CONTINUING EDUCATION
for Physical Therapists

THE SCIENCE OF REHABILITATIVE TAI CHI

4 CE HOURS

Course Abstract

Tai Chi is increasingly being touted as a rehabilitation technique – but do you understand, and are you able to explain to your clients, why it works? This evidence-based course provides insight into the scientific principles that support the use of rehabilitative Tai Chi, with attention to the practical application of each.

NOTE: Links provided within the course material are for informational purposes only. No endorsement of processes or products is intended or implied.

Approvals

To view the states that approve and accept our courses, CLICK HERE.

Target Audience & Prerequisites

PT, PTA, OT, OTA – no prerequisites

Learning Objectives

By the end of this course, learners will:

- ❑ Recall introductory concepts pertaining to rehabilitative Tai Chi
- ❑ Recognize elements of evidence supporting BodyMind connections and applications
- ❑ Identify the 6 body focus principles of rehabilitative Tai Chi, and the experiential exercises that pertain to each
- ❑ Identify breath fundamentals of rehabilitative Tai Chi
- ❑ Recall the application of vision and visualization to rehabilitative Tai Chi
- ❑ Recognize elements of evidence linking Tai Chi and painless rehabilitation

Timed Topic Outline

I. Introduction (40 minutes)
Tai Chi Philosophy, Tai Chi Physiology, Tai Chi in Rehabilitation Research, Rehabilitative Tai Chi Principles

II. BodyMind Foundations (60 minutes)
Bio-Energy Basics, BodyMind Connections & Applications

III. Body Focus Principles (60 minutes)
Posture, Efficient Breathing, Active Relaxation, Slow/Rounded/ Fluid Movement, Dantien Focus, Silk Reeling

IV. Breath Fundamentals
Anatomy & Physiology of Breath, Natural Breathing Methods, Abdominal Breathing Effects

V. Vision and Visualization (40 minutes IV + V)
Functional Vision, Visualization and Mental Imagery

VI. Painless Rehabilitation and Movement (20 minutes)
Pain Physiology, Autonomic Influence, Cross Mapping

VII. References and Exam (20 minutes)

Delivery Method

Correspondence/internet self-study with a provider-graded multiple choice final exam. *To earn continuing education credit for this course, you must achieve a passing score of 80% on the final exam.*

Cancellation

In the unlikely event that a self-study course is temporarily unavailable, already-enrolled participants will be notified by email. A notification will also be posted on the relevant pages of our website.

Customers who cancel orders within five business days of the order date receive a full refund. Cancellations can be made by phone at (888) 564-9098 or email at support@pdhacademy.com.

Accessibility and/or Special Needs Concerns?

Contact customer service by phone at (888) 564-9098 or email at support@pdhacademy.com.

Course Author Bio and Disclosure

Brian Trzaskos, PT, LMT, CSCS, CMP, MI-C, is a bodymind rehabilitation specialist who believes education is powerful medicine that allows people to access their own highest healing potentials. He is the founder and director of the Institute for Rehabilitative Qigong & Tai Chi, which specializes in teaching rehabilitation professionals how to practically integrate western bodymind rehabilitation science and the ancient healing arts of Qigong & Tai Chi.

As a practicing physical therapist and student of eastern movement and meditation practices for over two decades, Brian holds certifications in both Western and Eastern healing arts truly bringing together the best of both worlds in modern rehabilitative care. In addition to his private practice, he is a teacher, author, international health consultant, and thought leader in holistic rehabilitation. A graduate from the State University of New York at Buffalo, Brian and his family now live in the beautiful Lake Champlain Valley of upstate NY.

DISCLOSURES: Financial – Brian Trzaskos received a stipend as the author of this course. Nonfinancial – No relevant nonfinancial relationship exists.

SECTION ONE: Rehabilitative Tai Chi Introduction

Martial art, gentle exercise, and ancient philosophy, Tai Chi has slowly been finding its way into western culture and health related practices over the past fifty years. Long veiled in cultural mysticism, Tai Chi has received credit anecdotally for promoting uncommon longevity and enlightened wisdom. While these claims have drawn many seekers to practice Tai Chi, in the western world-view they have also tended to marginalize Tai Chi as a primarily esoteric practice with unsubstantiated physical benefits. Now, with the advancement of neuroendocrine, bio-energy, and neuromuscular research a new understanding of Tai Chi practice is emerging.

The contemporary western-minded rehabilitation system demands scientific validation of therapeutic techniques for both referral and funding sources. In the realm of western medicine, through the support of consistently positive research findings, Tai Chi is gaining greater acceptance as an effective therapeutic modality especially in the areas of balance enhancement, falls prevention, pain management, cardiovascular health, psychological wellness, and chronic illness amelioration. Stretching from balance enhancement to psycho-emotional wellness, perhaps no other single therapeutic practice has been studied more broadly than Tai Chi, and in the process a reservoir of research related to a true therapeutic bodymind modality has been amassed.

Considering the excessive amount of stress experienced by both professional caregivers and patients in the contemporary western medical system, the growing acceptance and validation of Tai Chi practice is both timely and necessary. This course has been specifically designed to explore human physiology and review modern research as it relates to the practice of Tai Chi for physical rehabilitation, with the goal of supporting Tai Chi as a scientifically validated therapeutic modality.

Tai Chi Philosophy

Far from a simple exercise program done by elderly people in parks, Tai Chi is an ancient philosophy describing how the universe operates. A closer examination of what most westerners call the Yin-Yang symbol reveals these two elemental forces of dark and light are in perfect balance. This symbol is actually called Tai Chi, which can be translated as "Supreme Ultimate Balance or Harmony".

The ancient philosophy of Tai Chi teaches us that despite appearances the universe is always naturally in balance. Through early behavioral conditioning and life experiences people tend to develop strong preferences for external conditions. Do some things make you happy and other things create agitation? If so, you have just revealed preferences for how you think the world "should" be. As people we often make certain things "right" and other things "wrong", some things "good" and other things "bad", we go through our lives avoiding pain and seeking pleasure. In reality there is never one condition that will either please or upset everyone. Two people could be watching the exact same event while one shrieks with pleasure and the other moans in pain. Have you ever watched a sporting event with people who were fans of opposing teams? As the game shifts back and forth so do their emotions in direct opposition to one another even though the objective situations of the game are the same for both? Tai Chi philosophy reminds us that it is how we perceive the world that causes us pain, not the world itself and that the more preferences we hold, the more likely we are to suffer both physically and emotionally.

Yin & Yang

According to Tai Chi philosophy, the material construct of the universe is born from the opposing elemental forces of Yin and Yang. These forces are archetypical and permeate all of our waking life. In material reality these forces not only oppose one another but are also mutually dependent and exist together at opposite ends of the same spectrum. We can only recognize "up" if we know "down" and "hot" if we know "cold". Simple comparisons of Yin and Yang elements are indicated in the chart below.

Yang	Yin
Male	Female
White	Black
Hot	Cold
Day	Night
Action	Rest
Up	Down
Out	In
Right	Left
Hard	Soft
Sky	Earth
Summer	Winter

Through this philosophy we may come to understand that even things that seem opposite are connected and that by eliminating what we dislike, we also destroy what we do like. Harmony is only found when we balance these opposite poles in dynamic co-existence.

Tai Chi Practice

Depending on historical reference, the physical practice of Tai Chi was developed in China, as a martial art, between 350-700 years ago. Tai Chi is considered a "soft" martial art where emphasis is placed on yielding and resiliency, so that an attacker's energy is redirected and used in turn to unbalance him. Effective Tai Chi practitioners are known to be soft yet powerful, light yet grounded, and relaxed yet firm; in a word they are physically, emotionally, and psychologically adaptable to all situations and circumstances. Balancing and applying these paradoxes of hardness and softness are inherent to both Tai Chi philosophy and practice.

The regular practice of Tai Chi has proven to be beneficial for multiple physical disorders such as high blood pressure, muscle weakness, poor flexibility, pain, and balance problems as well as depression, anxiety, mood disorders, sleep quality, and memory loss. How does moving slowly in certain patterns improve both physical and psychological disturbances? In accordance with Tai Chi principles, the practitioner "embodies" the universal philosophy of Tai Chi harmony, moving in perfectly balanced dynamic opposition; connecting body and mind into a seamless singularity. Through consistent Tai Chi practice students often remark that they not only feel better physically but also that old emotional triggers simply don't bother them anymore and they have come to see these things simply as they are, neither good nor bad. It seems that as we practice to embody physical balance our mind also becomes balanced, this is true bodymind medicine.

Qigong – The Mother of Tai Chi

Any reasonable discussion of Tai Chi would be incomplete without mentioning Qigong.

Qigong is the ancient bodymind practice that underpins all of traditional Chinese medicine and culture. It is a sister science to Ayruvadic Yoga/ Pranayama, tracing its roots back 5,000 years to shamanistic traditions in northern Asia. The word "Qi" can be translated simply as "breath", but is also the word used for "life force energy" by ancient Chinese culture. Qi is the energy that holds planets in orbit, makes trees grow, energizes the human body, causes us to fall in love, and for babies to be born; in short Qi is the animating force of the universe. It is interesting that it is also the word for breath, as the one discriminating factor between someone who is animated or unanimated, alive or dead is the presence of the breath. The practice of Qigong teaches us that breathing is the key to enhancing this life force energy or vitality in our own bodymind. The word "gong" can be translated as "work", "practice", or "cultivation". Thusly, Qigong is a practice in which the breath is used in certain ways to achieve certain goals or have certain experiences that enhance life. Qigong has been utilized through the centuries in ritualistic traditions and healing practices. The practice of Qigong can be considered to have four primary components or "baskets", which include movement, meditation, breathing, and massage.

Tai Chi employs all of the primary Qigong principles including posture, breath, movement, and mental focus specifically in the application of self-defense and thus may be considered a form of Qigong. In current health related research, Qigong and Tai Chi are often considered synonymous in both form and function (16).

Rehabilitative Tai Chi, holding true to Qigong principles, adapts and applies Tai Chi for the specific purpose of physical rehabilitation; of course true rehabilitation is never only physical. Physical healing at its most fundamental level must always correlate with positive emotional and psychological changes as well and as such, modalities that address this triad of holistic health are becoming more accepted in western medical systems.

Tai Chi Physiology

Our physical bodies are material aspects of the universe just like the planets, animals, trees, and oceans; and because of this are governed by the same elemental forces of Yin-Yang. When our body processes are in Tai Chi or homeostasis all physiologic functions are harmonious. In Traditional Chinese Medicine there are only two primary causes for every disease; Yin deficiency and Yang excess or Yin excess and Yang deficiency. Every organ system in the body has opposing chemical influences such as insulin and glucagon, aldosterone and atrial natriuretic peptide, and norepinephrine and acetylcholine. The health and function of all organ systems are determined by the inherent balance of these mutually dependent chemicals, and when out of balance will cause the metabolic processes of the system to either speed up (yang) or slow down (yin).

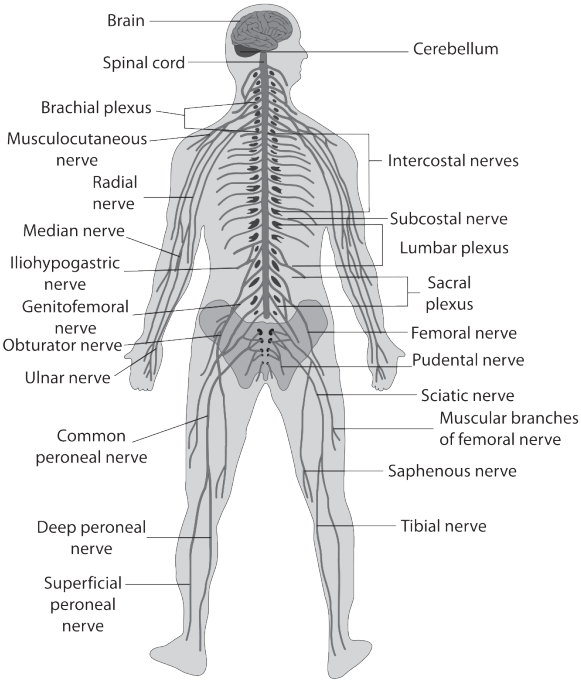
One example of Yin-Yang function in the human body can explained through muscle function. Both contraction (yang) and relaxation (yin) phases are necessary for normal muscle function. If the physiology were tilted toward Yang dominance then excessive muscle tone, spasm, and pain results; while Yin dominance would engender muscular hypo-tonus, weakness, and instability such as in Guillain–Barré syndrome. In order for someone to function most efficiently during activities like walking, lifting, and climbing an active Yin-Yang muscle balance is required.

