. These zones correspond to the cortical areas of the cerebrum and cerebellum responsible for CNS functions such as motor activity, sensory input, vision, speech, hearing, and balance.⁵⁹ By stimulating these reflex areas, SA can have direct effects on the cerebral cortex, cerebellum, thalamo-cortical structures, thalamus, hypothalamus, and pineal body. The neurological and endocrine related composition of the scalp makes it an ideal external field for treating disease of the entire body.⁵⁹

SA has shown to be beneficial in the case of PLP in a 71 year old female with a surgical amputation below the right elbow due to a traffic accident 2 years prior.⁶¹ The patient experienced recurrent wound infections and underwent split-thickness skin graft surgery. The patient felt severe numbness and pain from her phantom fingers up through her right forearm stump. She could also feel the missing limb's position in space and would attempt to use it to reach for objects. The patient also reported symptoms of heartburn, constipation. Two years of taking barbiturates, muscle relaxants, antidepressants, and analgesics supplied no relief, and she stopped taking them due to various side effects. The pain persisted throughout the night, affecting her sleep and overall quality of life. The initial examination showed her stump had fully healed, although the scar was uneven, and the residual part of her arm had normal muscle power and full range of motion. The patient's PLP on a VAS was at a 10. She had not previously received any form of acupuncture for her condition. Four scalp points on the vertex of the head, *Sichencong*, and one scalp line, MS7, on the contralateral side of the phantom limb were used in

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treatment. *Sichencong* is commonly used for insomnia and has been shown to enhance cardiac vagal function while suppressing sympathetic activity.⁷² The needles (.30x25 mm) were inserted at a 15 degree angle into the subaponeurotic space. They were stimulated by rapid small-amplitude lifting and thrusting movements for one minute to evoke *de qi* and left inserted for 20 minutes. The patient noted significant relief after the first treatment and described her pain as a 4 VAS by the second session. Six sessions of treatment over the course of 3 weeks were given. The patient continued to show improvement after each session, and by the sixth month final review, the patient reported her PLP was zero VAS.⁶¹

Treatment modalities that promote maximal cortical reorganization for pain syndromes similar in nature, such as chronic regional pain syndrome type 1 (CRPS1) and stroke would be potentially beneficial for sufferers of PLP. Clinical presentation and cortical responses to treatment can be measured for all conditions utilizing the same imaging techniques to compare features.⁵⁸ CRPS1 and stroke both share neuropathic characteristics of PLP and similar changes in sensorimotor activation patterns.^{59,60} Post-stroke and CRPS type 2 cortical reorganization can be influenced by therapeutic interventions, but may be limited by areas of permanent neuronal damage.⁵⁸ However, with CRPS1 and PLP, no such permanent neuronal damage is likely. There is growing evidence that CRPS1 involves the CNS at several integrated levels, including the somatosensory, sympathetic, and motor sensory systems.⁵⁸ CRPS1 cases usually involve a single limb, but have also been reported following trauma to the head, neck, chest, and with PTSD. Therefore, it can be surmised that CRPS1 and PLP would respond to treatment courses that restore normal cortical activity during post-stroke recovery and that effective stroke interventions would benefit patients with CRPS1 and PLP.⁵⁸

A study was conducted using SA on 14 patients with CRPS1 after conservative treatments failed to address their symptoms which included neuropathic pain, allodynia, impaired thermoregulatory sweating, and decreased range of motion.⁶⁰ SA was utilized 1-2 times weekly for up to 4 weeks. Results showed improvement in pain by more than 80%, with 9 subjects reporting zero pain and the other 5 reporting pain score of 1 VAS by the end of treatment course. The majority of patients only required 1-2 treatment sessions before achieving complete pain relief. The highest number of treatments given to one patient was 7, which also resulted in a pain

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score of zero. In addition, physical exams and therapy assessments showed decreased sensory changes and improved extremity function that maintained stability between treatments.

Treatment responses were sustained for up to 20 months at time of publication. This case series was highlighted at the 2009 American Academy of Pain Medicine Annual Meeting.⁶⁰

A randomized controlled trial was conducted to determine whether acupuncture has additional effects in early comprehensive rehabilitation for acute ischemic stroke and dysfunctions secondary to stroke.⁶² Two-hundred fifty patients were randomly assigned into two groups, acupuncture or no acupuncture, and were given 18 acupuncture treatments over a 3-week period. Subjects hospitalized with acute ischemic stroke and hemiplegia were included. The National Institutes of Health Stroke Scale (NIHSS) was used to blindly measure outcomes at weeks 1, 3 and 7. Motor and sensory scalp acupuncture points were chosen on the lesion side, and additional body acupuncture points were chosen on the affected side of the body for therapeutic functions. Points were added to treatments based on symptoms of dysphagia and cognitive impairments. Significant improvements of neurological deficit, lower extremity motor function, swallowing disorder, and cognitive impairment were shown with strong evidence compared with conventional rehabilitation alone. This study showed a low incidence of mild symptoms for acupuncture and no related adverse events were recorded. Many patients in China with stroke choose acupuncture therapy in the subacute stage, usually one month after onset, to promote rehabilitation.⁶² Sham acupuncture was not used in the control group which could have created a small placebo bias in the results. These findings suggest acupuncture plays an effective role in accelerating the recovery of brain function in the early stage of stroke, enhancing the recovery process and minimizing functional disability. Despite performing acupuncture treatment primarily on distal points mainly located in the extremities, the effect of acupuncture on limb function was not as significant as its effects on neurological deficits. This could be attributed to the large number of dysphagia patients in the acupuncture group who received additional acupuncture points around the nape of their necks. The mechanism of nape acupuncture may provide improvements in neurological functionality and deserves further investigation. In addition, the holistic concept in traditional Chinese medicine provides for improvements along meridian channels through the use of acupoints located proximally and distally to the diseased

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area of the body. The acupuncture points used located below the elbow and knee joints are especially useful in benefiting organ and meridian disease.⁶²

Cortical reorganization was studied in 17 clinically recovered Bell's Palsy patients that had been treated with acupuncture. Bell's Palsy patients had been assessed as recovered when their House-Brackman⁷ (HBS) grade was 1.⁶³ Results of fMRI were compared to 20 healthy control subjects by lip pursing and finger movement tasks. Imaging showed significant differences in cortical plasticity between the 2 groups, with the Bell's Palsy patients displaying higher activity compared with healthy controls. Functional MRIs showed increased activation during finger movements and decreased activation during lip pursing movements of the Bell's Palsy patients, demonstrating cerebral blood flow in the facial motor area was reduced while cerebral blood flow in the hand motor area was enhanced compared to healthy volunteers. The locations of hand and facial representations are adjacent in M1. This could be an indication of why distal acupuncture points of meridian channels are used in conjunction with facial points, such as LI4 *Hegu*, which is a common point used in the treatment of Bell's Palsy. It can be concluded that although the Bell's Palsy patients no longer showed signs or symptoms, cortical reorganization still existed in recovered patients after acupuncture treatments, implying acupuncture facilitates adaptive cortical reorganization in the sensorimotor cortex. Indications of reorganization exist in early recovery stages so it may be beneficial for patients to continue treatment even after clinical recovery to maximize full recovery potential of brain function.⁶³

Dr. Jason Hao DOM, MTCM, the president of the Neuroacupuncture Institute in Santa Fe, NM, and author of *Chinese Scalp Acupuncture*, recommends treating PLP using the sensory and motor areas of the foot, leg, and tremor regions. According to his clinical findings, 86% of patients instantly felt relief with only one SA treatment and often report long lasting effects.⁵⁹ Dr. Hao uses SA for conditions associated with the CNS including stroke, paralysis, and PLP and has presented the following case studies demonstrating the effects of this type of acupuncture:⁵⁹

⁷ The House-Brackman Scale is utilized for the clinical evaluation of facial nerve function based upon functional impairment ranging between I (normal) to VI (no movement).

Case 1

A patient presented with severe PLP after both legs were amputated a few months prior. Various types of medication provided little relief.⁵⁹ The pain was described as severe, painful tingling sensations in both feet. SA Recommendations for PLP are a combination of the above treatments. Areas to be used are sensory area, leg motor and sensory area, tremor area and motor area. The foot motor-sensory areas are known as primary treatment areas to treat limb pain and are bilaterally selected to treat any type of limb pain. The upper 1/5 sensory area is unilaterally selected to treat opposing leg and foot pain. The middle 2/5 sensory areas are unilaterally selected to treat opposing arm and hand pain. Tremor areas are classified as secondary areas to treat limb pain, and are bilaterally selected to treat spasm pain on either or both sides. As soon as the scalp acupuncture treatment began, the patient started to feel heat tingling sensations in both legs, followed by tingling and an electric-like sensation in his toes. Within 5 minutes, his phantom pain had considerably diminished, and after 10 minutes, had disappeared completely.

Case 2

A patient had been suffering from severe residual limb pain in his right stump for 5 months since his amputation surgery.⁵⁹ He described it as a 'wire tight up his leg' with debilitating spasms. Scalp acupuncture was used at the foot sensory area, motor area, and upper 1/5 sensory area, which are designated for limb pain in the feet. Four needles were inserted into his scalp and stimulated. Fifteen minutes later, the patient reported numbness and tingling in his residual limb, which started loosening up the feeling of tightness in his leg. After 5 more minutes, the patient's tight leg spasm was almost completely gone. Follow ups were not reported with this case.

Case 3

An Iraq war veteran was suffering from complex regional pain syndrome in his right leg due to multiple gunshot wounds sustained in combat.⁵⁹ The severe sensitivity in his right leg and foot prevented him from tolerating even the lightest touch, contact from a thin blanket or even wearing a sock. The debilitating pain in his right foot took away his ability to stand or walk. Upon insertion of the needles into his scalp, the patient reported a 'water-bubble-like' sensation moving from his right hip to his leg, and then to his foot and toes. Five to eight minutes later, the pain started to diminish and the patient was able to touch his leg and toes with little discomfort.

The patient was so excited to feel the results that he continually touched his leg and toes. He was asked to try to put on a sock and did so without showing pain or discomfort. The next day, the doctor returned to see the patient with both socks on and the patient reported very little pain with less sensitivity to touch. The patient was able to walk with virtually no pain after his treatment using only four needles. Each step he took brought on applause from observers.⁵⁹

Case 4

A patient suffered a stroke from a cerebral thrombosis 11 months prior.⁵⁹ However, paralysis in his right arm and hand had actually been present for 11 years. The Chinese medical pattern for a stroke is *qi* stagnation and blood stasis in the channels and network vessels. For treating motor dysfunction, the needle should be placed in the upper 1/5 region of the motor area to treat contralateral impairment of movements of the lower extremity, trunk, spinal cord, and neck. While the doctor rotates the needle, the patient should actively and passively move the affected limb. During treatment, patients may feel sensations of heat, cold, tingling, numbness, heaviness, distention, or the sensation of water or electricity moving along their affected limbs. This patient was instructed to do some passive exercise after needles were placed, with his wife moving his hand and raising his arm. After a few minutes, the patient was able to achieve some movement in his arm and hand. By end of session, the patient had full use of his limb, able to move his own arm, hand, and his fingers in any way or direction. A case of cerebral thrombosis such as this has the best prognosis for recovery from stroke compared to cerebral embolism and cerebral hemorrhage. It's necessary to point out the rarity in a full recovery after one scalp acupuncture treatment such as this one.⁵⁹

Case 5

A patient had developed quadriplegia due to a West Nile virus infection, which resulted in the loss of control of her body below the neck, paralysis of all four limbs, and incontinence of bowel and urine.⁵⁹ Depression emerged after multiple treatment failures. The muscular tone of her right arm ranked 2 out of 5 degrees, her left arm and both legs were zero out of 5 degrees (completely paralyzed), and all 4 extremities were very tight with occasional spasms. Her Chinese medical diagnosis was *qi* stagnation and blood stasis in the meridians, *qi* and blood deficiencies with stagnation in the kidney and liver channels. SA recommendations for quadriplegia are insertion

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in both upper 1/5 motor area, and middle 2/5 motor areas, stimulated bilaterally. Rotate needles at least 200 times per minute for 1-3 minutes, twirling as vigorously as the patient can tolerate, repeating stimulation every 10 minutes. Secondary areas of stimulation are chorea and tremor area or the foot motor sensory area depending on symptoms. Needles are retained for 30-45 minutes with treatment given 2-3 times per week with a therapeutic course consisting of 10 treatments.

Upon insertion of two needles in the scalp at the chorea and tremor area, the tightness in all four limbs loosened up and the spasms were gone. Soon after, both arms began to move and lift. After four more needles were inserted, the patient was able to stand up with the assistance of 2 people, and was walking around by the end of the treatment. The patient attended a scalp acupuncture seminar later that year, and was unrecognizable by her doctors when she walked into the conference room. The patient had not received further acupuncture treatment after her last 2 SA sessions because neither her insurance nor her own money could afford it. She had instead performed intensive exercise as instructed by her doctors months before and had experienced a complete recovery in the movement of her body, but was still experiencing urgent, frequent urination and some incontinence of urine. Two needles were inserted in the foot motor and sensory area and two needles in the reproductive area. After the treatment, the patient no longer had frequent urination and was able to hold her bladder for 2 hours. The patient received only three scalp acupuncture treatments and had fully recovered, which is highly unusual and can not be generalized across a similar population. Quadriplegia normally takes several months to two years to treat, and only 50% of patients have a chance of improving. Usually, the longer the duration of impairment, the more gradual the improvement occurs.⁵⁹

Acupuncture has demonstrated to have an analgesic and reorganizational ability on the central nervous system.^{55,57,62} It's been shown to provide immediate relief to patients and resolve symptoms that had been previously thought to be unrelated to pain.^{57,59,64} Integrations of energy-based medicine have paired the subtle energy bodies of Reiki with the meridian pathways of acupuncture. Reiki is a mind-body medicine that aims to restore and re-balance the body's energetic system by stimulating natural healing processes. The immediate effects of Reiki, or

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therapeutic touch (TT), were measured on nurses with Burnout Syndrome⁸ in a randomized, double blind, cross over study.⁶⁵ Results were shown to lower diastolic BP rates and increase immune function (sIgA), which measures a generalized hormonal immune function associated to produce relaxation effects.^{65,66}

With this type of therapy, the practitioner uses the palms of his/her hands to detect non-thermal imbalances in the energy field that can feel like friction or a magnetic repulsion emanating from the body against the hands of the practitioner. Tingling or heat sensations usually indicate symptomatic areas of pain. The energy field of the patient is then ‘smoothed’ out by slow sweeping motions made by the hands of the practitioner. This essentially clears out the obstructions in that area of the biofield. Patients have reported that their phantom limbs feel like they are being touched, while therapists have experienced subtle tactile sensations in the region of the missing phantom limb.⁹ This correlates with the notion that the phantom limb is an intact structure that still exists and occupies space even though it can’t be seen by the human eye.