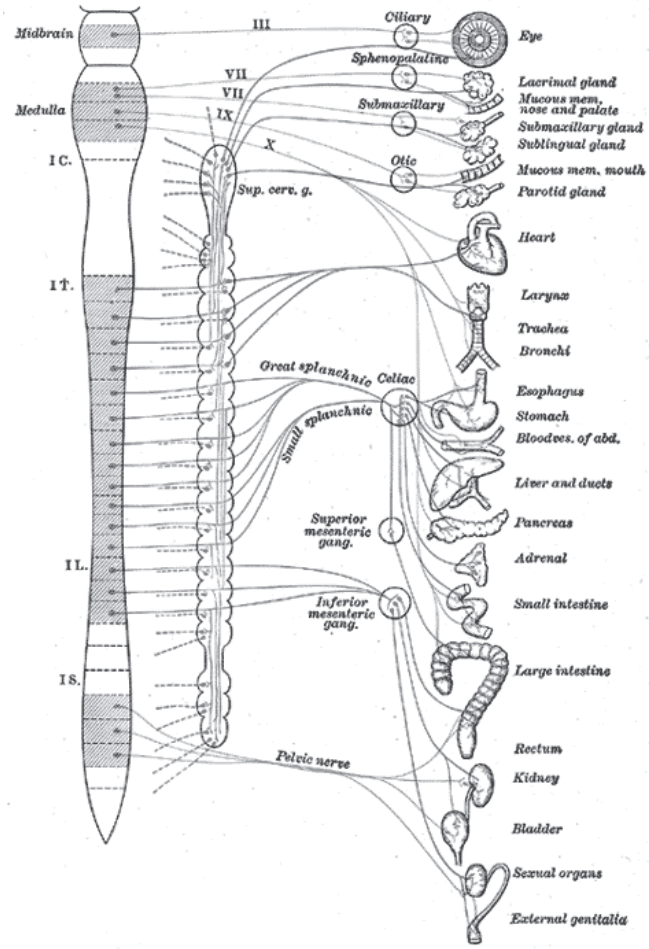
A Tale of Two Nervous Systems

Every function in our body is regulated or modified in some way though nervous system activity. The nervous system can be broadly divided into two halves, somatic and autonomic with generalized components below:

Somatic	Autonomic
Sensory-Motor Cortex	Sympathetic
Spinal Cord	Parasympathetic
Nerves	Glands
Electrical	Hormonal
Volitional	Perceptual

The somatic nervous system components include among other things portions of the brain, spinal cord, and peripheral nerves including both sensory and motor branches. The somatic nervous system is primarily electrical in nature with nerve conductions occurring in "all or none" fashion through the action of sodium and potassium. In general, normal somatic nervous system activity is volitional in nature, in other words it can be commanded to perform certain tasks. If you look at your hand, intend to make a fist and follow by doing so, you have just exercised volitional control of the somatic nervous system. Certainly many actions of the somatic nervous system are reflexive as well, however large areas of the parietal lobes, the sensory-motor region in the cerebral cortex, are dedicated to the refinement of purposeful movement.





The autonomic nervous system complements somatic nervous system function and can be studied as sympathetic, parasympathetic, and enteric divisions. (For the purpose of this work, the sympathetic and parasympathetic divisions will be dealt with most specifically.)

Perhaps the most appropriate single physiologic correlation to the Yin-Yang paradigm is the autonomic nervous system. The autonomic nervous system's sympathetic and parasympathetic branches regulate all physiologic processes, regulating metabolism in multiple organ systems simultaneously. Autonomic nervous system function and its relationship to physiologic balance will be explored further in upcoming sections. The chart below includes examples of Yin-Yang physiological processes.

Yang	Yin
Sympathetic	Parasympathetic
Systolic	Diastolic
Contraction	Relaxation
Red Blood Cells	White Blood Cells
Intellectual	Intuitive
Catabolic	Anabolic

While the autonomic nervous system does include nerve fibers, its primary target action is glandular, altering hormonal influences that activate or depress physiologic processes at multiple organ systems. In contrast to the somatic nervous system, which is primarily volitional, the autonomic nervous system shifts with our perceptions. It is worth noting that like the somatic nervous system the autonomic nervous system can be conditioned to respond in specific ways through either conscious or unconscious training.

Sympathetic Division

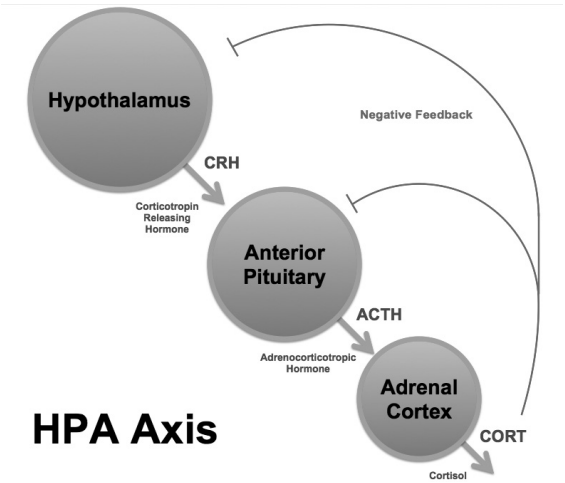
The sympathetic division activates the physiology with adrenaline, norepinephrine, and cortisol and when expressed in excess is commonly considered the "fight or flight" state. Historically the "fight or flight" response is a strong survival mechanism helping to ensure our ancient ancestors triumph over or escape from dangerous predators; in which case the event was usually brief and physically expensive. The sympathetic response is adaptive in nature and includes a cascade of consistently reproducible physiological responses listed below:

- Increased muscle tone
- Heightened reflexes
- Rapid, shallow breathing
- Increased heart rate
- Increased blood pressure
- Blood shunted to periphery
- Increased blood clotting
- Heightened sensory perception
- Cortisols break down muscles for fuel
- Blood sugar rises
- Slowed digestion
- Immune system suppression
- Slowed neurogenesis
- Decreased cortical function

The HPA Axis

The hypothalamic–pituitary–adrenal axis is a complex physiological feedback system responsible for governing the sympathetic nervous system response. When an environmental or internal (ie, pain, illness, disturbing thoughts) stressor is perceived the basic sequence of HPA axis function includes:

1. The hypothalamus releases Corticotropin Releasing Hormone (CRH) to be taken up in the anterior pituitary gland.
2. The anterior pituitary gland releases Adrenocorticotropic Hormone (ACTH) which is supplied to the adrenal cortex.
3. The adrenal cortex releases cortisol, which in a negative feedback loop ideally acts to inhibit further CRH and ACTH production. In cases of chronic stress, this negative feedback loop is disrupted and high cortisol levels cause cell death specifically in the hippocampus.



Under normal circumstances the sympathetic nervous system response occurs in direct proportion to a perceived threat. In other words, if you are walking through the woods and a grizzly bear jumps out, BIG threat response, if a porcupine crawls out, little threat response. The sympathetic nervous system response is important in responding to both external and internal demands and is necessary for our survival, as exemplified in Addison's Disease or primary adrenal insufficiency. Studies with juvenile mice show that a lack of stressful stimulation during early development leads mental retardation (7).

As noted above, the autonomic nervous system can be conditioned and in the case of the chronic sympathetic nervous system response most commonly this results as hyper vigilance. For example, image that you had indeed been hiking one day and narrowly escaped being mauled by a grizzly bear. Would you agree that the next time you were hiking even a twig snap might put you on edge? Even that porcupine would make you run for it? In fact, your sympathetic nervous system began heating up even before you entered the woods, simply anticipating the possibility of another encounter. Now, if this threat actually reoccurred routinely, the sympathetic nervous system response would remain elevated and adaptive responses would grow out of proportion.

General Adaptation Syndrome

In 1936 Hans Seyle outlined key physiological processes associated with the stress response which he coined the General Adaptation Syndrome (6).

> Stage 1: Alarm Stage (aka Fight or Flight): where the person perceives a significant environmental or internal threat, resulting in the HPA axis response as described above.
>
> Stage 2: Resistance (aka Adaptation): where the physiologic cascade described above aids the person in successfully dealing with the threat or stressor. During this stage the physiology remains on guard for subsequent threats and if repeated stressors occur a new, higher baseline of physiologic activity is conditioned.
>
> Stage 3: Exhaustion: where the heightened physiologic responses can no longer be maintained. This stage is characterized by symptoms of chronic illness including but not limited to essential hypertension, high cholesterol, diabetes, irritable bowel syndrome, chronic muscle and joint pain, autoimmune disorders, memory loss, anxiety, and depression.

In today's developed world, actual life or death situations are rare and we in turn experience low level, yet persistent chronic stressors on the order of nine to twelve episodes per day (12). How many times a day do we think about work, paying bills, our health, difficult relationships, or the condition of our homes and possessions? Each time we perceive a challenge our body responds with small doses of adrenaline and cortisol creating a catabolic cascade at the cellular level, which in turn elevates the baseline physiologic response. Clinically, chronic and persistent stress has been shown to dramatically slow tissue healing rates.

Psychological Stress and Wound Healing

In a study performed with hostile marital interactions as the stressor, it was shown that when 8-millimeter blister wounds were given to both hostile and supportive couples, the hostile couples healed at 60% the rate of supportive couples. This research indicated that the important inflammation response, during stressful experiences, was initially slowed following injury, causing a delay in healing. In addition, and maybe even more importantly, it has also been shown that pro inflammatory chemicals increase above normal thresholds throughout the body during prolonged periods of both physical and psychological stress; potentially causing cardiovascular disease, osteoporosis, arthritis, diabetes, certain cancers, frailty and functional decline (9,10).

Another study compared wound-healing times of Alzheimer patient caregivers and a control group. The two groups were matched for age and family income. A small 3.5-millimeter puncture wound was created and healing times monitored. The caregiver group took on average twenty four percent longer to heal than the control group (10). If it takes twenty four percent longer to heal a small puncture wound when someone is experiencing stress then imagine extrapolating this recovery time to a large wound like a total joint replacement, cardiac event, or neurological trauma, where an estimated six month healing process now requires eight months or longer.

Observational studies of how psychological factors effect healing have revealed that clients experiencing significant depression and anxiety have longer hospital stays, more postoperative complications, higher rates of rehospitalization, more infections, and delayed wound healing when compared to individuals who reported less distress (10).

Increasing blood lactate levels is another result of sympathetic nervous system activation. Studies have shown that individuals exposed to stressful situations have higher blood lactate levels, and interestingly normal subjects injected with similar levels of blood lactate have been shown to experience severe anxiety. Apparently elevated levels of blood lactate can have an effect of actually producing and perpetuating anxiety (7). So in reality this whole problem becomes a cycle, with more stress causing higher blood lactate, and higher blood lactate correlating to further anxiety and more stress.

Parasympathetic Division

Rest, digest, and recovery are words commonly used to describe the parasympathetic division of the autonomic nervous system. Oxytocin, vasopressin, endorphins, and natural opioids accompany a "parasympathetic shift" or what Herbert Benson coined the "Relaxation Response". During parasympathetic dominance the immune and digestive systems function most efficiently, the cardiovascular system relaxes allowing oxygen perfusion throughout the body, and the nervous system shifts activity to higher brain centers engendering elevated states of consciousness (1,7). Typical physiologic responses associated with the parasympathetic nervous system are listed below:

- Muscle tension decreases
- Blood pressure lowers
- Heart rate slows
- Breathing slows/deepens
- Alpha brain wave states occur
- Circulation to internal organs
- Digestion improves
- Immune function optimizes
- Neurogenesis occurs
- Enhanced cortical functioning

Feelings of being supported, inspired, relaxed, creative, and hopeful are emotional states associated with the Relaxation Response or parasympathetic nervous system shift. Interventional studies focused on improving healing rates by reducing psychological stress have been associated with improved post-operative outcomes, fewer medical complications, shorter hospital stays, and faster rates of cellular repair (10). Some of these interventions included meditation, Qigong, Tai Chi, emotional disclosure, and social support.

A nine-year long randomized study following heart disease patients who practiced daily meditation showed a decrease in risks of death, strokes, and heart attacks by 47% as compared to age matched controls (18). Jon Kabat-Zinn's renowned mindfulness based stress reduction program has shown consistent improvements with primary pain indexes, negative body image, mood ratings, and psychological distress measures in people suffering from chronic pain (19).

In wound healing research, higher plasma levels of oxytocin and vasopressin have been associated with faster healing of standard blister wounds (10). In a study with Siberian hamsters, researchers randomized subjects into groups including hamsters housed alone, with strangers, restrained, or with siblings. Healing rates for those hamsters housed with siblings exceeded rates in the other groups. In follow up studies, when hamsters housed with siblings were injected with an oxytocin receptor antagonist the beneficial impact of paired housing on wound healing was eliminated, indicating that oxytocin may have a direct role in cellular repair (10).

In light of better understanding of the autonomic nervous system and considering the chronic pace and demands of modern life it comes as no surprise that experts suggest up to 90% of all medical visits are directly related to excessive psychological stress. Recall that stress is adaptive and important for healthy neurological function, however when in excess physiology is unable to adapt to the chronic demands. Additionally, research in psychological and social sciences reveal that there may be an optimal ratio of sympathetic to parasympathetic states with regards to facilitating a balanced physiology and healthy personal relationships. Studies in sustainable, desired change indicate that on average, a ratio of 3:1, parasympathetic to sympathetic episodes respectively is required for optimal health; in long-term successful marital relationships the ratio 5:1 (12). Just to be clear, for optimal health and relationships a greater ratio of hopefulness to stress is required.