Dr. Eric Leskowitz, MD specializes in the psychosomatic aspects of pain processing and has utilized energy-based medicines such as TT and Energy Psychology with his patients. He presents a case of a 35-year old patient that worked as a cargo loader and had his leg crushed in a work incident 5 years prior.⁹ The patient underwent an above-the-knee amputation and experienced chronic PLP which was only marginally controlled with mediations and cognitive-behavioral therapy. Dr. Leskowitz used TT on the patient and described an energy ‘presence’ or magnetic push against his hands during the initial assessment phase including in the region of the missing limb. In the same instance, the patient reported he could feel the doctor’s hand touching his phantom leg. As the doctor continued sweeping the field around the phantom, the pain sensations seemed to be draining from the bottom of the phantom foot. To Dr. Leskowitz’s surprise, the patient asked him to stop the treatment before all of the pain was completely alleviated. The patient revealed that he feared becoming pain-free because it would feel as though his leg was in fact missing. In this case, the patient’s pain served the psychological

⁸ Burnout Syndrome is a prolonged response to chronic emotional and interpersonal job stressors which can be associated with low job satisfaction, stressful emotional interaction, and musculoskeletal pain. These stress-related issues can alter several immunological processes and can increase the risk factor of contracting infections.

function of defending him against the emotional impact of fully acknowledging his traumatic loss.⁹

Pain catastrophizing has been associated with phantom limb pain related to the attentional model of pain processing. Spontaneous pain, somatosensory activity and cortical responses were investigated through EEG of 18 upper limb amputees.⁶⁹ Subjects completed the pain catastrophizing scale along with NRS for pain levels. Non-painful electrical stimuli were applied to the residual limb and non affected arm. Results showed that catastrophizing was responsible for significant amounts of variance in relation to spontaneous pain, in particular worst pain at 64.1%.⁶⁹ On the affected side, catastrophizing was associated with the secondary somatosensory cortex which has been correlated with arousal and expectations. These findings suggest memory processing may be a key component between catastrophizing and pain. Patients who experience high levels of pain catastrophizing pay more attention to external stimuli and have increased negative expectations relating to the stimuli. Furthermore, catastrophizing explained significantly more of the difference in retrospective rating of worst pain compared to prospective ratings of average pain, which may indicate a link between pain measure and memory processing. The use of fMRI in future studies may give a clearer view of how catastrophizing affects the pain process.

In her book, *Energy Medicine: Balancing Your Body's Energies for Optimal Health, Joy & Vitality*, Donna Eden discusses how she incorporates acupuncture point locations into her Reiki healing practices.⁶⁷ She is seen as a pioneer in the field of energy medicine and is consulted frequently within both traditional and alternative health care settings. She presents a case of severe PLP and depression in a Vietnam veteran with bilateral limb loss due to combat. Acupressure was used along the Bladder *Foot-Taiyang*, Kidney *Foot-Shaoyin*, Liver *Foot-Jueyin* meridians in places along the phantom limb where the subject said were the most painful.^{67(pp51-53)} The energy healer was able to sense the friction in those areas and applied pressure to the related acupoints, seeming as though to be placing her hands in mid air on an invisible leg. The patient reported immediate relief of the phantom limb as well as a lifting of low back pain he had been concurrently experiencing. Low back pain is a symptom that is also indicated along the Bladder *Foot-Taiyang* meridian that travels the length of the posterior.^{13(p73)}

The session seemed to induce a catharsis that resolved the patient's depression and PTSD he'd had since the war. The Kidney *Foot-Shaoyin* meridian is associated with fear, and pressure on those points seemingly released unresolved trauma the subject had been holding on to. The Liver *Foot-Jueyin* meridian tonifies *blood* and *qi*, and is used to relieve pain, stress and anxiety in TCM.^{13(p81)} The combination of these points seemed to facilitate a physical and emotional release that was able to reset the subject's subtle body resulting in relief of his PLP.

Chinese medicine ascribes the functions of the brain to various *zang-fu* organs -the heart, liver, and kidney in particular.^{13(p41)} The heart and the liver have a close relationship in regard to emotional activity and blood circulation. The heart governs blood and the liver stores it. Only when heart blood is sufficient can the liver store it and regulate its volume to meet the physiological needs of the body. The liver maintains the free flow of *qi* and 'dredges' the circulation of *qi* and blood, ensuring neither stagnates, which benefits the function of the heart in circulating blood.^{13(p44)} The heart is associated with fire, located in the upper part of the body and belongs to yang. The kidney is associated with water, located in the lower part of the body and belongs to yin. Therefore, the nature of the relationship between heart and kidney reflects the balance of yin and yang, ascending and descending. This relationship of mutual communication and restriction is called 'harmony of heart and kidney'. When water and fire are in harmony, a relative balance between yin and yang ensures the normal physiological functioning of the heart and kidney. Disruption of this balance leads to pathological manifestations of backache, mental restlessness, palpitations, insomnia, poor memory, dream-disturbed sleep, edema, chills, cold limbs, shortness of breath, and hypochondrial fullness.^{13(p45)} Since the heart governs blood and the kidney stores essence, or *jing*⁹, there is a mutual causality of consumption of kidney essence and deficiency of heart blood. The heart houses the mind and the kidney essence produces marrow which communicates with the brain - the palace of intelligence.^{13(p45)} This relationship between heart, liver and kidney can be seen as psychological conditions manifesting physically, which parallels the relationship of emotional trauma creating a stagnation in the meridians resulting in imbalances in multiple energetic pathways that may eventually lead to pain if left unaddressed.

⁹ *Jing* is the Chinese expression for vital essence, stored in the kidney, and is the underpinning of all organic life.

A systematic review concluded individuals who reported exposure to trauma were 2.7 times more likely to have a functional somatic syndrome such as fibromyalgia, chronic widespread pain, chronic fatigue syndrome, temporomandibular disorder, or irritable bowel syndrome.⁶⁸ These disorders were associated with traumatic events, including abuse of a psychological, emotional, sexual, or physical nature sustained during childhood or adulthood, combat exposure, or PTSD. This correlation between PTSD and chronic pain syndromes supports the theory that trauma creates a functional somatic susceptibility to experiencing chronic pain if those associated emotions are not adequately processed, and further supports the theory that the human biofield transmutes emotional and mental imbalances related to traumatic experiences into physical pain.

The Measure Yourself Concerns and Wellbeing (MYCaW) questionnaire was utilized to measure mental and emotional health related to PLP before and after acupuncture.⁶⁴ In a case study of a 16 year old female patient for PLP after a hemi-pelvectomy due to osteosarcoma, auricular acupuncture was used as a non pharmacological adjunct therapy⁶⁴. The patient presented with PLP, unresponsive postsurgical pain, insomnia, ruminative thoughts and constant tension as symptoms of PTSD. PLP was rated as her greatest concern prior to treatment with a 6/6 and her general well-being was also a 6/6, being 'as bad as can be.' Using the NADA protocol (National Acupuncture Detoxification Association), needles were inserted bilaterally into 5 auricular acupuncture points: Neurogate (point 55), Liver (point 97), Kidney (point 95), Lung (point 101), and Sympathetic point (point 51). This protocol is utilized for behavioral health and addressing symptoms of addiction, detox, and PTSD. A total of 12 sessions were applied over 6 weeks. After treatment, the patient's MYCaW scores were 1/6 for PLP and well-being as 2/6, reporting she was more calm, more comfortable, and sleep had improved. There was also a substantial reduction in the patient's negative feeling, with the total energy score improving.⁶⁴

The relationship between overall anxiety levels prior to lower limb amputation were found to have a positive correlation with PLP. Quality of life, anxiety, and depression were evaluated in patients who presented with phantom limb pain post amputation surgery.⁸ Patients with PLP were found to have a compromised quality of life in both physical and mental health. This

mainly related to the impairment of daily activities with an increased anxiety level among young people (18-38 years old) and depression in the elderly (60-80 years old). The study concluded that these factors, along with change in the perception of body image, heavily impacted the patient's functional prognosis and adherence to the rehabilitation program. Depression has also shown to be a comorbid factor among persons with limb loss. A cross-sectional study observed that 28.7% of amputees suffer from depressive symptoms.⁷⁰ Risk factors included having residual limb pain, PLP, and other comorbid symptoms for persons aged 18-54. For those with severe depressive symptoms, 32.9% reported needing mental health services, but not receiving them, while 67.1% reported not needing mental health services.

A systematic review of the effectiveness of acupuncture for depression showed acupuncture lowered levels of depression when compared to sham acupuncture and when compared to no treatment.⁷¹ When acupuncture was given with medication versus medication only, acupuncture was found highly beneficial in reducing the severity of depression, although substantial variations resulted from different modes of acupuncture stimulation. A small benefit was found with acupuncture when compared to medication alone. Results were unclear when acupuncture was given when compared to psychological therapy. Although these results showed positive outcomes for the use of acupuncture, the low quality evidence of these trials does not provide for a conclusive outcome. Few trials conducted follow-up assessments and many did not include significant outcomes like quality of life when reporting.⁷¹

SUMMARY & CONCLUSION

Experts agree there are multiple mechanisms that play a role in producing phantom limb pain. Peripheral inputs, central desensitization, and maladaptive plasticity are among the causative factors in western medicine. These three mechanisms are not mutually exclusive and all are thought to contribute to PLP in varying degrees. However, the underlying cause of this condition

remains unseen. (See Figure 16) Imaging studies have correlated the existence of PLP with cortical reorganization (CR) in the sensorimotor cortex (S1/M1). Cortical reorganization can be viewed as a result of the disruption of *qi* in TCM, and it is inferred that the level of *qi* stagnation is related to the severity of pain felt by those suffering from PLP. The extent of trauma to the body correlates with the degree of *qi* stagnation and may require a longer course of treatment for desired results.^{31,57}

Centrally, it's been suggested that improvement of pain through pharmacological intervention is due to inhibiting cortical reorganization with the use of opioids.²³ Current research suggests this inhibition will prevent the brain from remapping neuronal pathways.⁴ This type of sedation represents a counteraction to the brain's attempts of adaptive plasticity. Opioids alter where attention is placed and do not address the root cause of the pain itself. A cessation in the flow of *qi* inhibits attempts of homeostasis and perpetuates imbalance in the pathways, resulting in the continued presence of pain when not under this type of sedation.

Conversely, motor excitability has been shown to induce cortical normalization and diminish PLP.^{20,28} Initial reorganization is likely to cascade changes in connectivity within and beyond the sensorimotor system. However, this cascade seems to have a reversal effect once motor activity increases. The amount of physical activity with the residual limb, as in the case with prosthesis, has demonstrated profound CR in M1.¹⁸ Evidence shows reduction in PLP over time was significantly positively correlated with extensive use of a myoelectric prosthesis.²⁰ Increased PLP may have motivated patients to decrease prosthesis use; however, this is unlikely as no patient in the studies reviewed reported increased PLP with prosthesis use or gave stump pain or PLP as a reason for discontinuing prosthesis use.²⁰

The energy needed for use with a prosthetic requires an increased number of neurons with movement. Thus, more *qi* would be needed in the area of amputation to complete the desired movements and consequently in S1/M1. This influx of *qi* in the associated meridian pathways results in a strengthening of the channels and an ability to clear any existing blockages in the meridians, subsequently allowing for adaptive reorganization of the sensorimotor cortex.

Targeted reinnervation (TR) has been successful in promoting adaptive plasticity and can be seen

as re-establishing an unobstructed *qi* pathway in the meridians allowing the body to return to a pain free state.

Positive results of both rTMS and tDCS demonstrate a connection between pain and cortical reorganization in M1.^{31,32} In TCM theory, it would seem these modalities altered the associated meridian pathways through use of noninvasive electromagnetic stimulation, resulting in less stagnation of *qi*. Pain relief through stimulation to the motor cortex suggests deafferentation resulted in a *qi* imbalance caused by cortical reorganization relating to pathways associated with M1, which was then restored through electromagnetic pulses. In addition, the tDCS stimulation of the hand area representation in M1 as corresponding with acupoint LI4 *Hegu*, as opposed to the M1 area of the missing limb, substantiates the function of that point in Chinese medicine as an empirical point for pain in the entire body and its function of tonifying *qi*.³² However, controlled trials involving tDCS are necessary to confirm these findings.

Both rTMS and tDCS resolved issues associated with pain in traumatic amputees, but not with non-painful sensations associated with the phantom limb.^{31,32} As with the case of congenital amputees, non-painful sensations were not evoked by TMS, which implies a previous neuronal pathway to M1 would be necessary for maladaptive CR to exist in that cortex.³⁴ This would suggest cortical reorganization of M1 is primarily related to the existence of pain experienced by amputees. It could be inferred that the characteristics of the pain would relate more with CR in S1. With these cases, it seems the most severe area of *qi* stagnation would take place in the pathways associated with the primary motor cortex. Further research would have to clarify if non-painful sensations were addressed by stimulation to the somatosensory cortex or other brain structures associated with cortical reorganization in non-congenital amputees.