An important correlation supporting Rehabilitative Tai Chi is the fact that positive psychological and emotional markers like hopefulness, support, and relaxation are associated with both increased rates of cellular healing and consistently reported experiences during Qigong and Tai Chi practice. On a very

fundamental level, cellular healing is only possible when the body is in a parasympathetic state, and even an expert rehabilitation therapist's technical skills are practically rendered useless when the client is in sympathetic dominance. It becomes paramount then that for truly superior treatment outcomes technical proficiency must be married to an environment, both internally and externally, which is actually conducive to healing.

Tai Chi in Rehabilitation Research

A PubMed/National Library of Medicine search with key work "tai chi" in April 2016 resulted in 4,541 study titles returned, including 255 RCT's, 204 systemic reviews, 51 meta-analysis, and 3 practice guidelines. For all conditions reviewed, the majority of studies (94.1%) reported positive effects with no reports of serious adverse events (17). A selection of comprehensive reviews has been chosen for specific citation and further discussion below.

A Comprehensive Review of Health Benefits of Qigong and Tai Chi (16) (Janhke, Larkey, Rogers, Etnier, Lin) American Journal of Health Promotion 2010

Abstract Objectives:

Research examining psychological and physiological benefits of Qigong and Tai Chi is growing rapidly. The many practices described as Qigong or Tai Chi have similar theoretical roots, proposed mechanisms of action and expected benefits. Research trials and reviews, however, treat them as separate targets of examination. This review examines the evidence for achieving outcomes from randomized controlled trials (RCTs) of both.

Results:

Seventy-seven articles met the inclusion criteria. The 9 outcome category groupings that emerged were: bone density (n=4), cardiopulmonary effects (n=19), physical function (n=16), falls and related risk factors (n=23), Quality of Life (n=17), self-efficacy (n=8), patient reported outcomes (n=13), psychological symptoms (n=27), and immune function (n=6).

Conclusion:

A compelling body of research emerges when Tai Chi studies and the growing body of Qigong studies are combined. The evidence suggests that a wide range of health benefits accrue in response to these meditative movement forms, some consistently so, and some with limitations in the findings thus far. This review has identified numerous outcomes with varying levels of evidence for the efficacy for Qigong and Tai Chi, including bone health, cardiopulmonary fitness and related biomarkers, physical function, falls prevention and balance, general quality of life and patient reported outcomes, immunity, and psychological factors such as anxiety, depression and self-efficacy. A substantial number RCTs have demonstrated consistent, positive results especially when the studies are designed with limited activity for controls. When both Tai Chi and Qigong are investigated together, as two approaches to a single category of practice, meditative movement, the magnitude of the body of research is quite impressive.

Tai Chi Chuan in Medicine and Health Promotion (11) (Lan, Chen, Lai, Wong) Evidence-Based Complementary and Alternative Medicine 2013

Abstract:

Tai Chi Chuan (Tai Chi) is a Chinese traditional mind-body exercise and recently, it becomes popular worldwide. During the practice of Tai Chi, deep diaphragmatic breathing is integrated into body motions to achieve a harmonious balance between body and mind and to facilitate the flow of internal energy (Qi). Participants can choose to perform a complete set of Tai Chi or selected movements according to their needs. Previous research substantiates that Tai Chi has significant benefits to health promotion, and regularly practicing Tai Chi improves aerobic capacity, muscular strength, balance, health-related quality of life, and psychological well-being. Recent studies also prove that Tai Chi is safe and effective for patients with neurological diseases (e.g., stroke, Parkinson's disease, traumatic brain injury, multiple sclerosis, cognitive dysfunction), rheumatological disease (e.g., rheumatoid arthritis, ankylosing spondylitis, and fibromyalgia), orthopedic diseases (e.g., osteoarthritis, osteoporosis, low-back pain, and musculoskeletal disorder), cardiovascular diseases (e.g., acute myocardial infarction, coronary artery bypass grafting surgery, and heart failure), chronic obstructive pulmonary diseases, and breast cancers. Tai Chi is an aerobic exercise with mild-to-moderate intensity and is appropriate for implementation in the community. This paper reviews the existing literature on Tai Chi and introduces its health-promotion effect and the potential clinical applications.

Conclusion:

Tai Chi is a Chinese traditional conditioning exercise that integrated breathing exercise into body movements. This literature paper reveals that Tai Chi has benefits in health promotion and has potential role as an alternative therapy in neurological, rheumatological, orthopedic, and cardiopulmonary diseases. There are several reasons to recommend Tai Chi as an exercise program for healthy people and patients with chronic diseases. First, Tai Chi does not need special facility or expensive equipment, and it can be practiced

anytime and anywhere. Second, Tai Chi is effective in enhancing aerobic capacity, muscular strength, and balance and in improving cardiovascular risk factors. Third, Tai Chi is a low-cost, low- technology exercise, and it can be easily implemented in the community. It is concluded that Tai Chi is effective in promoting health, and it can be prescribed as an alternative exercise program for patients with certain chronic diseases.

Evidence Map of Tai Chi (14) (Hempel, Shekelle) Department of Veterans Affairs 2014

Abstract:

This evidence map provides an overview of Tai Chi research and describes its volume and focus. It combines a systematic review of systematic reviews with a scoping review for the VA priority areas pain, posttraumatic stress disorder, and fall prevention. The evidence map summarizes patient outcomes reported in reviews of studies in patients practicing Tai Chi for health-related indications.

Results:

Tai Chi has been investigated as a treatment for a number of clinical indications. The systematic review identified 107 systematic reviews. Reviews addressing general health effects, psychological wellbeing, or interventions in older adults included between 31 and 51 randomized controlled trials (RCTs). The topic areas balance, hypertension, falls, quality of life, cognitive performance, and vestibulopathy have also been the focus of research; included reviews identified 10 or more pertinent RCTs per topic. Statistically significant effects across existing studies were reported for hypertension, falls outside of institutions, cognitive performance, osteoarthritis, chronic obstructive pulmonary disease, pain, balance confidence, depression, and muscle strength. However, review authors cautioned that firm conclusions cannot be drawn due to methodological limitations in the original studies and/or an insufficient number of research studies.

In majority findings, health related Tai Chi research substantiates evidence that regular Tai Chi practice both effectively promotes physical function and is quite safe for broad application with various disease processes, across varied client populations. Research has also been done in an attempt to determine which styles/forms might be most effective for certain indications like falls prevention (20). Consensus reports note that beyond any specific style there is a set of core principles common to all Qigong and Tai Chi practices potentially explaining why multiple forms of Tai Chi are broadly effective. Further understanding of the Science of Rehabilitative Tai Chi requires deeper investigation of these core principles and their effective application to clinical practice.

Rehabilitative Qigong & Tai Chi Principles

At the heart of all Qigong and Tai Chi practice lies a set of core principles, which both structure the practice and create specific physiologic effects. As previously noted these physiologic effects promote enhanced physical function, psychological-emotional balance, and more efficient cellular healing. These principles will be discussed more specifically in subsequent sections and are listed below as reference.

- Upright Spine
- Coordinated Breathing
- Active Relaxation (sung)
- Pole
- Slow
- Fluid
- Rounded
- Mindful Weight Shifting
- Balanced Center (Dantien)
- Imagery/Symbolism
- Light Heartedness

A review of both more contemporary and additional ancient movement system principles show a striking similarity to the list above. The Feldenkrais Method of Awareness Through Movement shares concepts of neuro-motor retraining through mindful attention, slow movement, and active relaxation. Moshe Feldenkais admits to the study of Tai Chi influencing his work. The Alexander Technique places specific focus on postural alignment, breathing, and relaxed, efficient movement. Yoga, like Qigong, has many different styles focusing on various aspects including physical health, emotional wellness, and spiritual evolution. The most recognizable Yoga principles include attention to posture, breathing, and relaxation.

Considering the number of principles listed above, effective clinical application of Rehabilitative Tai Chi requires a consistent, repeatable, and simplified yet undiluted methodological structure. Three points of primary focus act as the pillars of Rehabilitative Qigong and Tai Chi (RQTC) treatment: body, breath, and vision. These three points of focus act to encapsulate the group of general Qigong and Tai Chi principles above creating more specific treatment directions. In addition to the list of principles above Rehabilitative Qigong and Tai Chi include attention to painless rehabilitation and self massage. Painless movement is inherent to the healing aspects of both Qigong and Tai Chi and will be addressed in later sections.

SECTION TWO: BodyMind Foundations

Bodymind practices like Qigong and Tai Chi have been called the original total body rehabilitation methods, not only because they address the physical body but also affect what might be considered the psychological, emotional, and energetic bodies.

Consider for a moment the concept of body, mind, and spirit. How do you know that you have a body? In general, our five senses tell us so in that we can see, smell, touch, hear, and taste it.

How about the mind? Many people consider their ability to think, problem solve, and communicate evidence that they have a mind. Certainly different cultures, traditions, and even modern science have varied beliefs about what the mind actually is, however for now let's simply come to a consensus that we actually have access to one.

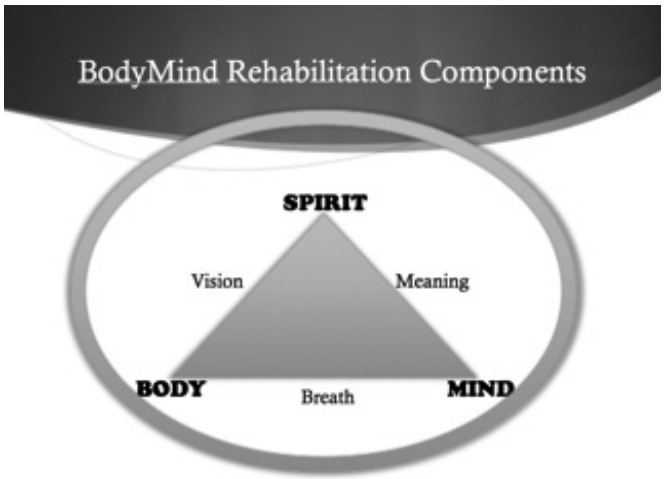
And finally, what is the evidence that we have a spirit? Obviously, this question has been explored for thousands of years through numerous traditions and is beyond the scope of this text; however, from the view of bodymind rehabilitation, "spirit" might be considered akin to "meaning. " In other words, why do you get up in the morning? What motivates your decisions and choices? What unseen force urges you to go into the world? Interestingly, many ancient philosophies and religious traditions also associate spirit with the breath. Words like "inspire," "spiritus," "pneuma," and "psykhe" all share roots that connect the spirit and breathing. (As discussed earlier, Qi is also considered to be both the breath and the animating force of life.)

The bodymind rehabilitation paradigm considers individuals as holistic beings with the body and mind functioning inseparably with all human activity. With a bodymind approach to physical rehabilitation the client is always considered first and diagnosis simply used as a categorizing reference. Without this emphasis, very often, diagnosis can act as inhibiting and misleading factors in affecting a client's expectations of recovery: for example, after having an MRI or X-ray that reveals some degenerative changes clients may become so focused on a particular finding being the reason for their pain that they close the door on any chance for improvement as long as that finding continues to exist.

A few studies have been done to discover the incidence of non-painful degenerative changes in normal subjects, and the results are quite interesting. It has been shown that 15% of 15 year olds, 30% of 30 year olds, and 60% of 60 year olds actually have non-painful herniated spinal discs. 40% of 35 year olds have findings of degenerative joint disease, as do 100% of 70 year olds with no associated pain at those particular joints. 100% of 42-year old people have non-symptomatic cracked spinal discs (11, 12, 13, 14). What these studies show is that pain and functional loss can never be blamed solely on what shows up on X-ray. Radiology studies are wonderful tools when devising a comprehensive treatment plan, but may have little to do with returning to a pain free and functional life.

In a very practical sense the holistic body, mind, spirit paradigm can be approached through the components of vision, breath, and meaning as seen in figure 2.1. How we use our eyes and visualization capacities, as well as our breath and intention, have been shown to affect both physical and autonomic nervous system function. In upcoming sections we will deal more specifically with each of these components; however, initially, foundational knowledge of bioenergetics is required.

The following discussion of bioenergetics and bodymind physiology empowers the application of Rehabilitative Tai Chi principles.



Bio-Energy

"Bio" or biology is the study of life, while "energy" is considered by Collins English Dictionary to be:

- The capacity of a body or system to do work
- A measure of this capacity, expressed as the work that it does in changing to some specified reference state
- A source of power

From a bodymind rehabilitation view, bio-energy is the energy that drives life: all metabolic processes require energy, whether from adenosine triphosphate (ATP) or the sun.

Brief History of Bio-energy

In 1906 Willem Einthoven discovered that electricity from the heart could be measured and recorded, opening the door for the electrocardiogram to be developed. Prior to Einthoven's Nobel Prize winning discovery, the heart may have been considered a simple mechanical pump. In 1929 Hans Berger discovered

that by attaching electrodes to the scalp, much smaller electrical fields could be measured from the brain.

Following up on this electrical field research, magnetic fields were subsequently discovered around the heart and brain respectively in 1963 and 1972. Of particular interest is that the magnetic field of the heart is 1000 times greater than that of the brain, and has been measured to extend at least 15 feet away from the body.

In 1968, C.A. Basset highlighted the biological significance of piezoelectricity in the human body, noting that connective tissue is crystalline in nature.

In the early 1980's Dr. John Zimmerman, using a magnetically shielded chamber, was able to measure a strong bio-magnetic field being emanated from the palms of practitioners trained in energy medicine. This work was confirmed by Seto et al (1992) reporting that, "an extraordinarily large biomagnetic field emanates from the hands of practitioners of a variety of healing and martial techniques, including Qigong, yoga, and meditation." Of interest, is that the biomagnetic fields measured from practitioners' hands pulsed at a variable frequency from.3 to 30 Hz with most activity in the 7-8Hz ranges (8).

Below we will consider several forms of bio-energy that have been measured in the human body.

Electro-Magnetism

Our central and peripheral nervous systems are made up of roughly 10 trillion nerve cells with action potentials being one of the primary functions. Action potentials occur in nerve cells when sodium and potassium ions cross a semipermeable plasma membrane, stimulating voltage-gated ion channels to conduct an electrical current. These action potentials travel in one direction and after reaching a firing threshold conduct in an "all or none" fashion; in other words they either conduct at 100% or not at all. Through the physiology of nerve conduction and action potentials, the human body can certainly be considered electrical.

Hans Christian Orsted accidently discovered the phenomenon of electromagnetism in 1820, while preparing for a lecture, when he noticed a compass needle move in relationship to a battery being turned on and off. We now know that electricity and magnetism are never separate; where there is an electrical current there is a magnetic field and if a conductor were placed within a magnetic field an electrical current would be produced. Effectively the human body is not only electrical but also electromagnetic with current research indicating that specific electromagnetic frequencies modulate cellular function to restore or maintain health (15).

Thermal

The human body produces thermal energy as a result of various metabolic functions. Consider for a moment the inflammatory response after a ligament sprain, where the local area typically becomes red, swollen, and "hot." The heat produced from these metabolic changes is indeed a form of energy identical to that used for cooking food and heating water, with various researchers developing technologies to convert bio-thermal energy into electricity (16).

Elastic/Kinetic

It is well known that tendon structures in animals contain elastic qualities, which are used to promote increased movement efficiency (17). Plyometric training in sports rehabilitation and athletic performance has been well established and used to promote increased power output through the elastic properties of musculotendinous systems.

Sound

Sound is a form of energy associated with vibration, as is all energy actually. As guitar strings or human vocal cords vibrate sound is created, and depending on the length, thickness, and vibrational frequency of the cord different pitches of sound are made manifest. Examples of human sound energy include vocalizations, clapping and stomping. Sound energy from the heart can be read by an echocardiogram. Sound energy is converted to thermal energy by using a therapeutic ultrasound in clinical treatment.

Piezoelectric

According to the Merriam-Webster Dictionary, piezoelectricity is electricity or electric polarity due to pressure especially in a crystalline substance. This form of bio-energy will be discussed in greater detail in upcoming sections.

Vibrational

Everything in the universe vibrates. On an atomic level, atoms vibrate to create heat, sound, and light. We distinguish between different sounds and colors because atoms are able to vibrate at different speeds, or frequencies. Everything that we identify as different is because everything has its own vibratory character, which can change with the addition or subtraction of energy. Consider water, which can be solid, liquid, or gas. Heating water speeds up the hydrogen and oxygen atoms vibrational frequency until they seemingly disappear; however they are simply vibrating faster than our visual senses can register. Every cell in our body vibrates in accordance with the atoms that comprise them and once again, every cell has its own vibratory character, which contributes to the orderly functioning of the entire organism (1, 8).

The Connective Tissue Matrix

A foundational understanding of bioenergetics might begin with a closer look at a single cell.

Over a century ago, with rudimentary microscopic equipment, the cell was imaged as a "bag" with a well defined border and its contents held in solution. This view of the cell led researchers in the direction of "solution" biochemistry where study focus was placed on the function of individual organelles held in the cytoplasmic contents. While this revealed very important information about internal cellular processes it has also fostered the idea of reductionism, or attempting to understand the whole by dissecting its parts.

With the advancement of microscope technologies a new view of the cell has been slowly emerging, where ubiquitous and delicate integrin fibers have been identified coursing through the entire cell. These fibers, collectively known as the connective tissue matrix, penetrate through the nucleus, cytoplasm, and plasma membrane of each cell connecting the entire organism together via a "solid" state. In a polar view to reductionist solution biochemistry, the recognition of a connective tissue matrix imparting function to the whole has spurred our understanding of *solid state biochemistry.*

In a very practical sense the entire body is connected through a web of microscopic fibers that organize both structure and function. The regular and repeatable arrangement of these integrin fibers creates a crystalline lattice, also known as a liquid crystal matrix.

We normally think of crystals as being hard; however, as James Oschman points out in his book *Energy Medicine: The Scientific Basis*, "crystalline arrangements are the rule and not the exception in living systems"(8). Evidence of liquid crystals surrounds our daily existence, from television to smart phone LCD screens, which alter their functions based on touch. In fact, a characteristic of crystals is their tendency to conduct piezoelectricity when physically compressed or deformed in some way.

Biological Electricity

The human body contains roughly 10 trillion nerve cells with many surrounded by myelin sheaths, lending to their designation as "white matter." In standard axonal depolarization, voltage gated ion channels open allowing sodium and potassium ions to pass across the cellular membrane resulting in an "all or none" conduction of bioelectricity. Because of this 100% conduction phenomenon these nerve cells are considered *conductors*, very similar to plugging a copper wire directly into the wall outlet where you would receive a full 110-volt jolt.

Schwann cells wrap around conducting axons enabling a more complete conduction of bioelectricity down the axon; as well as supporting nerves with nutritive functions Schwann cells act as insulators, similar to the rubber and plastic covering standard household appliance cords. Effectively, insulators block the flow of electricity.

In addition to conductors and insulators, we also need to consider *semiconductors*. Semiconductors used in computers are able to conduct electricity under some conditions and not others making them useful for performing specific functions. For example, when you use a toaster it can only do one thing – make toast – because it is a direct conduction from the electrical outlet to a heating element. In a computer, the power coming in can be diverted to perform different functions like mail, the Internet browser, and power point; semiconducting chips in the computer make these variable functions possible. It's important to remember that when semiconductors are programmed to perform certain functions then those are the only functions they will perform. For example when manipulating a smart phone with a liquid crystal display (LCD) we press an icon associated with a specific application like mail, itunes, or weather. When we press mail, itunes doesn't come up, mail does and vice versa when pressing itunes. Semiconducting chips in computers are often made of silicon, which is crystalline in nature and recall that a LCD touch screen needs to be physical compressed to perform its functions.

The human body is comprised of 100 trillion cells all invested within a connective tissue, liquid crystalline network. Liquid crystals conduct piezoelectric energy when compressed, stretched, or physically deformed in some way. Recall also that our cells crystalline nature, which is a semiconductor, can be programmed to perform specific functions just like the applications on smart phones. In essence, the piezoelectric charge propagated through the crystalline matrix now becomes more than simple electrical conduction but rather a conveyor of information.

Every time a cell is consistently compressed or stretched a piezoelectric charge is generated and propagated though the connective tissue matrix, with the rate, amplitude, and degree of the physical deformation determining the qualities or information contained within the charge. A slow connective tissue stretch will generate a different charge than a fast stretch, and a large stretch will generate a different charge than a small stretch. Unlike the "all or none" conduction along axons, piezoelectric conduction through connective tissue will vary based on the quality of its physical deformation, with these variations conveying specific information to specific cells throughout the body. Just like applications on a smart phone, cells are programmed to perform certain functions. In this way, piezoelectric conduction can inform numerous cells invested in the connective tissue matrix simultaneously, informing them of

current conditions and allowing them to alter physiology and affect function throughout the entire organism.

So what cells are primarily informed through piezoelectric conduction? Recall that there are three basic types of cells: "blasts" which build, "clasts" which break down, and "cyts" which maintain. "Generative" cells, including osteoblasts, myoblasts, fibroblasts, and collagen stem cells, act to repair and heal the body and are specifically activated or deactivated by piezoelectric information.

A practical example is Wolff's law (1892) in which, according to Mosby's Dictionary, German anatomist Julius Wolff concluded that, "biological systems such as hard and soft tissues become distorted in direct correlation to the amount of stress imposed upon them." Rehabilitation professionals regularly ask clients with osteoporosis to perform weight-bearing exercises, because it has been well established that weight-bearing exercises result in bone thickening; however, it is less well recognized how this occurs. Bone is by definition connective tissue, and of course connected to every other cell in the body via the connective tissue matrix. During upright exercise, weight-bearing bones are compressed and unloaded in regular fashion, creating a piezoelectric charge which is propagated through the entire system and informs osteoblasts to activate.

Of course, piezoelectric current is never only electrical; it is also electromagnetic, and bone has been shown to heal in the presence of strong magnetic fields (18). Bone stimulators used to heal non-union fractures offer further evidence of electromagnetic fields affecting cellular physiology and repair, and it's been shown that bone healing is stimulated when exposed to electromagnetic field frequencies of 7Hz (8).

In contrast, it is also well known that extended exposure to low gravity environments results in bone loss because osteoclasts become more active than osteoblasts. In these opposing situations different piezoelectric information is being propagated through the connective tissue matrix resulting in a different set of physiologic responses.

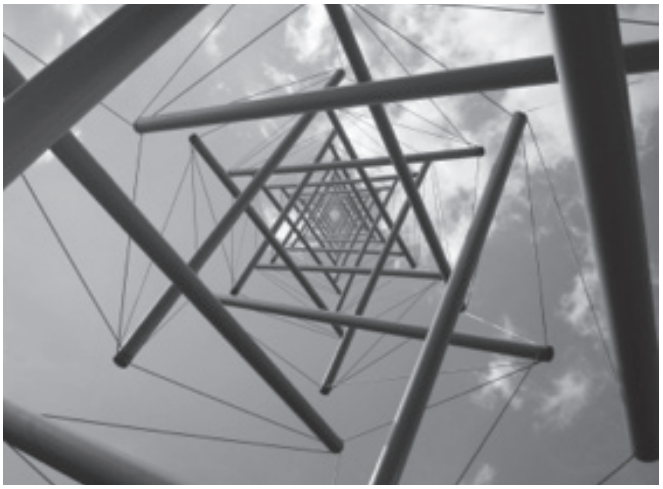
Macroscopic Connective Tissue Continuity

Thomas Myers' "myofascial meridians" concept expands our cellular connective tissue matrix understanding into whole body functional applications (7).

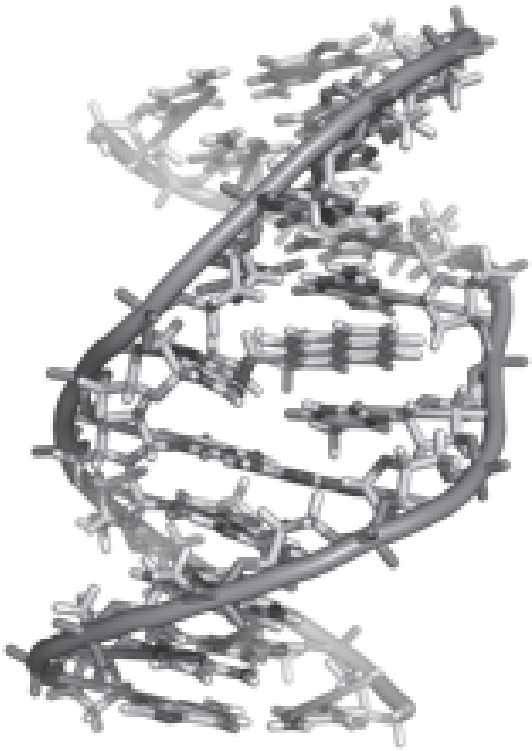
Through clinical observation, manual experience, and cadaver dissection, in his book *Anatomy Trains*, Myers outlines both anatomical and function lines of organized connective tissue continuity. Cadaver dissections of what Myers terms the Superficial Back Line include an intact and connected dissection of the plantar fascia, triceps surea, hamstings, sarcotuberous ligament, erector spinae, and epicranial fascia, revealing that none of these muscles acts alone but rather are both functionally and anatomically dependent on one another. Other myofascial meridians include the Superficial Front Line, Lateral Line, Deep Front Line, Spiral Lines, and Arm Lines, all indicating that whatever happens to one muscle in its designated line affects structure and function in the entire line. (Also of note is that while Myers admits to no original intention of correlating his myofascial meridians to those of acupuncture, an addendum in a second edition of *Anatomy Trains* highlights a fascinating overlay of structural, functional, and energetic connection.)