Studies of mental imagery have demonstrated a link to the visual stream correlating with a reduction of CR and PLP in amputees.¹⁹ Analyses showed repeated training was able to reduce the intensity of constant pain, but not the exacerbations associated with PLP. These findings suggest an underlying capability of reversible plasticity in S1/M1, but the visual stream is only one part of the components needed for adaptive CR. It can be reasonably assumed from the results of trials studying the use mental imagery, myoelectric prostheses, and electromagnetic

therapies of M1 that the visual stream is associated with intensity of PLP and motor excitability is associated with the presence of PLP.^{19,27,28,31,32} These results imply western therapies incorporating both movement and visual feedback would allow for the maximum adaptive CR for amputees.

Ronald Melzack theorized the *neurosignature* pattern had the capability of activating the *neuromatrix* to produce its own patterns of movement without the presence of external stimuli.¹¹ Subsignatures created from traumatic experiences and memories of those events directly affect the neurosignature and how pain is processed in the brain, which sends a constant stream of ongoing inputs to the *neuromatrix*. PLP experienced by amputees without external stimulation, as in the case of exacerbations or during sleep, coincides with this theory. The brain is a dynamic participant in the processing of pain and is capable of creating the perception of pain due to the residual effects of traumatic experiences unrelated to the current environment or external stimuli.¹¹ The subtle body is a significant part of the '*body-self*' *neuromatrix*, which exists regardless of the biological presence of a limb as shown with Kirlian photography and the existence of PLP.

These ongoing inputs from the *neurosignature* parallel the concept of standing wave patterns produced by the human heartbeat. Standing waves promote blood flow into specific organs and microvascular beds.³⁹ This, in essence, improves cell metabolism and enhances the human biofield. Resonance patterns exist between internal organs and TCM meridian pathways.³⁹ The frequency of the resonance pattern matches with a harmonic mode of the heart and affect pressure components all the way to the peripheral arteries.³⁹ A significant change will present itself in the spectrum of the pressure pulse and reduce efficiency of blood distribution into the organs. Photoluminescent BIOCERAMIC (PLB) material combined with BIOCERAMIC resonance (BR) devices have identified 'Propagated Sensations along Meridians' (PSM) corresponding to TCM acupuncture points and associated meridian channels.⁴⁰ PLB technology can map meridian pathways and acupuncture point locations on the body.³⁸ Meridians possess wave-induced flow characteristics, and imbalances in those variables have been correlated with disease in TCM.³⁸ BR has demonstrated positive results in addressing psychological conditions through modulating sound rhythm frequency and addressing imbalances in standing wave

resonance patterns, thus enhancing the biofield.⁴¹ Analysis of these standing wave characteristics could be used as a diagnostic tool for clinicians in the future.

Ultra-weak photon emission (UPE) utilizes photomultiplier tubes to show the dynamic metabolism of acupuncture points at the end of meridian pathways located in the fingertips and toes.⁴⁴ Correlations of these biophoton emissions were shown among subjects grouped together according to age, sex, and health status. Asymmetry of emissions were found in unhealthy subjects when compared to healthy controls. Acupuncture demonstrated a dual modulation of UPE of unhealthy subjects and healthy subjects reflecting its ability to balance *qi* in the body.

A systematic review of neuroimaging studies identified activation and deactivation patterns of points located along the same meridian channels that showed similarities in their functions as a group, but diversity in their individual actions.⁴⁶ These functions correlated with TCM theory in regard to their therapeutic properties. However, the included studies would be considered low quality and conclusions should be made with caution. Studies have utilized fMRI to link functions of commonly used acupuncture points to different brain structures further supporting Chinese theory.⁴⁸ These points have displayed an ability to exert a lasting influence on various neural networks even after needles were removed. This time-variant feature may be specific to certain acupuncture points.⁵⁰ Specialized CO₂ instruments have recorded emissions of body surface acupuncture points and have been able to correlate the energy metabolism of points along meridian channels compared to control points.⁴⁷ This method was also able to identify the points along the channel with the highest concentration of *qi* according to TCM theory. SQUID technology has been able to measure the brain's magnetic field after acupuncture point stimulation to map the internal pathway of LI4 *Hegu*.¹⁶ Researchers were able to make a correlation between the point's projection area of the face and mouth and its therapeutic properties of easing dental pain.

The effect of acupuncture on the brain can be seen as integrated on multiple levels. Evidence has shown the effects of acupuncture on the brain involve a task-negative network that is focused on the limbic system, a set of structures in the brain that are involved with emotions and memory that also regulates endocrine function in response to emotional stimuli.³³ Functional MRI studies

have identified a network from patterns of responses to acupuncture stimulation termed the limbic-paralimbic-neocortical network (LPNN). The limbic system, somatosensory areas, the DMN, and anti-correlated task positive network have all shown responses to acupuncture stimulation and are deactivated when *de qi* is evoked during treatment.³³

A hemodynamic response resulting in a decrease of blood flow has been shown in patients that experience *de qi*. Conversely, this response has been absent in patients that experience a sharp pain not relating to *de qi*. Therefore, a patient's response to acupuncture is not singularly related to the act of needling, or demanding attention of an external stimulus. There is an underlying mechanism resulting in a therapeutic effect when the LPNN is deactivated when *de qi* is achieved.³³ Studies have shown that 71% of acupuncture elicits *de qi*.³³ Variances were found between acupuncture points, with LI4 *Hegu* showing the most profound response.³³ Acupuncture point ST36 *Zusanli* increased activity in S1/M1 and the cerebro-cerebellar network when the LPNN was deactivated. These acupuncture points are known for relieving pain and promoting *qi* throughout the body.

Heightened connectivity between the DMN and other affective regions following acupuncture were correlated with decreased sympathetic and increased parasympathetic modulation.³³ Acupuncture showed greater activation of the DMN areas correlated with emotional/interoceptive and cognitive/evaluative subregions than sham acupuncture. In addition, the amygdala and hypothalamus decreased in activity during stimulation.³³ This may explain the general feeling of relaxation and pain relief experienced with this kind of treatment; i.e. genuine acupuncture leads to stronger DMN deactivation than sham acupuncture.

Treatments for conditions with similar neuropathic characteristics, such as CRPS1, Stroke, and PLP, may respond to treatments courses that promote adaptive CR. Clinical presentation and cortical responses to treatment can be measured for all conditions utilizing the same imaging techniques to compare features.⁵⁸ Acupuncture has shown to facilitate adaptive cortical reorganization in sensorimotor activation in fully recovered Bell's Palsy patients.⁵⁵ Improvements were also seen in post-stroke recovery patients with regard to neurological deficits, lower extremity motor function, swallowing, and cognitive impairments.⁵⁶

Acupuncture has demonstrated to have an analgesic and reorganizational ability on the central nervous system.^{55,57,62} Case studies have shown to provide immediate relief to patients and resolve symptoms that had been previously thought to be unrelated to pain.^{57,59,64} Scalp acupuncture (SA) is a specialized style based on representative regions of the cerebral cortex. Its stimulation has shown to affect cortical areas of the cerebellum and cerebrum, which are responsible for motor activity, sensory input, vision, speech, hearing, and balance.⁵⁹ The sensory, motor, and tremor areas on the scalp are recommended in the treatment of PLP and have shown effectiveness for other disorders of the CNS. Case studies of SA have presented beneficial results of PLP along with CRPS1, stroke, and quadriplegia in less than ten treatments with the use of only a few needles.⁵⁹ These results can vary based on the degree of *qi* stagnation and may warrant additional treatment.

The holistic concept of TCM provides for improvements along meridian channels through distal and proximal acupuncture points. This has been corroborated through SQUID technology, CO2 emissions, and fMRI studies correlating brain structures to the functionality of the acupuncture points. The interconnectedness of the meridian channels, as shown with PLB and UPE studies, allow practitioners to utilize contralateral points of the missing limb to alleviate PLP.⁵⁷ The extent of injury in relation to *qi* stagnation may determine the style of acupuncture and the sessions necessary for the desired result. Points related to stress, anxiety, fear, and local pain experienced on the phantom limb were utilized on the contralateral limb in patients with PLP and were shown to be beneficial. However, controlled trials are necessary for conclusive evidence of the effects of this medicine for PLP.

Patients who experience high levels of pain catastrophizing pay more attention to external stimuli and have increased negative expectations relating to the stimuli. Catastrophizing explained significantly more of the difference in retrospective rating of worst pain compared to prospective ratings of average pain, which may indicate a link between pain measure and memory processing. The TCM view connecting poor emotional and mental health with the stagnation of *qi* supports the findings that PLP has a positive correlation with increased anxiety, depression and lower quality of life. The patient's functional prognosis could also be affected by

the patient's state of mental and emotional health, slowing recovery time. Thus, it's essential to treat these issues along with the physical pain. Anxiety levels pre amputation have a positive correlation with PLP. The impairment of daily activities, change in perception of body image, was shown to increase anxiety levels and depressive symptoms among amputees.⁸ 28.7% of amputees have reported symptoms of depression with over a third not receiving the mental health services they believe they needed.⁸ Although neuroimaging studies have shown acupuncture stimulation affects areas of the brain associated with emotions and negative feelings such as the limbic system and DMN, low quality evidence has shown inconclusively of acupuncture for depression. Benefits were demonstrated when acupuncture was compared to no treatment, when given with medication, and when compared to medication alone, but controlled trials are needed to confirm these findings.⁷¹

Those exposed to trauma are 2.7 times more likely to experience chronic pain.⁶⁸ This correlation between PTSD and chronic pain syndromes supports the theory that trauma creates a functional somatic susceptibility to experiencing chronic pain if those associated emotions are not adequately processed, and further supports the theory that the human biofield transmutes emotional and mental imbalances related to traumatic experiences into physical pain. Energy-based medicines address this pain by clearing obstructions in the subtle body, and thus, creating a way for emotions related to these significant events to be adequately processed. Different levels of the human biofield are modulated by different therapies. Integration of Chinese meridian theory with therapeutic touch (TT) has shown effectiveness in case studies among energy healers.⁶⁷ Immediate results of TT alone in an RCT were shown to induce relaxation and increase generalized immune function.⁶⁵ More research is necessary to observe long term effects of TT and to make conclusions about its efficacy related to PLP.

Western medicine can be seen as regulating the physical body, or the densest of the energetic fields. Acupuncture facilitates *qi* in the meridian channels to modulate imbalances in the energetic pathways within the body. Therapeutic touch uses the external biofield to regulate interference in the surrounding subtle energy fields. Disturbances in one of these fields may manifest in another as these systems work synergistically to promote homeostasis. Acupuncture combines its energetic properties with physical stimulation that can be linked to physical

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structures in the brain and systems throughout the body. It has shown to be beneficial for both western and eastern diseases; however, the efficacy of acupuncture for PLP in this review is inconclusive. Compelling case studies warrant further investigation into the benefits of this ancient medicine. Clinical trials are essential in understanding the complex nature of phantom limb pain and additional research could provide for an energy-based model supported by scientific evidence that would pave the way for a more integrated approach between eastern and western medicine.

APPENDIX

DEFINITION OF TERMS

Acupuncture - a key component of Traditional Chinese Medicine (TCM) that utilizes sterile needles to puncture the skin and surrounding tissues for relief of pain and pathological disease; this medicine is based on a meridian system of energetic pathways connected throughout the body; the needles are inserted into acupoints along the body to achieve *de qi* and facilitate healing

BIOCERAMIC Resonance Device - a device applied to the surface of the skin of the anterior chest wall enabling the emission from photoluminescent BIOCERAMIC (PLB) material to interact with rhythmic sound frequencies to provoke hydrogen bond weakening to achieve resonance with the tissues of the whole human body

Biofield - a large field of energy, also termed biomagnetic field or aura, that surrounds and extends out from the body that is comprised of both measurable electromagnetic energy and subtle energy, or *qi*; this energy field increases in vibration and decreases in density the further it extends from the physical body

Biomagnetic Field - the electromagnetic field comprised of the magnetic fields produced by all living organisms

Biophoton Emission - also termed ultra-weak photon emission (UPE), is the spontaneous emission generated by all living systems mainly attributed to oxidation reactions without external excitation that can be measured using a photomultiplier tube

Body-self neuromatrix - the phantom body that is still present in the absence of physical body parts with multiple dimensions involving sensory, affective, evaluative, and postural characteristics coined by R. Melzack in his explanation of the *neuromatrix*

Central Sensitization - enhanced excitability of dorsal horn neurons that is characterized by increased spontaneous activity, expanded neuronal receptive fields, and an increase in the N-methyl-D-aspartate, or NMDA, activity in the dorsal horn of the spinal cord making

them more susceptible to activation; sensitization of dorsal horn neurons often occurs following tissue injury and inflammation and is believed to contribute to hyperalgesia

Cerebellum - a major structure of the hindbrain located near the brainstem that is responsible for voluntary movements and functions related to motor skills including balance, coordination, and posture

Chakra System - chakra is derived from the Sanskrit word meaning 'wheel', and describes the 7 main energy centers of the body starting from the base of the spine to the crown of the head which correspond to bundles of nerves and major organs as well as psychological, emotional, and spiritual states of being

Collaterals - energetic pathways of the body that run transversely and superficially from the meridian network and constitute branches of the meridians

Complex Regional Pain Syndrome (CRPS) - a chronic pain condition that most often affects one limb (arm, leg, hand, or foot) usually after an injury and is believed to be caused by damage to, or malfunction of, the peripheral and central nervous systems; Type 1 may occur after an apparent trivial injury with no confirmed nerve damage; Type 2 may occur after a more severe injury or trauma with confirmed neuronal damage

Cortical Reorganization (CR) - remapping of the cortices of the brain, when the cortical areas representing the amputated extremity are taken over by the neighboring somatotopic representational zones in the sensorimotor (S1/M1) cortex

De Qi - the excitation of Qi, or vital energy, through stimulation of an acupuncture needle inside a meridian; sensation may feel intense and accompanied by numbness, soreness, heaviness, distention, dull pain, or sharp pain

Deafferentation - the interruption of the afferent connections of nerve pathways, considered one of the possible causes of PLP

Default Mode Network (DMN) - an interconnected network of brain structures known to be active when a person is not focused on the outside world, when the brain is in a wakeful resting state of relaxation; network includes medial temporal lobe, medial prefrontal cortex, posterior cingulate cortex, ventral precuneus and parts of the parietal cortex