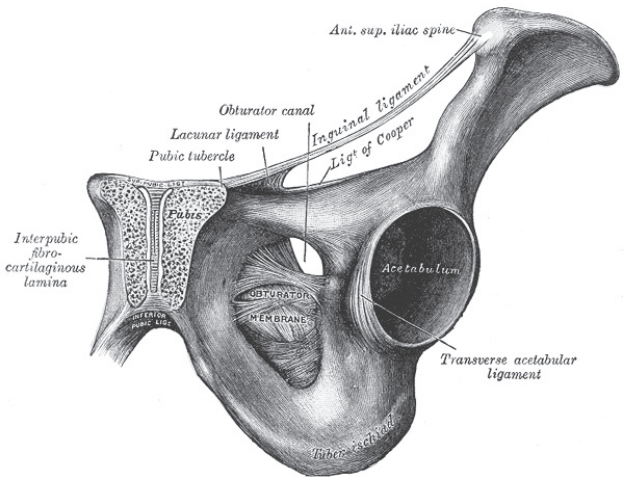
Biotensegrity

The concept of architectural tensegrity was developed by Buckminster Fuller in the 1960's and realized in his creation of the geodesic dome. Tensegrity structures are comprised of bars or struts being suspended between precisely tensioned cables. Tensegity models have since been adapted for children's toys and suspension bridges alike, with the core idea that light materials can be made into incredibly strong and resilient structures.



The term *biotensegrity* was coined by Dr. Stephen Levin as a way to describe how biological structures like bone, muscles, ligaments, and tendons are made stronger through compression and tension (19). Notice the arrangement of ligaments in the obturator membrane in Fig 2.5.





As described above, Thomas Myers builds upon this foundation with his myofascial meridian concept. Donald Ingber, a Harvard physician and scientist, has done work correlating tensegrity models to molecular biology indicating that geometric shapes are found throughout nature including the helix shape of DNA (20). The current evidence and understanding of biotensegrity allows us to conceptualize the connective tissue matrix being simultaneously structural, vibrational, and energetic.

Structurally, tensegrity models disperse incoming forces to be distributed across the entire structure. Imagine compressing the surface of a free standing camping tent and watch the entire tent change shape. Tensegrity structures are not only lighter however also more resilient and as James Oschman notes, "The more flexible and balanced the network (the better the tensional integrity), the more readily it absorbs shocks and converts them into *information* rather than *damage*. (8)"

Like a guitar sting that is plucked, connective tissue vibrates from the DNA through the entire connective tissue matrix (21). As described earlier, from electrons to jackhammers, vibration is energy, with the qualities of the vibrations determining the specific energetic information.

Vibrational Frequencies

As previously indicated, everything in the universe vibrates including cells in the human body. Minute, micro-pulsations in delicate integrin fibers throughout the connective tissue matrix create harmonics that inform specific cells to alter physiology (22).

Let's consider now how vibrations become "encoded" with information. Imagine that you are listening to your favorite country music station tuned to 103.5 FM. How did your favorite artist's voice get in the radio? Somewhere off in country music land a DJ was playing your favorite song which was then attached to a radio wave oscillating at 103.5 Hz or pulses per second. The radio wave was transmitted from a radio tower into the atmosphere where you decoded it with your radio

receiver and out pops your favorite song. If you switch to 104 FM, heavy metal radio, a much different style of music will emerge. In this case however, the heavy metal band was sent up the radio tower at 104 Hz not 103.5Hz. 104.5 FM might be talk radio and 105 FM classical; depending on what frequency you are listening to would you agree that you are receiving different information?

Have you ever been driving down the road listening to a really upbeat song and then noticed that you were speeding? Or how about listening to a friend bemoan the state of their lives only to feel like you weigh a thousand pounds after the discussion and have difficulty moving quickly? The information that we receive automatically alters how we feel and more importantly our behavior – consider that when your children are fighting they race to you first to bias you with their story, even if they know they were wrong! Once you receive the information you must take it into account, and it alters your behavior, just like our cells that receive information and direction from the vibrational frequencies and fields that they come into contact with (15).

Physiologic Coherence

Specific to cellular repair and healing, our physiology naturally becomes most balanced when in the presence of electromagnetic frequencies that are coherent (1, 3, 4, 5, 6, 8, 23). In physics, two waves are coherent if they have a constant phase difference and the same frequency, meaning that the wave oscillations are regular and consistent rather than disorganized and erratic. This might also be known as constructive interference. The concept of physiologic coherence becomes the pinnacle of the foundational information discussed to this point and is perhaps best defined by the Institute of Heart Math (2003) researcher Rollin McCraty PhD:

> "It (coherence) is the harmonious flow of information, cooperation, and order among the subsystems of a larger system that allows for the emergence of more complex functions. This higher-order cooperation among the physical subsystems such as the heart, brain, glands, and organs as well as between the cognitive, emotional, and physical systems is an important aspect of what we call coherence. It is the rhythm of the heart that sets the beat for the entire system. The heart's rhythmic beat influences brain processes that control the autonomic nervous system, cognitive function, and emotions, thus leading us to propose that it is the primary conductor in the system. By changing the rhythm of the heart, system-wide dynamics can be quickly and dramatically changed.
>
> "We use the term "coherence" in a broad context to describe more ordered mental and emotional processes as well as more ordered and harmonious interactions among various physiological systems. In this context, "coherence" embraces many other terms that are used to describe specific functional modes, such as synchronization, entrainment, and resonance.
>
> "Physiological coherence is thus a specific and measurable mode of physiological functioning that encompasses a number of distinct but related phenomena. Correlates of the physiological coherence mode, which will be considered in further detail in this monograph, include: increased synchronization between the two branches of the ANS, a shift in autonomic balance toward increased parasympathetic activity, increased heart-brain synchronization, increased vascular resonance, and entrainment between diverse physiological oscillatory systems. The coherent mode is reflected by a smooth, sine wave-like pattern in the heart rhythms (heart rhythm coherence) and a narrow-band, high-amplitude peak in the low frequency range of the HRV power spectrum, at a frequency of about 0.1 hertz."

Physiological coherence is affected by environmental frequencies; however, it is most dependent on internal states, informed by personal actions, emotions, and thoughts (1, 4, 5, 6, 8, 24). Ultimately, from a rehabilitation perspective, the body is responsible for and capable of healing itself while treatments and technologies simply make the internal environment more conducive for doing so.

The ancient practices of Qigong and Tai Chi have been shown to have a positive effect on circulating, cellular, and genomic markers of inflammation (25), as well as improve cardiopulmonary health, balance, and quality of life (26). Support from microscopic to macroscopic research, reveals that practicing Qigong and Tai Chi promotes positive trends towards cellular healing and physiologic balance.

Far from magic or superstition, Qigong and Tai Chi are ancient systems of breathing, movement, and intention that allow a natural state of physiological coherence to occur; a state in which cellular healing and repair is most efficient and productive. Obtaining this state is simpler than one might realize and at times more elusive than one desires. The primary Qigong and Tai Chi principles, which will be specifically discussed in upcoming sections, are the traditional gateways to allowing physiological coherence or what might be called the "Qigong State" and in general include attention to alignment, breathing, gentle movement, and active relaxation.

Therapeutic Entrainment

Organisms that tend towards physiologic coherence have the capacity to influence other organisms (8). This process, known as therapeutic entrainment, is an avenue of healing well known to manual therapists and energy medicine practitioners. Once again, Rollin McCraty of the Institute of Heart Math has outlined the relationship of coherence and entrainment:

"Just as oscillators provide the timing for computers, coordination of body function via rhythms such as heart beat and respiration are described by coherence and entrainment.

"The term coherence is used to describe two or more waves (or systems) that are either phase- or frequency-locked. This is also called entrainment. In the coherent mode, respiration, heart rhythms, and blood pressure rhythms become entrained and oscillate at the same frequency. The term cross-coherence is used to specify this type of coherence. Note that this use of the term coherent is different than its use to describe coherent waves, which are man-made concentrated radiation that can harm biological organisms. Physiological coherence is a state characterized by:

- High heart rhythm coherence (sine wave-like rhythmic pattern)
- Increased parasympathetic activity
- Increased entrainment and synchronization between physiological systems
- Efficient and harmonious functioning of the cardiovascular, nervous, hormonal and immune systems

"An exchange of electromagnetic energy produced by the heart occurs when people touch or are in proximity. Signal averaging techniques are used to show that one's electrocardiogram (ECG) signal is registered in another person's electroencephalogram (EEG) and elsewhere on the other person's body. While this signal is strongest when people are in contact, it is still detectable when subjects are in proximity without contact. Sustained positive emotions affect bodily functions. Thus, there are physiological correlates of positive emotion. This is called psychophysiological coherence. This mode, characterized by heart rhythm coherence, increased heart-brain synchronization and entrainment of diverse physiological oscillatory systems, is associated with increased emotional stability, improved cognitive performance, and a range of positive health-related outcomes.

"Additionally, individuals frequently report feelings of increased spiritual connectedness during psychophysiologically coherent states. Through the use of tools and technologies that foster positive emotions and psychophysiological coherence, individuals can effectively initiate a repatterning process, whereby habitual emotional patterns underlying stress are replaced with new, healthier patterns that establish increased emotional stability, mental acuity, and physiological efficiency.

"The heart generates the largest electromagnetic field in the body. Its electrical field as measured in an electrocardiogram (ECG) is about sixty times greater in amplitude than the brain waves recorded in an electroencephalogram (EEG). The magnetic component of the heart's field, which is around five thousand times stronger than that produced by the brain, is not impeded by tissues and can be measured several feet away from the body with Superconducting Quantum Interference Device (SQUID)-based magnetometers. Clear rhythmic patterns in beat-to-beat heart rate variability are distinctly altered when different emotions are experienced. These changes in electromagnetic, sound pressure, and blood pressure waves produced by cardiac rhythmic activity are "felt" by every cell in the body, further supporting the heart's role as a global internal synchronizing signal." (McCraty R., *Clinical Applications of Bioelectromagnetic Medicine*, 2005.)

If physiologic coherence can be shared between individuals, then who determines the frequencies that most effectively promote cellular healing and repair?

A German physicist named W.O. Schumann, in the 1950's, proposed the idea that the space between the earth's surface and the ionosphere acts like a large resonance cavity. This idea was eventually confirmed and further discovered that regular lightning strikes around the globe determine the average resonance frequency of the atmosphere to be 7-10Hz (8).

Recall that in our earlier bioenergy history section, Seto et al mapped electromagnetic emission from the palms of energy practitioner's hands primarily in the 7-8Hz ranges. More recent energy medicine research connects physiologic entrainment between patient and practitioner EEG's occurring in concert with the Schumann resonance (27).

In essence, the most consistent electromagnetic field to which we are exposed is that of Earth's atmosphere, which vibrates at an average frequency of 7-10 Hz and correlates to the same physiologic frequency at which cellular repair and healing most effectively occur. In addition, when we allow physiologic coherence or the Qigong State to occur, our physiology tends towards an average frequency of 7-10Hz as well (4).

BodyMind Connections

With a basic understanding of bioenergetics, recognizing how the body and mind interface becomes more tangible.

How can you tell someone is depressed simply by looking at them? Slumping, with a forward head and rounded shoulders is a clear indication, yet is the slumping posture conscious? Does a person say, "I'm depressed, I think I'll slump?" In contrast, how can you tell someone is angry? Body language gives us away every time, and is the easiest way to recognize the bodymind connection. What happens in one's mind is instantly reflected in one's body,

even though we may not be conscious of the physical change. Poker players make their living reading body language in determining whether their opponent is bluffing or telling the truth, while crime investigators intuitively steer questioning based on their suspects physical responses. Parents know when their children are lying… and kids know precisely when to ask for money.

Thomas Hanna in his book *Somatics* effectively outlines how mental states correlate to basic postural reflexes (2).

> The withdrawal reflex is ubiquitous in animal physiology and observed through a systemic contraction of ventral musculature. Imagine a caterpillar curling into a ball, a dog slinking away with a tail between the legs, or a traumatized child curling up into the fetal position. By definition the withdrawal reflex is a spinal reflex intended to protect the body from damaging stimuli and occurs instantaneously below the level of conscious awareness. Jaw clenching, eyebrow furrowing, upper trapezius contraction, biceps facilitation, and abdominal shortening are all characteristics of the withdrawal response as well as indicators of emotional distress. Flexed body postures and slowed gait speed have been associated with sadness and depression (28).
>
> The Landau reflex, which is noted in babies after 3 months of age, is opposite that of the withdrawal reflex. The Landau reflex is recognized by a firing of the body's extensor muscles, primarily the erector spinea and associated with emotional states of activation. Imagine the characteristic posture of someone who is outwardly angry, with chest puffed out, back arched, and shoulders drawn back.
>
> All patterns of physical movement require muscle contractions to occur, and patterns of movement that are routinely performed tend to become more automatic or habituated; this is commonly known as motor memory. Through observation it becomes evident that the manner in which people tend to use their bodies engenders what we might call that person's "posture." Consider the posture of someone who works at a desk all day, in contrast to someone who works as a manual laborer. Integrated spinal reflexes underpin physical movement and therefore, to a large degree, the spinal reflexes that are facilitated most regularly once again determine our posture.
>
> Hanna's assertion is that consistent withdrawal and Landau reflexes, which are physical expressions of psycho-emotional states, have a profound effect on our posture and subsequent physical function; thus the mind becomes the body.

Amy Cuddy and colleagues at Harvard Business School have done some interesting research on posture, emotions, and physiology.

> In a study requiring participants to undergo a job interview she randomized subjects into two groups; one group was asked to stand up tall with hands on hips for two minutes, while the other group was asked to sit folded forward in a chair. Following the job interviews, the group asked to stand tall was more likely to receive a second interview regardless of job qualifications. Follow up blood samples revealed that the group asked to stand tall had a rise in the confidence promoting hormone testosterone and a drop in the stress hormone cortisol, while the group asked to fold forward had exactly the opposite effect with a rise in cortisol and a drop in testosterone.
>
> To determine the effects that posture and hormonal changes may have on behavior, Cuddy repeated the process prior to sending subjects into a casino and found that the standing tall participants were more likely to take riskier bets (10).
>
> From Cuddy's research we summarize that purposely-performed postures alter hormonal levels, which subsequently influence behavior; thus the body becomes the mind.

Epigenetics and Psychoneuroimmunology

Candace Pert, the first person to discover how opium interfaced with brain neurons, went on to foster a new branch of medicine and research called Psychoneuroimmunology. Psychoneuroimmunology studies the relationship between psychological processes and the nervous and immune systems, and proposes that emotions are the mediator between thoughts and physiology (29).

We have already discussed, in Section One, the effect of psychological stress on the immune system and wound healing. In line with this discussion, Pert's work focused around the discovery of the endogenous molecules she called *neuropeptides*; in her landmark book *Molecules of Emotion*, she outlines the interface between our internal biochemistry and emotional states (9).

Epigenetics is the study of gene expression as a result of environmental influence. The environment in this case includes physical, social, and electromagnetic surroundings as well as our beliefs, perceptions, and behaviors. We have already indicated that Qigong and Tai Chi have a positive effect on gene expression with regards to decreasing cellular inflammation markers (25). Epigenetics research is beginning to alter the idea that our inherited DNA creates a fatalistic map of our health, but rather that our perceptions and behaviors cause genes to express themselves in selected ways (6). As an example, two identical twins may have exactly the same DNA makeup at birth; however, they express it differently, causing their health to be dramatically different.

BodyMind Foundations: A Summary

As a reference for upcoming sections, here is a summary of the preceding discussion of bioenergetics and bodymind physiology:

- We are holistic, integrated beings
- We ARE energy
- Energy can be frequency encoded to carry information
- Energy-Information (EI) propagates through the connective tissue matrix
- This EI primarily informs "generative" cells and processes
- Our mind becomes our physiology
- How we use our body informs and directs the mind
- Emotions are the mediator between thoughts and physiology
- Highly stable thoughts, emotions, and physiology = Coherence
- Coherent EI has the tendency to entrain external systems through resonance
- Our personal level of coherence has vibrational influences on our own physiology and the people around us

SECTION THREE: Body Focus Principles

There are literally thousands of Qigong and Tai Chi forms and gestures, which have evolved over the centuries in accordance with local traditions and contemporary beliefs. Common to all of them, however, is a set of principles which act as the scaffolding for a wide variety of movements. More than any particular gesture, adherence to these principles engenders specific physiologic activities, parasympathetic shift, and subsequent healing responses.

In this way, through application of principles, Qigong & Tai Chi can easily be adapted for a variety of functional activities in support of specific rehabilitative goals. The Rehabilitative Qigong & Tai Chi method sorts these principles into three categories of focus: body, breath, and vision (BBV).

In this section we will address the body focus principles, including Tai Chi posture, efficient breathing, active relaxation, slow, rounded, and fluid movement, Dantien focus, and silk reeling.

Tai Chi Posture

The most primary Tai Chi principle is obtaining an upright yet relaxed spinal posture. Common to many bodymind practices including Qigong, Tai Chi, Yoga, and Pilates, employing an upright and flexible spine engenders efficient breathing, biomechanical ease, improved balance, and relaxed, focused awareness.

Experiential Exercise: The Tai Chi Posture

Stand or sit with feet positioned hip width apart and flat on the ground. Sense your feet connected to the ground and allow body weight to sink downward. Keep your knees relaxed and slightly unlocked, making them feel like bouncy shock absorbers.

Next, imagine that a 20′ long dinosaur tail extends from your sacrum reaching far behind you and allow it to settle on the ground. You may additionally imagine lifting your tail slightly off the ground suspending it for several seconds and then pressing it firmly into the ground noticing the natural anterior and posterior pelvic tilts that respectively result. This specific imagery method has proven very effective in teaching pelvic neutral to even the most physically unaware patients. Settling your tail, so to speak, opens and distracts the lumbar spine in the caudal direction.

Now bring attention to the crown of the head and imagine a string lifting this point skyward making the vertebrae "a string of pearls suspended from heaven" as the Tai Chi classics suggest. The shoulders are relaxed and rounded slightly with arms hanging out from the sides.

Spinal Tensegrity

For many years the theory of spinal structure depended on the idea that vertebrae are blocks stacked on top of each other with weight-bearing forces directed through vertebral bodies and intervertebral disks acting as shock absorbers. Physics, however, refutes this theoretical model, calculating that simple forward trunk flexion would result in an excess of 450 pounds of damaging force at the 5th lumbar vertebrae. In addition, D. L. Robbie reports that vertebral bodies

are primarily composed of spongy bone making them inappropriate as weight bearing structures (6).

An updated model of spinal structure and function follows the concept of tensegrity (introduced in Section Two). Tensegrity structures contain continuous systems of tendons and discontinuous struts, as in a modern freestanding tent that can be held in any position and still maintain its shape. In a tensegrity system, forces causing local deformation are absorbed through the entire structure resulting in greater adaptability and responsiveness.

As we also discussed in Section Two, Dr. Steven Levine, the orthopedic surgeon who coined the term *biotensegrity*, highlights the existence of tensegrity systems in biological organisms. With regards to properly aligned spinal posture, Robbie supports this idea, reporting that articular processes in the lumbar spine are composed of compact bone in alignment with connective tissue forming "slings" that suspend each vertebra from the one below it (6).

In a series of surgical investigations, Dr. Levine reported, "Axial loads were applied to joints in live subjects under anaesthesia during surgical intervention for a variety of conditions. Joint studies included the knee, ankle, elbow and metatarsal-phalangal joints. In our studies at no time could the **articular surfaces** of these joints be forced into contact with one another as long as the ligaments remained intact." With regards to spinal dynamics Dr. Levine notes that the anterior and posterior longitudinal ligaments are in continuous tension, and if cut, "the vertebral column expands (10)."

From an elastic-energetic potential perspective we might summarize that the human skeletal system, including the spine, is actually in a constant state of dynamic expansion rather than compression. As practiced in the Tai Chi posture, the simultaneous sinking of the tail and lifting of the head in dynamic opposition further facilitates this natural spinal expansion, which in turn unloads vertebral segments, interverbral disks, and sensitive neural structures. Through this model it also becomes apparent that the spinal system has the capacity to store elastic-kinetic energy, which can be used in functional activities such as pushing, pulling, bending, and lifting.

A review of tensgrity models like camping tents and children's toys reveals that at rest, these structures naturally adopt mid-range positions where movement in any direction is possible. Similarly, the Tai Chi posture assumes a pelvic neutral stance where the zygapophyseal (facet) joints of the lumbar spine are suspended in mid-range and able to efficiently access all six directions of spinal movement. (Clinically, hyper-lordotic and excessively flexed spinal postures in combination with spinal rotation and side bending commonly contribute to acute back episodes.)

MicroCurrent

As previously outlined, the somatic nervous system includes the spinal cord, which contains multiple nerve tracts that conduct electrical current through axonal depolarization. Once again, since nerve tissue conducts bioelectricity it also implies a magnetic field must be present. The spinal cord is arguably the largest and most important nerve conduit in the body, connecting the brain with a multitude of peripheral structures via 31 pairs of spinal nerves. Each of these peripheral nerves exits and enters through a foraminal canal at the junction of adjacent vertebrae. The spinal cord itself travels through the spinal canal, which is immediately posterior to the vertebral bodies and enclosed by the laminar and pedicle ring.

Efficient, unimpeded conduction of electrical information through the spinal cord and spinal nerves is dependent on normal spinal alignment and clear foraminal openings. It is well known that spinal cord and peripheral nerve conduction is impeded by structural compression (12). Normal spinal alignment and foraminal opening is largely dependent on the positional relationship of adjacent vertebrae and function of the zygapophyseal (facet) joints through a biotensegrity system (5, 6, 10).

The Tai Chi posture emphasizes a neutral spine where the facet joints are in a relaxed, mid-range position, possibly allowing more efficient conduction of electrical information through the spinal cord and nerves.

Neuro-Hormonal

As outlined in Section Two, holding an upright posture alters hormone profiles to increase blood testosterone and decrease blood cortisol levels. Higher levels of blood testosterone have been associated with improved bone thickening, muscle strength, and metabolic enhancement (14). Classic Tai Chi instruction includes an exercise called *standing pole*, which is highlighted below and purported to be the fastest way to "build Jing Qi." (In this case Jing Qi is referring to the energy that builds and supports the body's physical structures like blood, bone, muscle, tendons, and ligaments. Recall that the ancient practice of Qigong was primarily experiential in nature as the technology for neuro-chemical physiological assessment was not available until the past century. Even with this potential limitation in understanding why the physiology responds differently to postural changes, the ancient Qigong masters continued deeper into the experience itself to prove that the practice produced consistent results in enhancing physical strength and health.)

Standing pole, which may be referred to by other names including "tree hugging" and "Wuji standing," is the most fundamental of all Tai Chi practices. Standing pole begins with the Tai Chi stance as

described above, and commonly, but not exclusively, positions the arms and hands as if hugging a tree. The shoulders are relaxed and dropped while the chest is held slightly concave and back slightly rounded. Settling your dinosaur tail opens the low back and in addition a "sinking" into the pelvis relaxes the pelvic and hip musculature.

In summary and support of our physiologic discussion above, Yang Yang Ph.D. notes that standing pole, "strengthens the core and lower extremity musculature, enhances economy and efficiency of movement, improves balance, and enhances sleep quality (7)."

Efficient Breathing

As discussed earlier, breathing is a foundation component of Qigong and Tai Chi practice and will be afforded more complete attention in Section Four; for now let's consider how posture affects the mechanical efficiency of breathing.

Experiential Exercise: Breath

Stand in Tai Chi posture with relaxed knees, settled tail, and head suspended from the sky.

Notice the relative ease or difficulty of abdominal breathing. Now exhale slowly, contracting abdominals and intercostal muscles to empty the lungs completely. Again notice the relative ease or difficulty of the natural abdominal breath that follows complete exhalation.

Next, move into your best dysfunctional forward bent posture including a forward head, rounded thoracic spine, and rounded shoulders. Return to noticing the relative ease or difficulty of abdominal breathing as compared to the Tai Chi posture. Additionally, evacuate the lungs completely as previously done and once again compare the quality of these two posture-breath experiences. Which posture affords more easeful and fluid breathing?

Now stand up as tall as possible with your chest pushed out and spinal muscles engaged. Allow your spine to arch like an overstrung bow and once again exhale completely. Notice the relative ease or difficulty of the breath returning into the lungs. Experiment with a variety of common postures like sitting at a desk or mimic holding a baby on your hip and once again compare the relative ease or difficulty with which the breath naturally flows.

Anatomically, the diaphragm has root connections to the 4th lumbar vertebrae and like a filled parachute via the central tendon radiates fibers out to the posterior xiphoid process and inner surfaces of ribs 7-12. Imagine how much more effective a fully lofted parachute might be compared to one flattened on one side. Following the exercise described above, many people report more difficulty in taking a full breath when in a flexed or extended spinal posture. Returning again to a biotensegrity model, ease of breath is dependent on efficient lines of muscular pull available only when the diaphragm is properly positioned.

Active Relaxation (Sung)

Traditional Qigong practice emphasizes the importance of mindful relaxation or "*Sung*" for healing purposes via vasodilation, enhanced blood and lymph flow, immune response, digestion, and nervous system function (3). Traditional Tai Chi martial arts further use relaxation as a means to employ energy efficient movement and "yield" to incoming forces (7), whether an opponent's punch or our body contacting an object during a fall or high-speed accident. In either case, a relaxed neuromuscular system can absorb forces through the whole body as described in a preceding section on tensegrity, while a resistant or rigid system will result in greater localized damage. For this reason, teaching and practicing "active" relaxation techniques promotes physical adaptability and resiliency.

The concept of *Sung* is perhaps best visualized in cats, who appear to be quietly resting, but can spring into action instantly if a mouse runs by or a dog approaches. *Sung* is characterized by a very relaxed body and a highly aware mind.

Muscular weakness is typical of dysfunctional aging; however, it has been observed that muscular stiffness and rigidity typically precedes this phenomenon (15).