Electronic Acupuncture - a form of acupuncture where a small electric current is passed between a pair of acupuncture needles often used to alleviate pain

Five Element Theory - the basis of Traditional Chinese Medicine, known as *Wu Xing* that holds all phenomena in the universe correspond in nature to Wood, Fire, Earth, Metal, or Water, and that these are in a state of constant motion and change; these elements are considered to be five indispensable materials for the maintenance of all life and production

Functional Magnetic Resonance Imaging (fMRI) - Blood Oxygen Level Dependent (BOLD) neuroimaging that depicts changes in deoxyhemoglobin concentration related to task-induced or spontaneous modulation of neural metabolism

Hypothalamus - a small collection of nuclei located at the base of the brain near the pituitary gland that's involved in releasing hormones and regulating body temperature

Gate Control Theory - proposed by R. Melzack and P. Wall in 1965 emphasizing the dynamic role of the brain in pain processing as an active system that filters, selects, and modulates inputs along with the dorsal horn of the spinal cord

Limbic System - a set of structures in the brain that are involved with emotions and memory; regulates endocrine function in response to emotional stimuli and reinforces behavior; structures include the amygdala, hippocampus, thalamus, hypothalamus, basal ganglia, and cingulate gyrus

Limbic-Paralimbic-Neocortical Network - a task-negative network for acupuncture that is centered on the limbic system identified from patterns of responses during acupuncture stimulation by fMRI similar to the default mode network (DMN) during attention-demanding tasks

Magnetoencephalography (MEG) - a functional neuroimaging technique for mapping brain activity by recording magnetic fields produced by electrical currents occurring naturally in the brain using very sensitive magnetometers

Meridians - energy pathways mapped throughout the body, existing in corresponding pairs, with many acupuncture points along each pathway, connecting different parts of the body

Myoelectric Prosthesis - refers to electric properties of muscles; an externally powered artificial limb that is controlled with the electrical signals naturally generated by the muscles of the residual limb; one or more sensors receive electrical signals when it is intentionally engaged by specific muscles in the residual limb and relay information to a controller which translates the data into commands for the electric motors and moves the joints

NADA Protocol - a set of auricular acupuncture points from the National Acupuncture Detox Association targeting behavioral health, addiction, and detox symptoms; 5 auricular acupuncture points inserted bilaterally: Neurogate (point 55), Liver (point 97), Kidney (point 95), Lung (point 101), and Sympathetic point (point 51)

Neuromatrix - the anatomical substrate of the ‘body-self’; a large widespread network of neurons that consists of loops between the thalamus, cortex, and limbic system whose spatial distribution and synaptic links are initially determined genetically and are later sculpted by sensory inputs; the loops diverge to permit parallel processing in different components of the network and converge to permit interactions between the output products of processing; the repeated cyclical processing and synthesis of nerve impulses through the *neuromatrix* forms a characteristic pattern which is imparted on all nerve impulse patterns that flow through it and is termed the *neurosignature*; portions of the neuromatrix are specialized to process information related to major sensory events such as injury, temperature change, and stimulation of erogenous tissue, and may be labeled as *neuromodules* which impress subsignatures on the larger *neurosignature*; part of R. Melzack’s research on pain processing

Neuromodule - a component of the *neuromatrix* specialized to process information related to major sensory events such as injury, temperature change, an stimulation of erogenous tissue that impress subsignatures on the larger *neurosignature*; part of R. Melzack’s research on pain processing

Neurosignature - a product of the *neuromatrix*; the repeated cyclical processing and synthesis of nerve impulses through the *neuromatrix* that forms a characteristic pattern, which is imparted on all nerve impulse patterns that flow through it; the *neurosignature*, which is a continuous outflow from the *body-self neuromatrix*, is projected to areas of the brain where the stream of nerve impulses (the *neurosignature* modulated by ongoing inputs) is transformed into a continually changing stream of awareness; *neurosignature* patterns may also concurrently activate a *neuromatrix* to produce patterns of movement; portions of the *neuromatrix* that process information related to major sensory events, called *neuromodules*, impress *subsignatures* on the larger *neurosignature*; part of R. Melzack’s research on pain processing

Opioid - a class of drugs prescribed by doctors to treat moderate to severe pain that may have potential risks and side effects; common types include morphine, oxycodone, hydrocodone, and tramadol

Phantom Limb Pain (PLP) - pain perceived by a region of the body that is no longer present

Phantom Limb Sensation (PLS) - non-painful physical sensations perceived to be originating from a missing or amputated body part

Phantom Motor Execution (PME) - proposed treatment for PLP that aims to reactivate the original central and peripheral circuitry involved in motor control of the missing limb along with increasing dexterity of the stump muscles; hypothesizes that training of phantom movements induces gradual neural changes that disentangle pain processing circuitry by competitive plasticity

Photoluminescent BIO-CERAMIC Material (PLB) - Photoluminescence is governed by the law of interaction between electromagnetic radiation and matter. PLB material absorbs a portion of the electromagnetic spectrum and emits lower energy wavelengths, providing a usable visible light source. This type of material facilitates the breakup of large clusters of water molecules by weakening hydrogen bonds, which allows water molecules to act in various ways under different conditions. Through meridian point irradiation, its effects on the meridian current flow can be detected by the alteration of liquid characteristics in the meridian channels to show if a specific meridian channel current is indirectly affected by another which has been treated with PLB irradiation. Because the meridian channels and their corresponding acupuncture points are located in distinct locations, typical light energy irradiation should not be able to affect the electrical resistance of the skin or other meridian channels if no interconnecting network exists.

Post-traumatic Stress Disorder (PTSD) - a set of reactions that is triggered by a terrifying event which symptoms may include flashbacks, nightmares, severe anxiety, panic attacks, ruminative thoughts, and depression

Primary Motor Cortex (M1) - located in the frontal lobe of the brain along the precentral gyrus; generates efferent neural impulses that control the execution of movement; motor representation is somatotopically arranged from the toe, at the top of the cerebral hemisphere, to the mouth, at the bottom, along a fold in the cortex call the central sulcus which separates M1 and S1

Propagated Sensation along Meridians (PSM) - a phenomenon that a sensation moves along energetic pathways during stimulation of an acupuncture point

Qi - a vital circulating energy, or life force, often used in Chinese Medicine and Eastern philosophies thought to be the fundamental substance constituting the universe and that all phenomena were produced by its changes and movements; denotes both the essential substances of the human body and its vital functional activities; flows through the meridian pathways and is modulated by that act of acupuncture needling

Qi Stagnation - a disruption in the flow of qi in the meridian pathways that is the cause of pain and pathological disease in Chinese medicine, which results in imbalances of deficiency, and excess in the meridians

Reiki - also termed therapeutic touch (TT), a way to balance energy systems of the body with or without physical contact with the patient; the practitioner uses the palms of his/her hands to detect non-thermal imbalances in the energy field that can feel like friction or a magnetic repulsion emanating from the body against the hands of the practitioner; tingling or heat sensations usually indicate symptomatic areas of pain; the energy field of the patient is then 'smoothed' out by slow sweeping motions made by the hands of the practitioner which essentially clears out the obstructions in that area of the biofield

Repetitive Transcranial Magnetic Stimulation (rTMS) - the application of a figure-eight wire coil over the scalp to map brain activity and induce excitability changes in the motor cortex by generating a magnetic field that passes through the scalp indirectly and noninvasively.

Residual Limb Pain (RLP) - perceived pain experienced in the remaining stump of the amputated limb, also known as stump pain (SP)

Scalp Acupuncture (SA) - uses transcutaneous insertion of acupuncture needles in motor and sensory area lines on the scalp with a specific rotational technique; the location of SA regions are based on the Western medicine reflex somatotopic layout organized on the surface of the scalp; these areas do not relate to the meridian pathway theory in TCM and are a new type of concept integrating western brain mapping with eastern needle technique; these zones correspond to the cortical areas of the cerebrum and cerebellum responsible for CNS functions such as motor activity, sensory input, vision, speech, hearing, and balance; this style of acupuncture requires a specialized technique to achieve desired results and is not practiced by all acupuncturists

Sensorimotor Cortex (S1/M1) - the area of the brain that comprises the precentral and postcentral gyri covering the primary sensory and motor areas of the brain

Somatosensory Cortex - located in the postcentral gyrus; receives and processes sensory information from the entire body involving touch, temperature, proprioception, i.e. the position of the body in space, and nociception, i.e. pain; sensory representation is somatotopically arranged from the toe, at the top of the cerebral hemisphere, to the mouth, at the bottom, along a fold in the cortex call the central sulcus which separates S1 and M1

Somatotopic Brain Mapping - the projection of an area of the body onto a specific point on the central nervous system or the brain area responsible for function of that body part; sensory and motor processing is arranged from the toe, at the top of the cerebral hemisphere, to the mouth, at the bottom, along a fold in the cortex call the central sulcus which separates S1 and M1

Stroke - a sudden interruption in the blood supply of the brain; ischemic strokes are caused by an abrupt blockage of arteries leading to the brain; hemorrhagic strokes are caused by bleeding into the brain tissue when a blood vessel bursts

Stump Pain (SP) - perceived pain experienced in the remaining stump of the amputated limb, also known as residual limb pain (RLP)

Subtle Body - various layers of increasing vibrating energy and decreasing density that form a human biofield beyond the physical body, all being of the same consciousness at different levels; meridian pathways are one layer of the subtle body

Superconducting Quantum Interference Device (SQUID) - a very sensitive magnetometer used to measure extremely subtle magnetic fields based on superconducting loops containing Josephson junctions; sensors convert a magnetic flux, or a measure of magnetic intensity, into a voltage that can be recorded; has been used to measure brain magnetic fields evoked by needling acupuncture points

Telescoping - the perception of progressive shortening of the phantom body part resulting in the sensation that the distal part of the limb is becoming more proximal

Thalamus - brain structure of gray matter lying between the cerebral hemispheres on either side of the third ventricle that relays sensory information from various parts of the body to the cerebral cortex for interpretation as touch, pain, or temperature

Therapeutic Touch (TT) - also termed Reiki, a way to balance energy systems of the body with or without physical contact with the patient; the practitioner uses the palms of his/her hands to detect non-thermal imbalances in the energy field that can feel like friction or a magnetic repulsion emanating from the body against the hands of the practitioner; tingling or heat sensations usually indicate symptomatic areas of pain; the energy field of the patient is then 'smoothed' out by slow sweeping motions made by the hands of the practitioner which essentially clears out the obstructions in that area of the biofield

Transcranial Direct Current Stimulation (tDCS) - a non-invasive therapy that increases the excitability of the motor cortex (M1) by means of anodal electrical brain stimulation

Transcranial Magnetic Stimulation (TMS) - the application of a figure-eight wire coil over the scalp to map brain activity in the motor cortex by generating a magnetic field that passes through the scalp indirectly and noninvasively

Ultra-weak Photon Emission (UPE) - also termed biophoton emission, is the spontaneous emission generated by all living systems mainly attributed to oxidation reactions without external excitation that can be measured using a photomultiplier tube

Zang-fu Organs - This is a general term for the internal organs of the human body, and includes 6 *zang* organs, 6 *fu* organs, and the extra *fu* organs. The heart, lung, liver, spleen, kidney, and pericardium are known as the *zang* organs. The gallbladder, stomach, small intestine, large intestine, bladder, and triple energizer are known as the 6 *fu* organs. The brain, marrow, bones, vessels, gallbladder, and uterus are known as the extra *fu* organs. The main physiological functions of the *zang* organs are to manufacture and store essential substances, including vital essence, *qi*, *blood*, and body fluid. The main physiological functions of the *fu* organs are to receive and digest food, and transmit and excrete the waste.

FIGURES & TABLES

Figure 1. Study Flow Chart

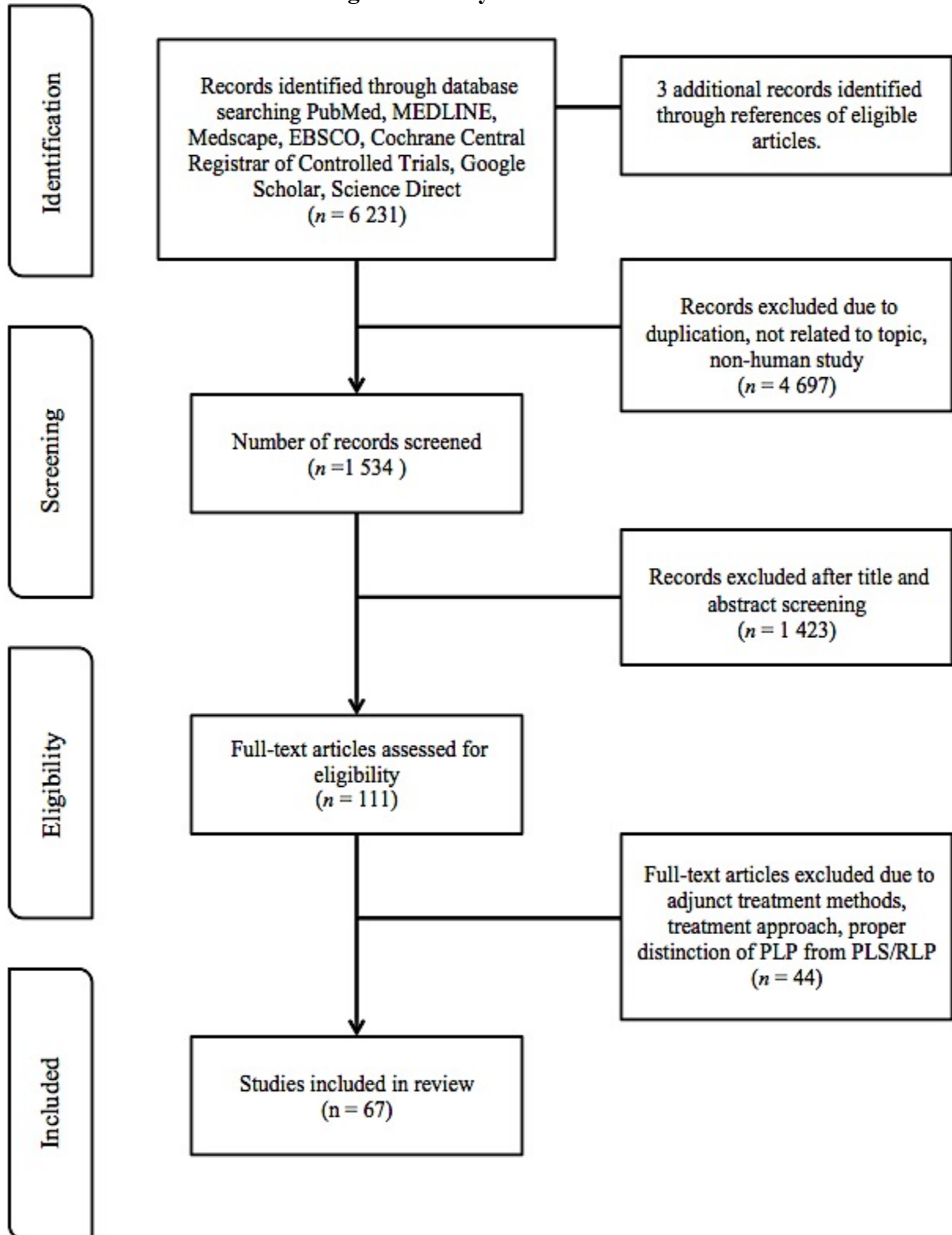


Table 2. JADAD RCT Quality Assessment

	Randomization reported?	Appropriate randomization?	Blinding reported?	Appropriate blinding?	Withdrawals reported with description?	Total Score
Chen et al. 2016	1	1	0	0	1	3
Diaz-Rodriguez et al. 2011	1	1	1	1	0	4
Huse et al. 2000	1	1	1	1	1	5
Malavera et al. 2016	1	1	1	1	1	5
Wu et al. 2018	1	1	0	0	0	2