Functional strength may be regarded as the difference between average resting tension and the structural threshold of contractile tissue. For discussion purposes let's consider that the absolute minimum resting tension level in order to maintain an upright posture is ten units of force while the maximum contractile capability of the system is one hundred units of force; any less than ten units and the body succumbs to gravity, any more than one hundred units and contractile tissue tears. In this scenario the available functional strength is ninety units.

Chronic muscle contraction as a result of trauma, injury, and emotional stress increases the average resting tension of associated musculature (15). Continuing with our above example let's say resting tension increases to forty units of force while the maximum contractile capability remains the same; now the functional strength is sixty units or a resultant 30% loss.

While resistance training is certainly effective for increasing functional strength by raising the top number, its effectiveness is inevitably capped by an individual's genetic capacity and consistency of training. Active relaxation training inherent to Tai Chi practice adds an overlooked and potent method to enhancing functional strength and sensitive motor control.

Sensitivity enhancement is also a key component of *Sung* and an important martial arts and life skill. When incoming forces contact the body, the nervous system must sense and respond to those forces in order to prevent injury. Whether it's a receiving a punch, or

a box falling from a high shelf, the nervous system's degree of sensitivity will determine the degree of response. For this reason, enhanced neuromuscular sensitivity would allow the body to sense external changes when they are small and make adjustments before the external forces become potentially dangerous.

This concept can be explained through the Weber Fechner rule, which essentially states that the nervous system is only able to receive and quantify incoming information in relationship to the total amount of information entering the system. For example, when you are in a quiet room a dripping faucet is easy to hear. If a radio were playing loudly in the same room, the dripping faucet would be drowned out by the louder noise. Another example would be easily seeing a flashlight on a dark night while during a sunny day you may not even know the flashlight is on even when looking directly at it. Considering our neuromuscular system, you would generally be able to feel the weight of a small bird landing on your finger; however, if you were already holding a five-pound book, adding the bird's weight would be indistinguishable.

Practically speaking, if the central nervous system is overloaded with sensations from excessive neuromuscular tension, then it would be unable to sense additional changes that may become dangerous. Consider someone who injures his or her back while bending over to pick up a pencil. Obviously the pencil isn't too heavy to pick up; rather the person had such excessive spinal muscular tension that they weren't able to sense that the small additional stress would cause a problem: the proverbial straw that broke the camel's back. Practicing *Sung* and lowering excessive neuromuscular tension enhances sensitivity, allowing physiologic adaptations to occur before both internal and external forces become dangerous.

Experiential Exercise: Cloud Hands

Sit in an upright position on a firm surface. Assume the Tai Chi posture by keeping your feet on the ground, tail settled, and crown of the head lifted towards the sky.

Begin performing Cloud Hands by holding your left hand approximately 18 inches away from your body at shoulder level and looking at your palm while your right hand is at waist level with palm facing the floor. Slowly turn your body to the left and when you have turned as far as comfortable switch hands by lowering the left and raising the right. When the right hand is at shoulder and the left at waist height slowly turn your body to the right again reaching the comfortable end of rotation and switching hands.

Continue turning from the waist slowly side to side. Relax your neck and shoulders as much as possible, inhaling on the hand switch and exhaling slowly with the turn. Do this a few times while assessing relative levels of tension in your upper body.

Next, make tight fists by squeezing your hands as much as possible. Continue performing Cloud Hands and again reassess tension levels in the upper body. How does increasing hand tension effect upper body tension and quality of movement?

Now relax your body as much as possible and reassess tension levels while employing what Tai Chi calls a "lady like" hand.

The above exercise illustrates that the human nervous system doesn't compartmentalize its effects in separate body regions. When the hands carry excessive tension, so does the entire body – in particular the upper half.

This knowledge allows us to access the benefits of generalized relaxation by focusing our attention on key body areas that act as thermostats for the rest of the body. The hands and jaw muscles in general guide the upper half of the body while the pelvic floor and anal sphincter lead the lower half; through employing progressive muscle relaxation exercises inherent to Qigong and Tai Chi in these specific areas, overall neuromuscular tonus can be balanced.

Progressive muscle relaxation is an effective way to enhance active muscle relaxation. It was first developed and described in contemporary literature by Dr. Edmund Jacobson in the early 1920's; however, predating Jacobson by 5,000 years, Qigong lymph pumping practices included similar processes.

Progressive muscle relaxation exercises, such as those employed with Rehabilitative Qigong and Tai Chi lymph pumping, have been shown to decrease muscle tension, enhance mood states in young athletes, decrease anxiety and depression as well as improve quality of life markers in cardiopulmonary patients, and significantly decrease fatigue and pain in cancer patients (19, 20, 21).

The basic concept of progressive muscle relaxation involves sequentially contracting and relaxing body areas progressively until the entire body is participating. The degree of contraction also slowly progresses from light to moderate. Most often during states of chronic tension, the neuromuscular system is carrying reflexive tension, which occurs below the level of conscious awareness. Consider when your neck muscles are tight from a stressful day and even though you tell yourself to relax they stay contracted; reflexes don't obey volitional command. Progressive muscle relaxation slowly returns active control of the neuromuscular system to volitional processes by contracting muscles slightly above the level of reflexive tension, while upon the relaxation phase the muscle tension will reflexively drop below the previous tension levels (11). For example, if the baseline resting tension is 50, then the progressive muscle relaxation is best targeted to approximately 52. Upon relaxation, the baseline tension will reflexively drop to 48. While these numbers are for example only, they outline the basic concepts for application below.

Experiential Exercise: Squeezing the Sponge

Sit in an upright position on a firm surface. Assume the Tai Chi posture by keeping your feet on the ground, tail settled, and crown of the head lifted towards the sky.

Moving slowly, raise hands over your head and end by looking towards the ceiling as if framing a photograph between the hands. Be sure to stay in a comfortable range of neck and spine range of motion.

Next, slowly fold your spine forward bringing hands towards the abdomen. Repeat this simple spinal flexion and extension exercise a few times to learn the movement. Now begin coordinating your breathing by inhaling on the way up and exhaling on the way down. Once again repeat a few times until you're comfortable.

Finally begin adding a gentle contraction-relaxation cycle by squeezing your pelvic floor (as if stopping the flow of urine) and abdominals with a 50% contraction on the way down while exhaling and a complete release of the contraction on the way up while inhaling. With each successive exhale and contraction cycle add another body part into the contractions in a progressive manner. Contracting from the center of the body outward, begin with the pelvic floor and abdominals, adding in gluteals and shoulders, thighs and arms, and calves and fists. After each successive contraction, relax completely by inhaling and allowing arms to float overhead.

When you have progressed to involving the whole body in 50% contractions, slowly add 5% effort with each additional contraction until you reach 70%. Remember to relax completely between contraction cycles with the idea of letting go of all the tension that was created.

Continue with the exercise for ten minutes or until relaxed, remembering to breathe slowly and deeply with the movements.

Slow Movement

Slow, graceful movement is evident in well-practiced students of Tai Chi and becomes a natural extension of *Sung* discussed above. In the Rehabilitative Qigong & Tai Chi (RQTC) paradigm we primarily consider three reasons for moving slowly: efficiency, coordination, and accuracy.

Efficiency can be defined as the ability to accomplish a task with minimum expenditure of time and effort. Physiologically we can discuss efficiency by looking at the law of reciprocal inhibition, which governs how agonist and antagonist muscles operate. Consider the biceps and triceps of the upper arm; when the biceps contracts, the triceps relax in a relative ratio to allow elbow flexion. Ideally if the biceps asks for 60%, the triceps gives it 60% and this would be considered efficient. If the triceps only gives 40%, then the biceps has to work 20% harder simply to overcome the additional triceps tension and this would be considered less efficient.

The law of reciprocal inhibition reminds us that smooth movement depends on an efficient give and take even at the cellular level; truly a Yin-Yang relationship. Aging, pain, injury, and excessive muscle tension cause a tug of war between agonist and antagonist muscle groups resulting in dysfunctional co-contraction, which we call stiffness, splinting, and rigidity.

Extremely efficient movement across multiple muscle groups and joint systems is what we call good coordination. Have you ever watched an Olympic gymnast or ice skater – a person that makes their effort look so easy a child could do it? Actually these highly skilled athletes are extremely efficient and using all of their energy in direct association with their task: nothing is wasted, and it looks as if they aren't using any energy at all.

This high level of coordination naturally yields improved accuracy. Accuracy is defined as the quality or state of being true, precise, or exact. In the case of the previously-mentioned athletes, it means hitting every landing perfectly and exactly where they intended.

Slow movements engender all three of these qualities, and beginning with efficiency, allows agonist and antagonist muscle groups to communicate most effectively.

> Have you ever moved furniture with a partner, and while rushing to complete the task ended up in a tug of war and screaming match, only to watch the movers move the same piece of furniture easily without even saying a word? We may be tempted to believe that the movers are just bigger and stronger; however, they could be fighting each other as well. Instead, they learned over time to communicate about how it may be easiest to lift, handle, and

move different pieces of furniture – and they started off by doing it slowly. After becoming more efficient and best predicting what the other might do, they were able to speed up and appear more coordinated in their minimal effort.

Physiologically speaking, moving slowly in complex motor patterns like Tai Chi enhances whole body synergy through neuroplasticity mechanisms.

Yang Yang notes that, "Multiple stimuli and responses can be processed in parallel pathways and the learning continuously improves the efficiency of parallel processing (7)." In other words, moving slowly causes the brain to process and adapt to more information simultaneously, meaning that the over time the brain grows and becomes more efficient.

Practicing specific movements slowly naturally enhances accuracy through feedback and feed-forward mechanisms.

When someone attempts to touch a target or perform a novel task quickly, they often miss the target or mis-perform the task without knowing why. Sensory input from fast movements is more difficult for the brain to process and adapt to, especially when new learning is required. Moving slowly allows time for central nervous system processing, including visual and proprioceptive feedback, which offers us the opportunity to better identify where the performance error is taking place. Once the performance error is identified we can predict when and where it may occur again so that a prior correction can be made; this is called feed-forward.

In short, slow movement allows our nervous system to better identify both where performance errors exist and the most efficient ways to correct them.

Slow movement also engenders greater functional power output. This may sound paradoxical, as power generation typically involves speed (power = force x time). Let's consider that if power output is fixed and movement was slowed down, then force must increase.

Clinically, when exercise movements are slowed down, more motor units are called upon to perform the desired task, resulting in greater muscle hypertrophy and force development over time. Any given muscle has multiple motor unit groups, with the strength of the contraction being determined by the number of motor units engaged by a single nerve. When a muscle contracts motor unit groups engage in a cyclical process to maintain prolonged force output. For example, if the quadriceps contained 100 motor units, then only twenty-five of those motor units would initially engage. After a short period of time those twenty five motor units would fatigue and another group of twenty-five would come online. If the contraction were sustained then this cyclical process would continue until the initial motor unit group was once again called upon to activate, by which time it would have recovered.

In short, fast movements engage less motor units, while slow movements require more motor units to activate over time. This repeated activation of motor units results in cellular adaptations to the motor units themselves causing them to become thicker, which in turn creates greater force output; this is called muscle hypertrophy.

Power development is naturally a continued extension of efficiency, coordination, and accuracy. Remember the Olympic athlete who made it look easy? If less energy is being wasted with inefficient movement, then increased and more accurate force output can be directed to performing specific tasks at greater speeds. Research at the University of Illinois compared Tai Chi to standard exercise in age matched controls and found that not only did power development improve equally in both groups, but that the Tai Chi exhibited better force-control exertion (7).

Force control is a measure of how accurately someone uses the muscle force available to them. For example, what good is a 350 horsepower engine in a school zone? You could certainly drive 70 mph both on the highway and through a school zone, but that would be dysfunctional behavior. The Tai Chi subjects in this study basically developed a 350 horsepower engine just like the standard exercise group, however were able to drive 20 mph in the school zone and 70 mph on the highway becoming both more accurate and efficient with specific force output.

Professional golfers, tennis players, and martial artists know that learning new motor sequences slowly ensures precision performance when speed of movement increases. As the Tai Chi classics say, "The whole body is one family; the released energy focuses on one point, then every touch can penetrate the bone." In other words, a strong foundation of movement efficiency and whole body coordination leads to improved accuracy of movement and power output in any direction at any given time.

In addition to skill performance, slow movement also protects the body from soft tissue, joint, and nerve injury, especially during physical rehabilitation.

Cellular healing involves complex mechanisms of repair and adaptations that can at times create dysfunctional neural hypersensitivity and kinesiophobia or fear of movement. While pain physiology and the process of pain-free movement will be discussed further in later sections, for now let's agree moving slowly allows the nervous system to explore potentially painful ranges of motion with less risk of further injury. In fact, during the healing process, slowly progressing movement

into restricted ranges is a prerequisite for healthy connective tissue development, whereas rapid movements may cause further tissue damage and delay healing.

Recall our discussion in a previous section on *Sung* where someone injures himself or herself by picking up a pencil? Moving slowly in combination with active relaxation becomes highly effective in properly aligning connective tissue fibers, desensitizing painful structures, and rehabilitating lost ranges of motion.