Table 3. ARHQ Cross-sectional Study Assessment

	Darnall et al. 2005	Padovani et al. 2015
1. Research question or objective clearly stated?	✓	✓
2. Study population clearly specified and defined?	✓	✓
3. Participation rate of eligible persons at least 50%?	✓	✓
4. All subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	✓	✓
5. Sample size justification, power description, or variance and effect estimates provided?	✓	✓
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?	✓	✓
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	✓	✓
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?	✓	✓
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓	✓
10. Exposure(s) assessed more than once over time?	✗	✗
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓	✓
12. Were the outcome assessors blinded to the exposure status of participants?	✗	✗
13. Was loss to follow-up after baseline 20% or less?	✓	✓
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?	✓	✓
Study Quality	Good	Good

Table 4. Newcastle - Ottawa Quality Assessment for Cohort Studies

	He et al. 2014	Raichle et al. 2015
Selection		
Representativeness of exposed Cohort?	1	1
Selection of non-exposed Cohort?	1	0
Ascertainment of exposure?	1	1
Demonstration that outcome of interest was not present at start of study?	0	1
Comparability		
Comparability of cohorts on design basis or analysis controlled for confounders?	1	1
Outcome		
Assessment of Outcome?	1	1
Follow-up long enough for outcomes to occur?	1	1
Adequacy of follow-ups of cohorts?	1	0
Study Quality (Good, Fair, Poor)*	Good	Good

*Good = 3 or 2 pts in Selection AND 1-2 pts in Comparability AND 2-3 pts in Outcome

*Fair = 2 pts in Selection AND 1-2 pts in Comparability AND 2-3 pts in Outcome

*Poor = 0-1 pt in Selection OR 0 pts in Comparability OR 0-1 pt in Outcome

Table 5. Case-Controlled Quality Assessment Tool

	1. Was the study question or objective clearly stated?	2. Was the study population clearly and fully described, including a case definition?	3. Were cases consecutive?	4. Were subjects comparable?	5. Was intervention clearly described?	6. Were the outcome measures clearly defined, valid, reliable, and consistent across all study participants?	7. Was the length of follow-up adequate?	8. Were the statistical methods well-described?	9. Were the results well-described?	Study Quality
Bai et al. 2009	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Chang et al. 2020	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Chen and Tai et al. 2013	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Fang et al. 2009	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Hahamy et al. 2019	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Hommer 2012	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Huang et al. 2007	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Hui et al. 2009	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Kikkert et al. 2018	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Lee et al. 2016	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Leung et al. 2015	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Lotze et al. 1999	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Lotze et al. 2001	✓	✓	✓	✓	✓	✓	✓	✓	✓	
MacIver et al. 2008	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Napadow et al. 2009	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Park et al. 2009	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Parrish et al. 2005	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Preibler et al. 2013	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Preibler et al. 2017	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Reilly et al. 2011	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Seo et al. 2019	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Vase et al. 2012	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Wang et al. 2010	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Yang et al. 1995	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Zhang et al. 2009	✓	✓	✓	✓	✓	✓	n/a	✓	✓	
Zhang et al. 2017	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Zhang et al. 2018	✓	✓	✓	✓	✓	✓	n/a	✓	✓	

<https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools>

Table 5. Case Series, Case Study Quality Assessment Tool (Continued)

	1. Was the study question or objective clearly stated?	2. Was the study population clearly described, including a case definition?	3. Were cases consecutive?	4. Were subjects comparable?	5. Was intervention clearly described?	6. Were the outcome measures clearly defined, valid, reliable, and consistent across all study participants?	7. Was the length of follow-up adequate?	8. Were the statistical methods well-described?	9. Were the results well-described?	Study Quality
Bradbrook 2004	✓	✓	X	✓	✓	✓	✓	✓	✓	✓
Bolognini et al. 2013	✓	✓	X	✓	✓	✓	✓	✓	✓	✓
Chen et al. 2013	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hao et al. 2012	✓	✓	X	✓	✓	✓	X	n/a	✓	✓
Kurath-Koller et al. 2015	✓	✓	n/a	n/a	✓	✓	✓	n/a	✓	✓
Mizuguchi et al. 2019	✓	✓	✓	✓	✓	✓	n/a	✓	✓	✓
Ortiz-Catalan et al. 2014	✓	✓	n/a	n/a	✓	✓	✓	✓	✓	✓
Tseng et al. 2014	✓	✓	n/a	n/a	✓	✓	✓	n/a	✓	✓

<https://www.nhibi.nih.gov/health-topics/study-quality-assessment-tools>

Table 6. AMSTAR Systematic Review/Meta-analysis Quality Assessment

	Afari et al. 2014	Alviar et al. 2016	Gunduz et al. 2020	Huang et al. 2012	Smith et al. 2018
PICO Components? (Population, Intervention, Comparator Group, Outcome)	✓	✓	✓	✓	✓
Review methods established prior to conduct?	✓	✓	✓	✓	✓
Deviations from protocol?	✓	✗	✓	✓	✓
Descriptoin of study designs for inclusion?	✓	✓	✓	✓	✓
Comprehensive literal search strategy used?	✓	✓	✓	✓	✓
Authors performed study selection in duplicate?	✓	✓	✓	✓	✓
Authors provide list of excluded studies and reasons?	✓	✓	✓	✗	✓
Authors described included studies in detail?	✓	✓	✓	✓	✓
Appropriate technique for RoB of included studies?	✓	✓	✓	✗	✓
Report of sources of funding for included studies?	✓	✓	✓	✗	✓
If meta-analysis, appropriate statistical methods used for combining data?	✓	n/a	n/a	✓	n/a
If meta-analysis, assess impact of individual studies' RoB in statistical results?	✓	n/a	n/a	✓	n/a
Authors accounted for individual studies/ RoB when discussing/interpreting results of review?	✓	✓	✓	✗	✓
Provided satisfactory explanation for, and discussion of, any heterogeneity observed in results?	✓	✓	✓	✓	✓
If quantitative analysis, adequate investigation of publication bias (small study bias) and its likely impact on results?	✓	n/a	✓	✓	✓
Reported any potential sources of conflict of interest, including any funding they received for conducting review?	✓	✓	✓	✓	✓

Figure 7. The Phantom Leaf Effect

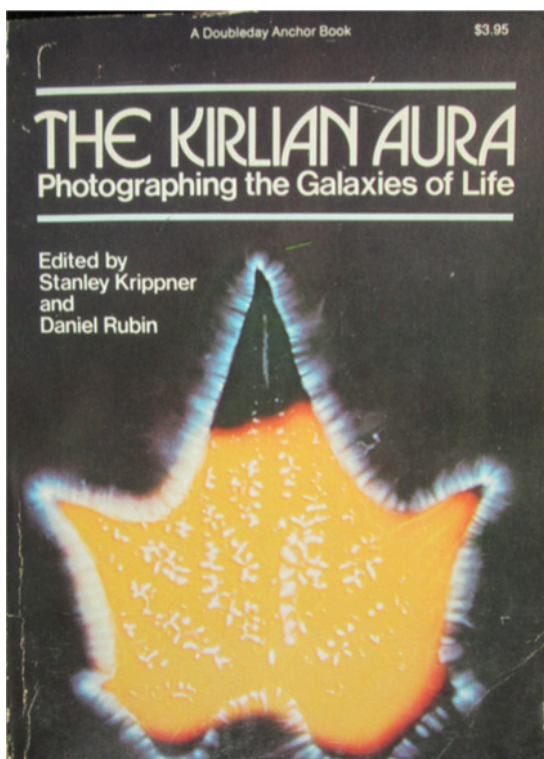


Figure 7. The 'Phantom Leaf Effect' demonstrated that Kirlian electromagnetic or energetic fields were independent of biological structures, and were a component of the subtle body that existed with or without the tip of the leaf.

Figure 8. PIP Image of Below Knee Amputee

Figure 8. Polycontrast Interference Photography (PIP) developed by researcher Harry Oldfield produced Moiré patterns by recording light reflected off the human body to image the entire human biofield. However, no evidence was seen of a phantom biofield extending past the edge of amputation.

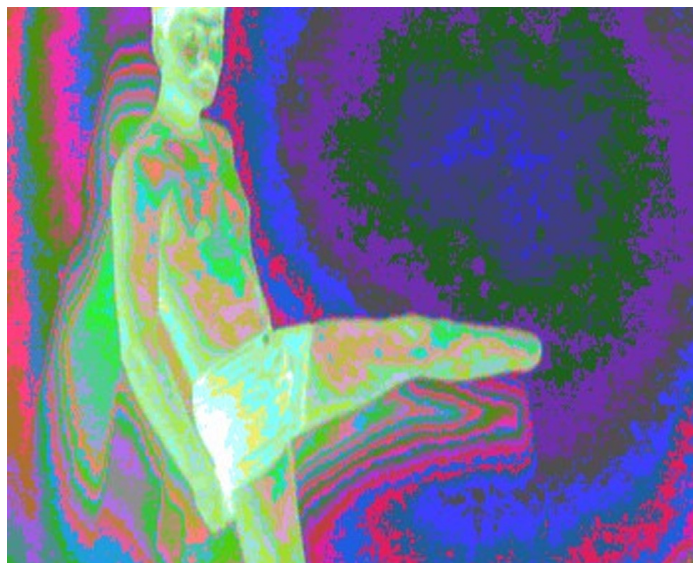


Fig. 7 & 8

Leskowicz E. Phantom Limb Pain: Subtle Energy Perspectives. Subtle Energies & Energy Medicine Journal Archives. 1997;8(2). <https://journals.sfu.ca/seemj/index.php/seemj/article/view/235/198>.

Figure 9. Major Acupuncture Meridian Pathways

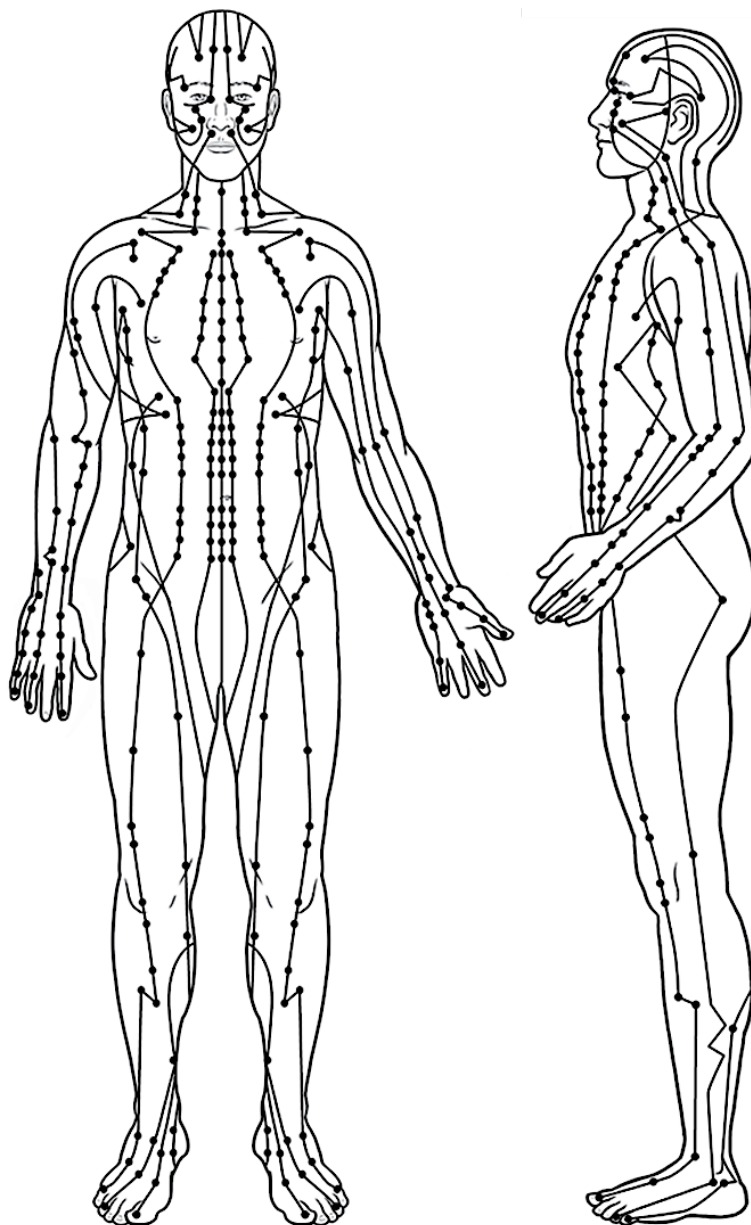


Figure 9. The 12 major meridians are bilateral and form one continuous loop, where one channel ends, another begins.

Figure 10. Somatotopic Representations of Cortical Reorganization

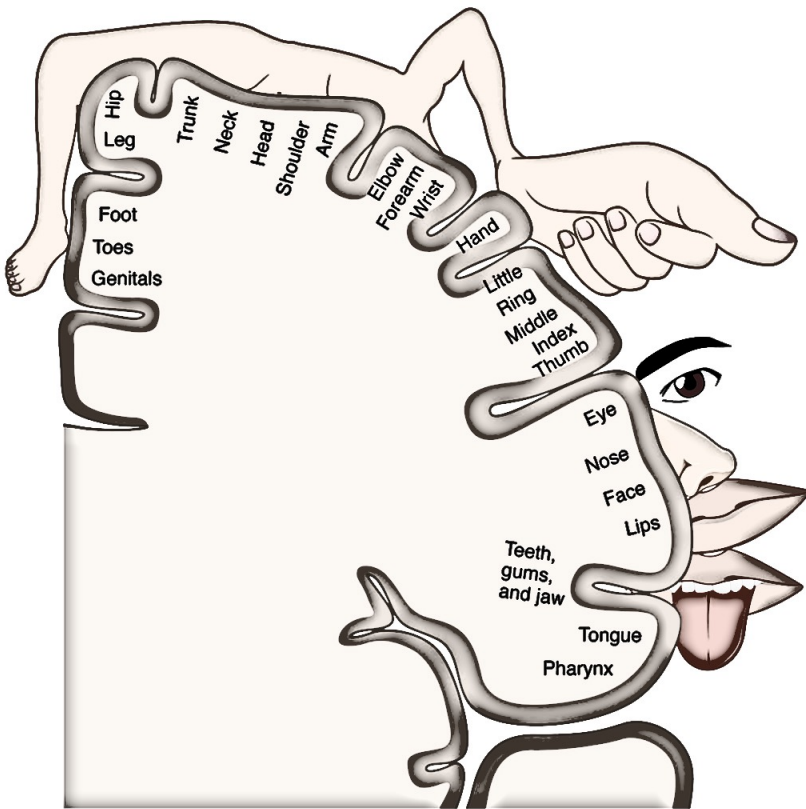
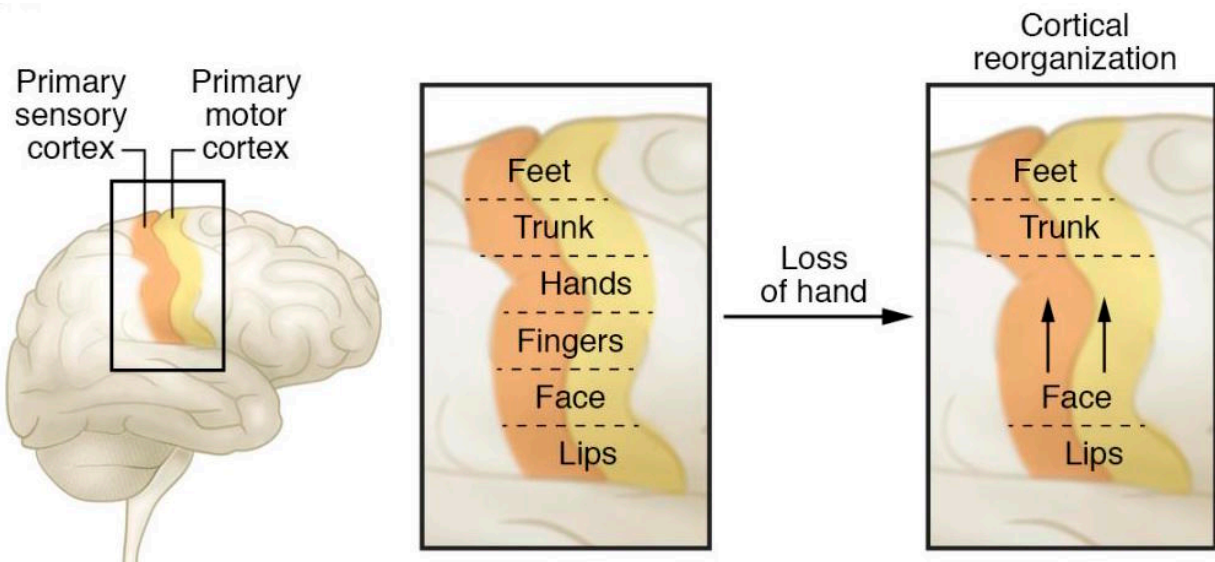


Figure 10a. Sensory Homonculus - Somatotopic map of body regions organized in the sensorimotor cortex along the central sulcus.

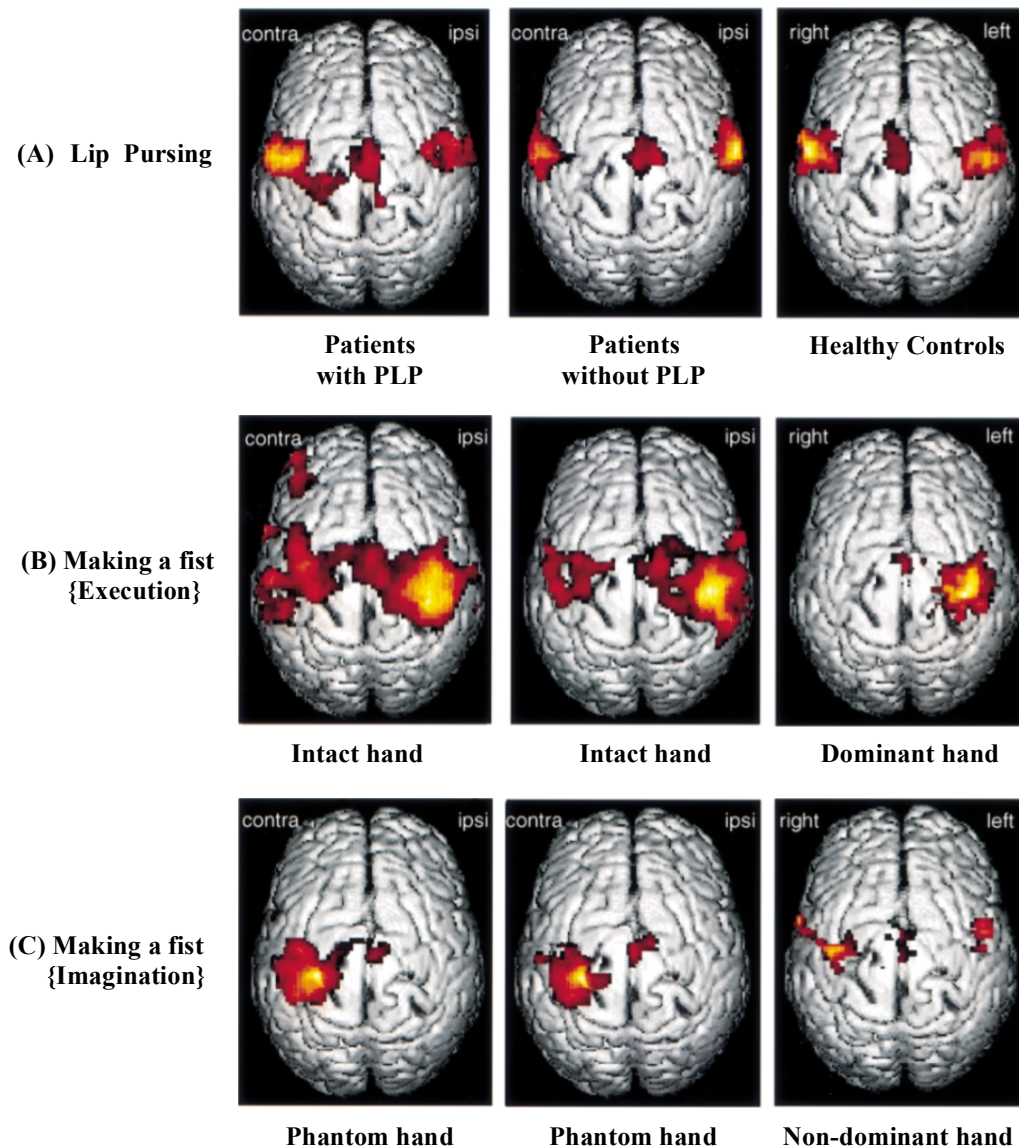
Illustration from Anatomy & Physiology, Connexions Website. <http://cnx.org/content/col11496/1.6/>

Figure 10b. Cortical Reorganization of Sensorimotor Cortex



J Clin Invest. 2018;128(6):2168-2176. <https://doi.org/10.1172/JCI94003>

Figure 11. fMRI Maladaptive Plasticity¹⁸



(A) Lip representations among upper limb amputees with and without PLP, and healthy control subject with intact upper limbs. Imaging with PLP shows lip area primary remapping on representation of missing limb area during lip pursing movement. Imaging without PLP and healthy control show no remapping of lip area representation.

(B) Executed fist movements show secondary (horizontal) remapping of subjects with and without PLP into the hand area representations contralateral to the missing limb with movement of the intact hand. However, primary remapping of the lip representation into the missing hand area contralateral is only shown in subjects with PLP. Healthy controls show no primary or secondary remapping.

(C) Imagined fist representations of subjects with PLP show primary remapping of lip area into the missing limb representation in addition to expansion of the missing limb area representation. Patients without PLP show little to no remapping of lip area representation into the missing limb area, but do show autonomous expansion of the missing hand area during imagined movements. Healthy controls show no remapping and a significantly smaller area representation of the imagined hand area.

Figure 12. Human Biofield³⁸

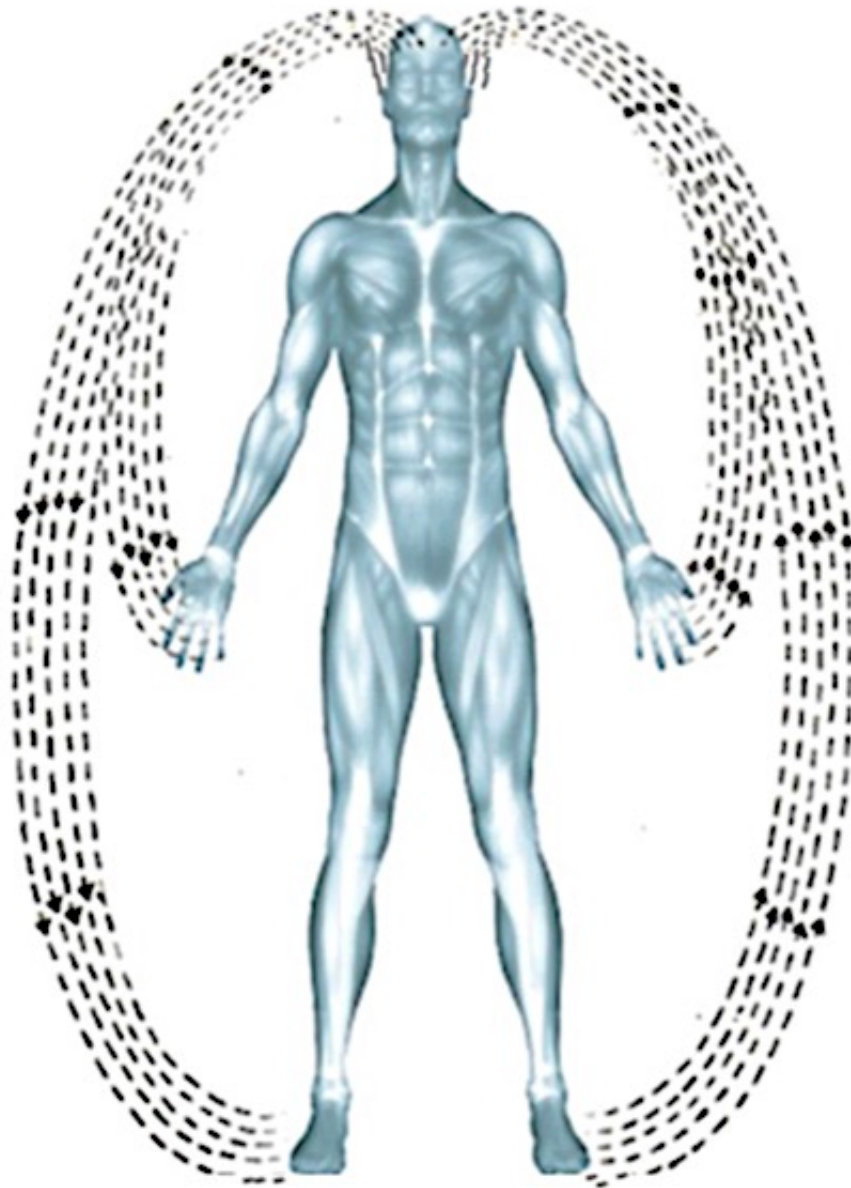


Figure 12. Schematic drawing of the virtual human biofield connecting the ears, hands, and feet.

Figure 13. UPE Patterns of Western and Eastern Disease Concepts⁴⁴

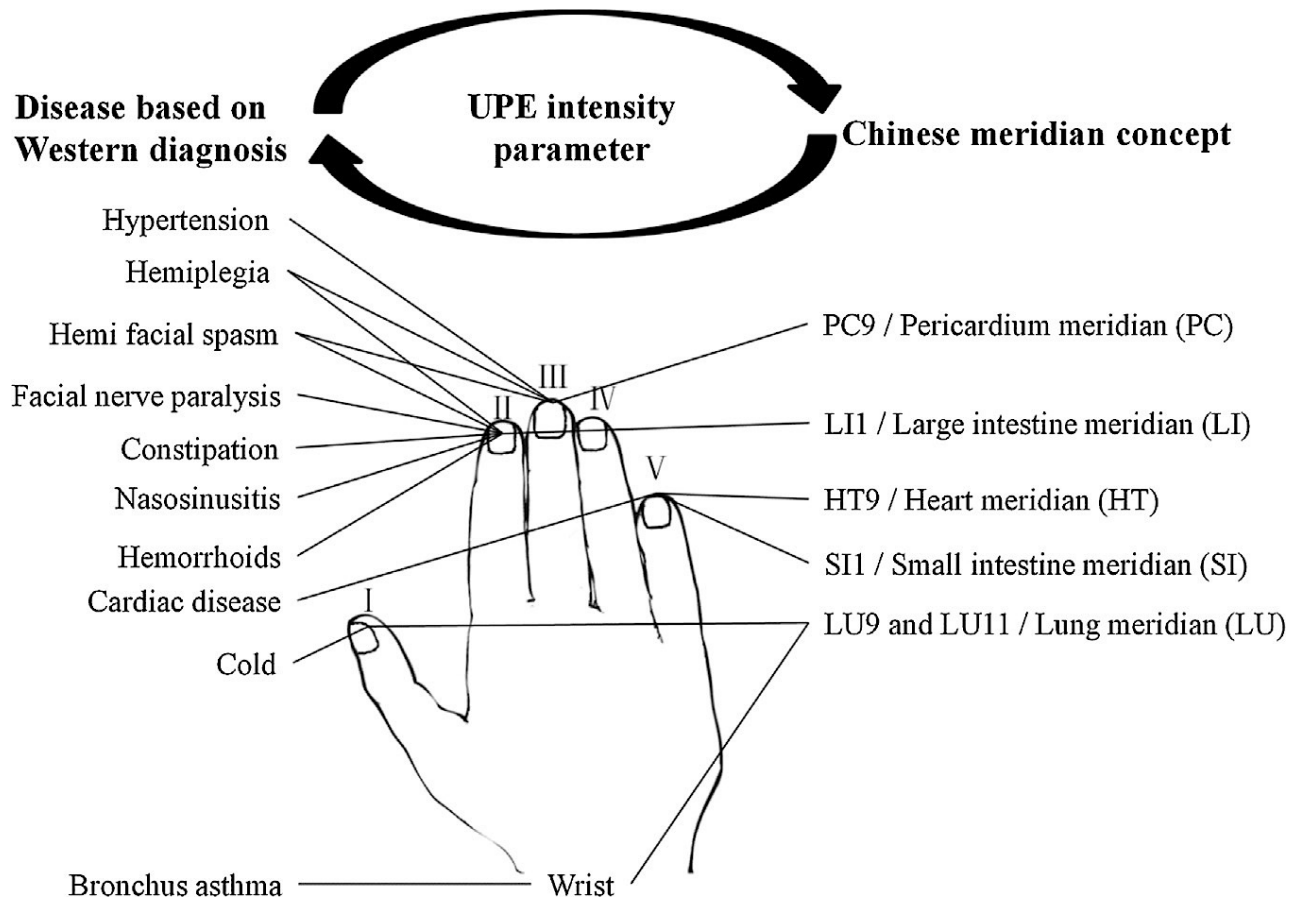


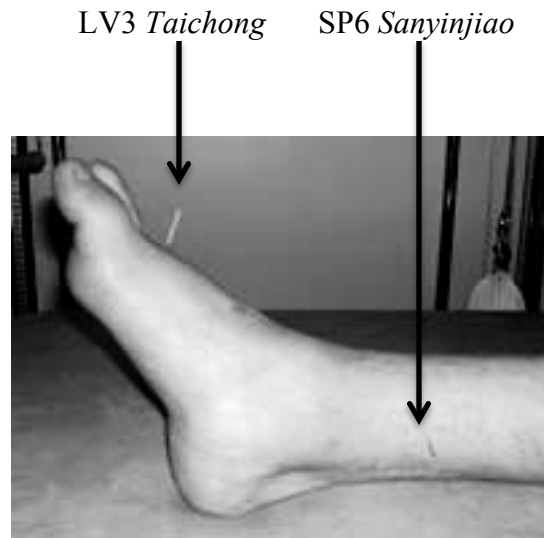
Figure 13. Western medicine disease descriptions corresponding to TCM acupuncture points and specific UPE intensity asymmetries.

- Finger I - LU11 *Shaoshang* acupoint on tip of thumb
- Finger II - LI11 *Shangyang* acupoint on tip of index finger
- Finger III - PC9 *Zhongchong* on tip of middle finger
- Finger V - SI1 *Shaoze* acupoint on radial side of tip of little finger
- Finger V - HT9 *Shaochong* acupoint on ulnar side of tip of little finger
- Wrist - LU9 *Taiyuan* acupoint on radial side of wrist

Figure 14. Needling of Intact Leg for Phantom Limb Pain⁵⁷



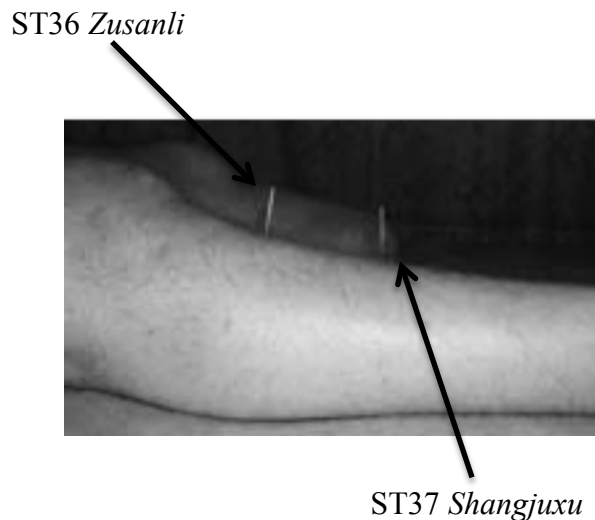
Left transtibial amputation stump due to congenital talipes



Needles placed in LV3 *Taichong* and SP6 *Sanyinjiao* in the right leg



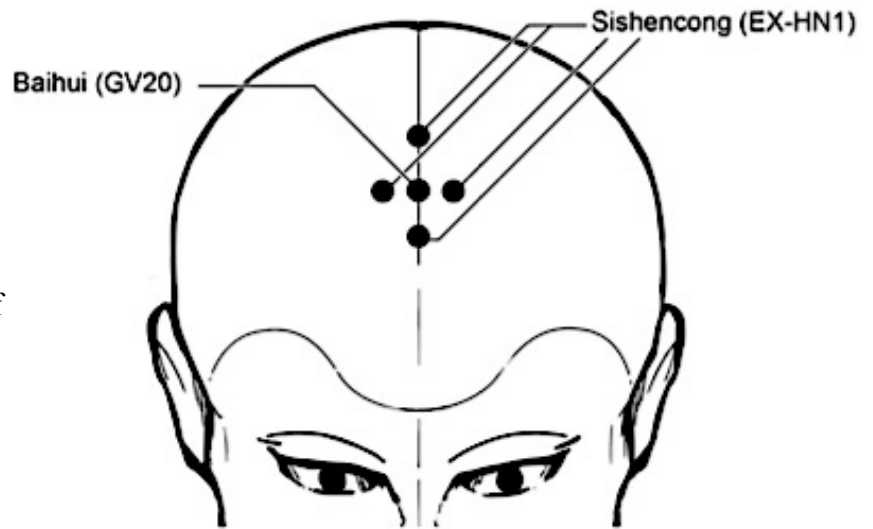
Needles placed in ST32 *Futu* in the right leg



Needles placed in ST36 *Zusanli* and ST37 *Shangjuxu* in the right leg

Figure 15. Scalp Acupuncture for Phantom Limb Pain⁶¹

Sishencong consists of the 4 scalp points surrounding Governing Vessel 20 *Bai Hui* on the vertex of the head.



MS7 is located on the lateral side of the head, parallel and posterior to MS6, extending from GV20 *Bai Hui* to GB7 *Qu Bin*. This line relates to the underlying sensory area of the brain.

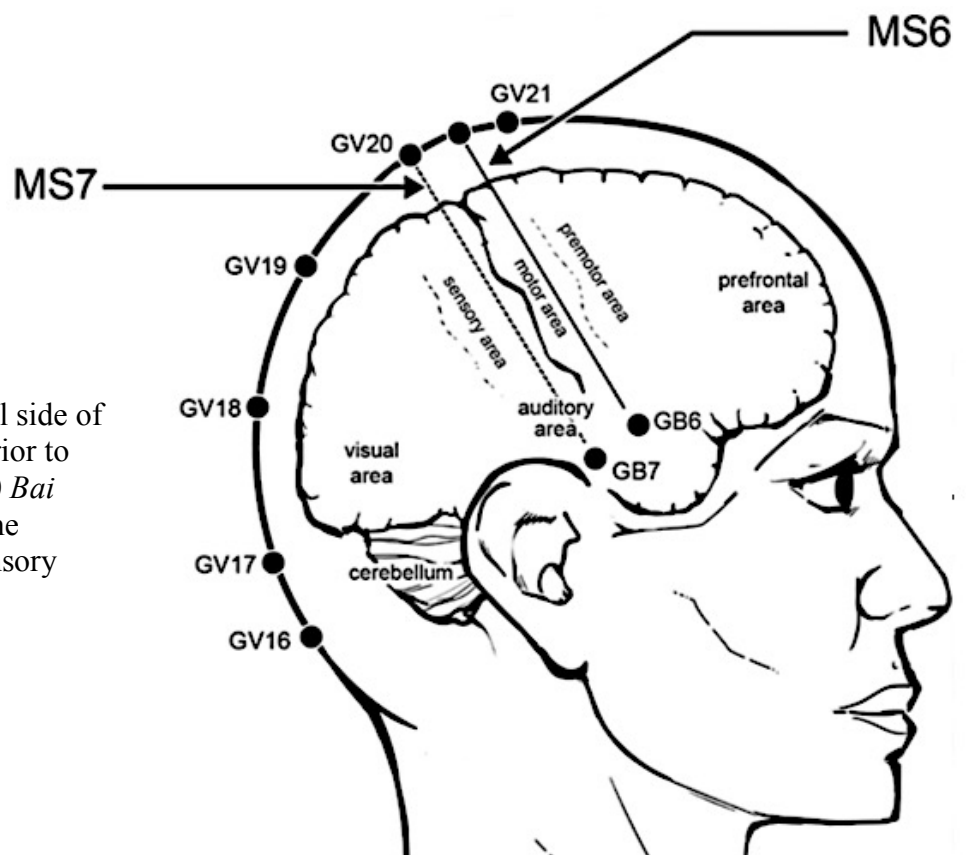


Figure 16. Proposed Mechanisms of Phantom Limb Pain

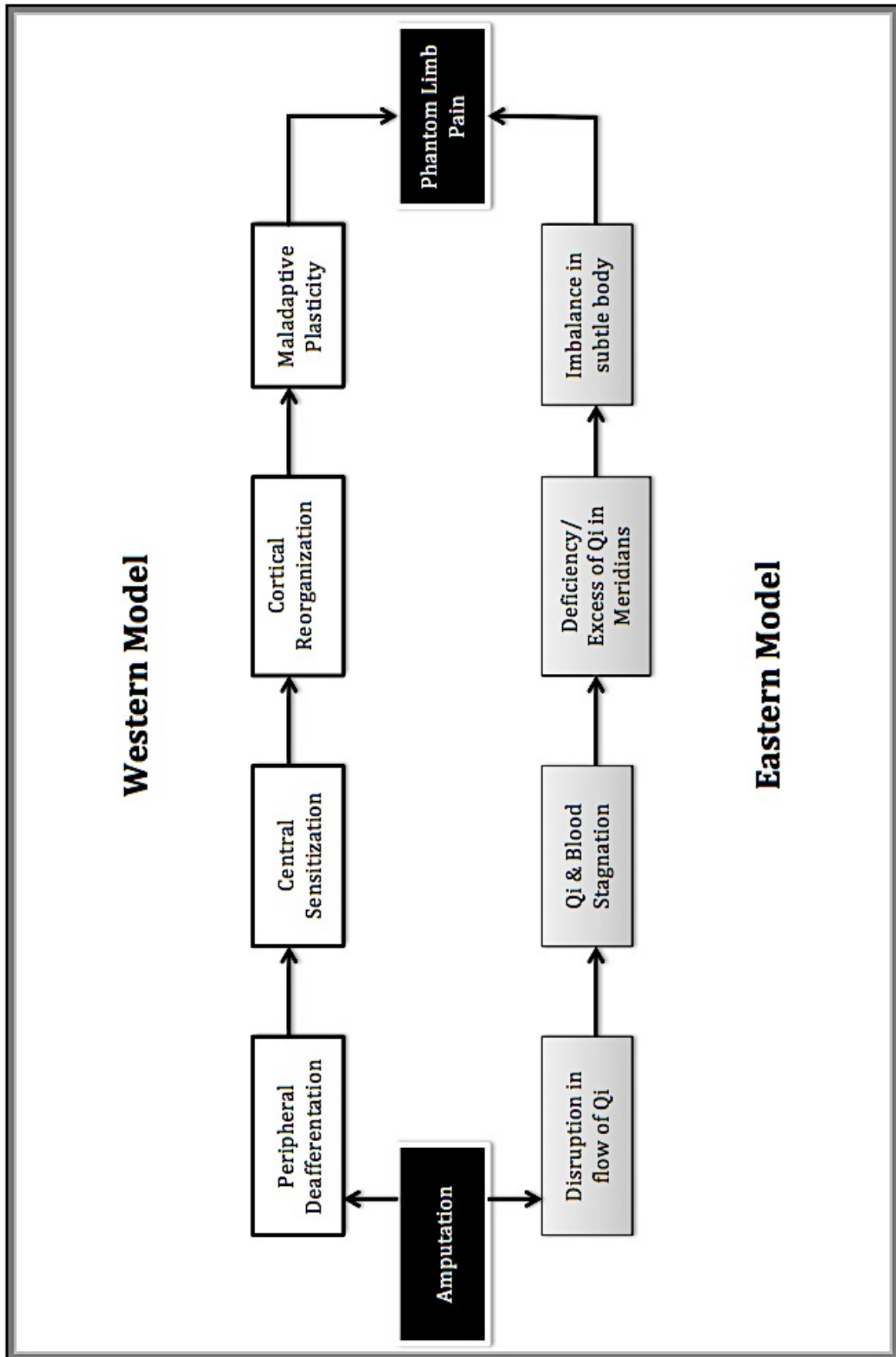


Figure 17. Acupuncture Treatment Mechanism of Phantom Limb Pain

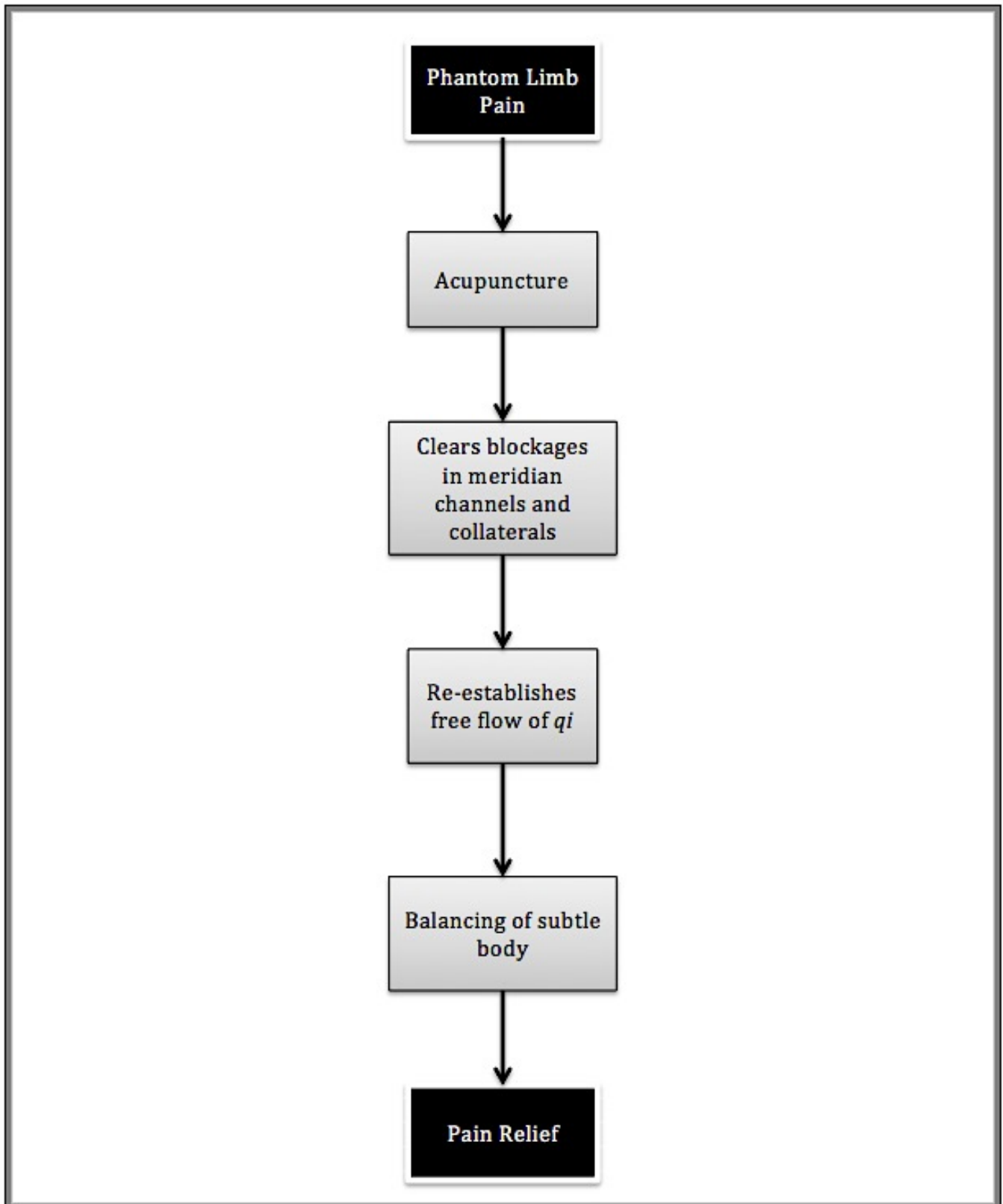


Table 18. List of Published Works in Reference to TCM Meridian and Acupuncture Point Theory

Title of Publication	Abstract	Ref. No.
Theory and Applications of the Harmonic Analysis of Arterial Pressure Pulse Waves	The meridian channels as conceived in TCM are various standing waves arising from harmonic rhythmic sound frequencies originating from the human heartbeat. The pressure pulse wave distributes blood throughout the body, and the resonance of organs with the heartbeat implies that each harmonic is tuned to an organ and its corresponding meridian.	39
BIOCERAMIC Resonance Effect on Meridian Channels: A Pilot Study	BIOCERAMIC is a kind of material which emits nonionizing radiation and luminescence, induced by visible light. BIOCERAMIC also facilitates the breakup of large clusters of water molecules by weakening hydrogen bonds, which allows water molecules to act in diverse ways under different conditions. A "Propagated Sensation along Meridians" (PSM) was experienced in all BIOCERAMIC Resonance patients, but not in any of the control patients. The BR device enhances microcirculation through a series of biomolecular and physiological processes and to subject the specific meridian channels of TCM to coherent vibration.	40
A Technology Developed from Concept of Acupuncture and Meridian System, the Clinical Effect of BIOCERAMIC Resonance on Psychological Related Sleep Disturbance with Findings on Questionnaire, EEG and fMRI	Patients with chronic sleep disorders were applied with BIOCERAMIC Resonance (BR) device on chest skin surface. Sleep quality improved in all patients, especially those with psychological reasons for insomnia. The result of fMRI found corresponding cerebral and cerebellar areas of activation and deactivation. BR can improve sleep disorder due to psychological causes, with transient alter brain wave activity and functional activation on specific locations of the brain.	41
Evaluation of Reflexology by "BIOCERAMIC Resonance" Operation producing Weak Force Field During Simultaneous Acupoint Stimulation of Urinary Bladder Point on Subject's Ear Resulting in Electric Current Change on Urinary Bladder Reflex Point on Subject's Hands, and Related New Research Finding	Electric Current Detection (ECD) compares changes before and after a BR session of areas correlative to organs and glands loci to reflex points according to standard reflexology of the ears, hands, and feet. Findings suggest the existence of presupposed virtual channels or reflex points on the skin surface of the feet, hands, and ears that connect or somehow reflect back to specific internal organs. In addition, kirlian photography depicted corona intensities from 5 zones indicating subjects affected by BIOCERAMIC patches. The operation of a BR device is able to produce weak force field throughout the body, which is objectively measurable and thereby scientifically integrating the concepts of reflexology, meridian channels, and biofield therapy.	42
A Chinese Literature Overview on Ultra-Weak Photon Emission as Promising Technology for Studying System-based Diagnostics	To present the possibilities pertaining to linking ultraweak photon emission (UPE) with Chinese medicine-based diagnostics principles, data were summarized from human clinical studies and animal models published from 1979 through 1998. UPE has clear potential in terms of understanding the systems view on health and disease as described using Chinese medicine-based diagnostics, particularly from a biochemistry-based regulatory perspective, and can bridge the gap with Western diagnostics.	44

(continued)

Magneto-Acupuncture Stimuli Effects on Ultraweak Photon Emission from Hands of Healthy Persons	Ultraweak photon emissions (UPE) were measured from the hands of 45 healthy persons before and after magneto acupuncture stimuli by using 2 photomultiplier tubes in the spectral range of UV and visible. The changes on the UPE rates of hand for the magnet group were detected conclusively in the quantities of the averages and standard deviations.	45
Characterizing Acupuncture Stimuli Using Brain Imaging with fMRI - A Systematic Review and Meta-analysis of the Literature	From a descriptive perspective, multiple studies reported that acupuncture modulates activity specific brain areas including somatosensory cortices, limbic system, basal ganglia, brain stem, and cerebellum. Brain response to acupuncture stimuli encompasses a broad network of regions consistent with not just somatosensory, but also affective and cognitive processing.	46
The Distribution of Transcutaneous CO2 Emission and Correlation with the Points Along the Pericardium Meridian	A highly sensitive CO2 instrument was used to measure transcutaneous CO2 emission at 13 points along the pericardium meridian line (12 points and 1 beyond the line) and 13 control points beside them. Results showed a strong correlativity of energy metabolism activity between the body surfaces along the meridian, and an even stronger correlativity between the acupoints on the meridian.	47
A Neuromagnetic Study of Acupuncture LI-4 (Hegu)	Brain magnetic fields evoked by needling LI4 Hegu were measured by using a SQUID (superconductive Quantum Interference Device) Biomagnetometer. The excitation of LI4 Hegu's projection area overlapped, and therefore could inhibit, the jaw's and face's projection area upon stimulation of the point which supports the therapeutic function of LI4 Hegu of easing dental pain.	16
Functional Magnetic Resonance Imaging of Real and Sham Acupuncture - Noninvasively Measuring Cortical Activation from Acupuncture	The results from this study demonstrate that fMRI can identify specific cortical regions associated with acupuncture stimulation reflecting significant blood-flow changes within the appropriate regions of the brain (visual and auditory cortices) in response to lower leg acupoint stimulation. Stimulation of a sham point, an actual acupuncture point having nothing to do with audition or vision, resulted in no activation changes in the previously defined anatomical regions.	48
Comparative Study of the specificities of Needling Acupoints DU20, DU26, and HT7 in Intervening Vascular Dementia in Different Areas in the Brain on the Basis of Scale Assessment and Cerebral Functional Imaging	Needling on conventional acupoints (DU26 <i>Renzhong</i> and HT7 <i>Shenmen</i>) plus DU20 <i>Baihui</i> could effect the inner temporal system, thalamencephalon system, and prefrontal cortical system to improve memory and executive capacity of VD patients. Acupoints simultaneously could effect rather roundly multiple aspects of the nervous system related to intellectual activities, to elevate recognition, and to enhance the executive capacity.	50
The Salient Characteristics of the Central Effects of Acupuncture Needling: Limbic-paralimbic-neocortical Network Modulation	Acupuncture produced extensive deactivation of the limbic-paralimbic-neocortical network (LPNN). Acupuncture may mediate its anti-pain, anti-anxiety, and other therapeutic effects via this intrinsic neural circuit that plays a central role in the affective and cognitive dimensions of pain as well as in the regulation and integration of emotion, memory processing, autonomic, endocrine, immunological, and sensorimotor functions.	52

(continued)

Acupuncture Mobilizes the Brain's Default Mode Network and its Anti-correlated Network in Healthy Subjects	Acupuncture during 201 scans and tactile stimulation during 74 scans for comparison at acupoints LI4, ST36, and LV3 was monitored with fMRI and psychophysical response in 48 healthy subjects. Clusters of deactivated regions (LPNN) showed virtual identity with the DMN and the anti-correlated task positive network in response to acupuncture stimulation. The amygdala and hypothalamus, structures not routinely reported in the DM literature, were frequently involved in acupuncture. When acupuncture induced a sharp pain, the deactivation was attenuated, or became activated instead. Tactile stimulation induced greater activation of the somatosensory regions but less extensive deactivation of the LPNN. These results indicate that the deactivation of the LPNN during acupuncture cannot be completely explained by the demand of attention that is commonly proposed in the DM literature. Acupuncture mobilizes the anti-correlated functional networks of the brain to mediate its actions, and that the effect is dependent on the psychophysical response.	53
Brain Encoding of Acupuncture Sensation--Coupling On-line Rating with fMRI	Brain encoding of acupuncture sensation (more persistent and varied, leading to increased cognitive load) demonstrated greater activity in both cognitive/evaluative (posterior dmPFC) and emotional/interoceptive (anterior dmPFC) cortical regions. Hence, acupuncture may function as a somatosensory-guided mind-body therapy.	54
Acupuncture-induced Changes in Functional Connectivity of the Primary Somatosensory Cortex with Pathological Stages of Bell's Palsy	fMRI was used to investigate the effect of acupuncture on the functional connectivity of the brain in BP patients and healthy controls. Results showed acupuncture induced significant connectivity changes in the primary somatosensory region of both early and late recovery groups, but no changes in the healthy group or recovered group.	55
Structural Changes Induced by Acupuncture in the Recovering Brain after Ischemic Stroke	Acupuncture evoked structural reorganization in the grey matter tissue (frontal areas and the network of DMN areas) in Ischemic stroke patients, which may be the potential therapy target and the potential mechanism where acupuncture improved the motor and cognition recovery.	56
Chinese Scalp Acupuncture Relieves Pain and Restores Function in Complex Regional Pain Syndrome	CSA was used on CRPS upper extremity patients and resulted in improvement in the pain VAS or NRS up to 100%, sensory changes decreased, and improved function were observed. Results maintained in between treatments and sustained at 20 month follow up.	60
Additional Effects of Acupuncture on Early Comprehensive Rehabilitation in Patients with Mild to Moderate Acute Ischemic Stroke: A Multicenter Randomized Controlled Trial	Post-stroke sequela patients randomized into 2 groups, acupuncture and no acupuncture. 18 treatments over 3 week period. Acupuncture has effects of improvements in neurological deficits, swallowing disorder, cognitive impairment, and lower extremity function, but had no significant improvement for upper extremity function during this short-term study.	62
Cortical Reorganization in Patients Recovered from Bell's Palsy: An Orofacial and Finger Movements Task-State fMRI Study	There were significant differences of brain functional status between recovered BP patients and healthy controls during fMRIs of lip pursing and finger movements that showed cortical reorganization in BP patients after acupuncture treatment.	63

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An Alternative Method to
Enhance Vagal Activities and
Suppress Sympathetic Activities
in Humans

Manual acupuncture on the Sishencong points enhanced cardiac vagal activity and suppressed sympathetic regulations of the heart in humans when compared to control group using ECG and frequency-domain analysis. Needles were inserted 2mm deep into skin at Sishencong points located on the vertex of the head, 1 cm from *GV20 Baihui*

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