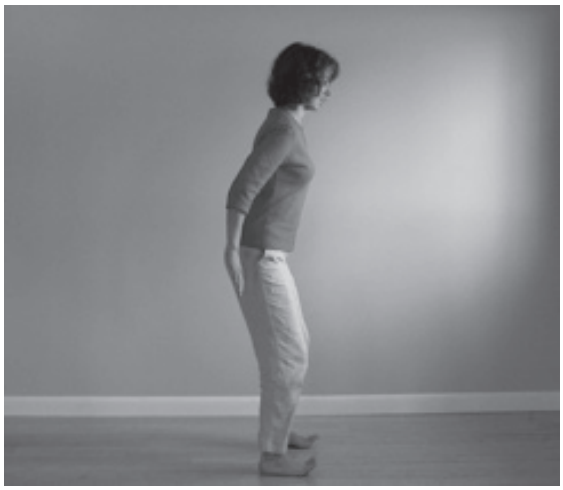
Experiential Exercise: Flowing Motion

Stand in the Tai Chi stance with knees relaxed, tail settled, and crown lifted towards the sky.

The movement pattern for Flowing Motion is simply to raise hands, palms facing up, to the front until they reach shoulder height and then turning hands palm down and dropping them down past your hips, slightly behind the center of gravity. Before beginning, stand quietly and sense your hands, forearms, arms, and shoulders. How many body parts can you sense simultaneously?

Next, begin moving very slowly in the Flowing Motion pattern. Deeply inhale as arms raise and completely exhale as they lower. Move as slowly as you can and once again sense your hands, forearms, arms, and shoulders. How many areas can you sense simultaneously by moving slowly? Continue this for two minutes gathering as much sensory information as possible.

Now begin moving faster, essentially swinging arms up and down. As your speed increases once again sense the previously scanned body regions. How many areas can you sense simultaneously? How does moving slowly versus quickly effect your ability to receive sensory feedback from the body?



Rounded Movement

How we move and use our bodies has been shown to effect neurotransmitter profiles and shifting of physiologic processes (13).

Play researchers observing children at free play (defined as movement without purpose) in sandboxes and playgrounds have noted that they move in rounded and curvilinear patterns. In contrast, when these children are asked to perform work directed tasks, or movement with purpose, they move in linear and angular patterns. These differences have also been noted in animals during play fighting versus attack and defend behaviors; in this way it's easy for us to recognize a playful "bowing" dog from a "rigid," hair-standing-on-end, aggressive one.

Researchers have also discovered that play is a key factor in stimulating prefrontal cortex and cerebellar pathway development, showing that play deprivation at key developmental ages results not only in reduced physical coordination but also decreased cognitive capacities and anti-social behaviors (1).

In his book *Play: How it Shapes the Brain, Opens the Imagination, and Invigorates the Soul*, Stuart Brown notes that play promotes enhanced emotional regulation or the ability to determine what types of responses are most appropriate in a variety of situations. In other words, how do we know when someone is joking or serious, or playful or aggressive? Our ability to sense these things more accurately will determine the ability to regulate our responses in order to facilitate the best outcomes. In addition, Brown reports that regular play enhances mental resiliency and flexibility, meaning that problem solving abilities improve.

Strong similarities between regular play and Tai Chi practice also include research showing that both result in hippocampal neurogenesis (15, 16). Alzheimer's disease is typified by a loss of hippocampal cells, and consistent with functional memory disturbances as well as a variety of neuromotor dysfunctions.

Finally, both play and regular Tai Chi practice have been shown to result in better quality sleep (17). Stuart Brown reports that during REM sleep, the brain organizes efficient use of new material learned during the day. In other words, while awake we are applying different strategies to novel situations in an effort to manipulate a specific outcome; during sleep is when those strategies are integrated to create the most efficient combinations. For this reason high quality sleep is critical for breaking through performance plateaus, where we may feel stuck and fruitlessly trying many different strategies to succeed. Elevating above the plateau is often more a case of discovering the best combinations of things we have learned rather than finding a magic bullet.

Experiential Exercise: Sensing Internal States

Choose a relatively quiet place to sit or stand for a few minutes. Check into your body especially around the area of your neck, throat, chest, and stomach.

Now quietly repeat the word "play" to yourself and bring to mind something that you enjoy doing for the sheer pleasure of it. Allow this idea to naturally shift into images of other play activities that you enjoy. Notice once again how your body responds to play images in your mind's eye.

Next, take a couple deep breaths and repeat the word "work" to yourself and allow images of work tasks to fill your mind. As these images move from play into work, notice again the body areas we have previously considered. Are there any differences? How would you describe what happens in your body when you shift from images of play to images of work?

After performing the above exercise, many people report that they felt more relaxed when imagining play and tense when thinking about work.

It is important to remember that the BodyMind is a two-way street: if play creates a parasympathetic shift and naturally accompanies rounded movements, then does consciously performing curvilinear movements in Tai Chi practice engender a parasympathetic state? The research we have reviewed earlier from Amy Cuddy of Harvard University would suggest so, as she has shown that consciously altering body posture affects neurohormone expression and resultant psycho-emotional shifts. The rounded movement patterns of Tai Chi are meant to resemble flowing water, engendering softness and relaxation, which are also typical of a parasympathetic nervous system shift.

In addition to rounded movement patterns being accompanied by a parasympathetic response, normal joint kinematics might also be considered. In vogue for several decades, both fitness and therapeutic exercises have trended towards resistance-based linear movement patterns with multiple repetitions. A brief review of large synovial joints (ie shoulder, hip, knee, elbow, spine) elucidates that their adjacent surfaces are rounded. In other words, joints are not linear! While substantiating research is not yet available, it is the author's opinion that resistance-based repeated linear exercises might contribute to joint degeneration and perpetuate articular dysfunction. Rounded movement patterns, especially at the shoulders and hips, more naturally approximate joint surfaces and respect normal kinematics. Rounded movements also include multiple joint angles and directions to create complex functional patterns.

In summary, rounded patterns in combination with slow and relaxed movements typical to Tai Chi may naturally engender a parasympathetic nervous system shift, contribute to hippocampal neurogenesis, and improve functional joint kinematics.

Fluid Movement

"Move like water" is a common theme in classic Tai Chi and Chinese literature. In fact, the human body is approximately 75% water, and has the capacity to become suppler with intention and practice.

Recalling the above paragraph on movement efficiency, quality of movement fluidity is directly proportional to the effectiveness of reciprocal muscle activity. Subsequently, slow movement naturally enhances fluid movement that will persist even as functional movement speed increases.

As with rounded movements, mindfully moving in a fluid manner elicits a parasympathetic shift observed during Tai Chi and Qigong practice. Parkinson's disease, associated with decreased levels of dopamine, is characterized by rigid and uncoordinated movement patterns; mild to moderate Parkinson's disease symptoms have been shown to improve with regular Tai Chi practice (9). One possible contribution to this effect may be increased dopamine production in the subcortical brain that occurs during meditation, which is an active component of Qigong & Tai Chi (7).

Dantien Focus

The Qigong paradigm acknowledges three distinct body regions known as Dantiens or elixir fields, which act like energetic storehouses for various physiologic functions.

The lower (Jing) Dantien is in the belly, halfway between the navel and pubis roughly three inches deep; this region also correlates with the human body's center of gravity. The Jing Dantien acts as the "battery" for our physical makeup at the cellular level. For the purposes of RQTC programs, the lower (Jing) Dantien is simply referred to as the Dantien.

The middle (Xin) Dantien is also called the Heart-Mind Dantien as it supports our emotional health, personal expression, and belief systems. Of interest is our discussion in Section 2 where we discussed the importance of the heart's electromagnetic field to system coherence. The Qigong and Traditional Chinese Medicine paradigm consider the heart-mind to be both

the physical and energetic expression of our persona and emotional states; and in fact the Institute for Heart Math has shown that the heart's electromagnetic field indeed fluctuates with different emotions, becoming more coherent with states of compassion and kindness.

The upper (Shen) Dantien, located between a vertical line descending from crown of the head and a horizontal line extending back from the "third eye" point, acts as our connection to spirit. The Shen Dantien has also been located at the pituitary gland, which incidentally contains rods and cones similar to the eyes, and has further supported the "third eye" concept in many ancient cultures.

The lower Dantien (or simply Dantien for our discussion) functionally acts as the body's center of gravity and the point around which all other movement takes place. Consider that any other body part can move closer to or further away from the Dantien, however relative to our body's ability to balance the Dantien consistently remains in the center. Tai Chi practice places great emphasis on mindful and controlled weight shifting initiated from the Dantien or center of gravity (COG), which is referenced frequently in balance related research. Tai Chi principles promote the importance of stepping and grounding the foot *before* committing to shifting weight. This concept is well employed in sports like baseball, tennis, and golf where the front foot is planted prior to powerful skill execution. Therapeutically, encouraging weight shift after foot placement as practiced in Tai Chi safely enhances balance in clients at risk for falling.

The Dantien also acts as the center of the deep core cylinder comprised of muscle groups including transverse abdominis, multifidus, pelvic floor, and diaphragm. Contemporary research points to the deep core muscles' importance in promoting spinal stability and management of back pain, while sports performance training considers core stability key in power development and movement control. Traditional Tai Chi and Qigong practices, at times, included core-pumping techniques to build and move Qi throughout the body. In essence, these internal contractions also strengthen the deep core cylinder and contribute to core stability and decreased back pain. Core-pumping exercises are coordinated with specific breathing techniques as the diaphragm plays an important role in core stability.

Experiential Exercise: Core Pumping

Assume the Tai Chi stance with feet under hips, knees relaxed, tail settled, and crown lifted towards the sky.

Take a moment to feel the spine lengthen slowly. Begin by slowly exhaling completely to engage deep abdominal breathing. Progressively deepen the breath with longer and smoother exhalations. Once your exhalations have deepened bring awareness to your pelvic floor. Still focusing on long and slow exhalations, begin contracting the pelvic floor (as if stopping the flow of urine) during the last 1/3 of your exhale. You may imagine contracting the pelvic floor as assuming a dome shape and squeezing out the last of the breath. Progress slowly and mindfully while remaining in the comfort zone.

Once you feel coordinated with exhaling and pelvic floor contractions bring attention to your abdominal wall. Transverse abdominis contractions are typically performed by drawing your belly button inward towards the front of the spine, and thus begin adding this gentle abdominal draw to the pelvic floor contractions during the last 1/3 of exhalation. Remember to keep your tail settled so that the spine remains in a balanced, neutral position.

In this particular exercise the exhalation is coordinated with abdominal wall and pelvic floor contractions and inhalation with relaxation. Upon inhalation allow the pelvic floor to drop towards the ground as if assuming a bowl shape and imagine the entire abdomen filling like a balloon and expanding in all directions. Eventually this core pumping exercise can be coordinated with more complex Tai Chi form movements to further enhance power development, balance, and functional spine stability.

With regards to clients suffering from chronic back pain, it is well known that the deep core cylinder muscles delay firing when pain is either experienced or anticipated (18). While this concept of core muscle inhibition will be explored further in later sections, it is generally considered that functional core muscle weakness contributes to the perpetuation of low back pain. The Tai Chi posture advocates a neutral and long spine with all movements, including bending and lifting, which as explored above contributes to normal spinal alignment and efficient tensegrity models. In addition, maintaining the Tai Chi posture during lifting enhances core muscle contraction and protective functions.

Experiential Exercise: Core Stability

Assume the Tai Chi stance with feet under hips, knees relaxed, tail settled, and crown lifted towards the sky.

As practiced above, contract and relax the pelvic floor and abdominal wall several times. Next, attempt to maintain a pelvic floor contraction and abdominal draw while lifting your tail high into the air (anterior pelvic tilt). Were you able to maintain the contraction?

Return to the neutral Tai Chi posture and once again contact and relax the core cylinder a few times. Now, once again hold the core contraction while squashing your dinosaur tail down into the ground (posterior pelvic tilt). Were you able to maintain the contraction?

For a further demonstration of core muscle contractibility and posture attempt the contract the core muscles while lifting something light from the ground. Practice holding the core cylinder in all three pelvic positions; tail up, tail squashed, and tail resting.

Silk Reeling

Silk reeling or spiraling movement is easily observed in experienced Tai Chi practitioners, although a novice witness may not actually know what they are seeing. While silk reeling movement is quite beautiful to watch, it can be difficult to comprehend without firsthand experience. Yang Yang Ph.D. notes that the silk reeling spiraling motions, "are a *manifestation* of Taiji (Tai Chi) movement; if the movements are performed in accordance with essential principles, then the spiraling/twining movements of the *chansi jin* (silk reeling) will naturally be expressed and the body will be connected as one big, rotating, Taiji ball (7)."

Essentially, silk reeling movements are the natural expression of correctly employing the body principles listed above, and just like a wonderful soup that was created simply through properly combining high quality ingredients, the final effect is much more than just a sum of its parts. Silk reeling movements contribute to synovial fluid production, joint hydration, blood and lymph circulation, tendon and ligament stretching, and efficient muscular energy transfer.

Since silk reeling movement is the natural expression of all Tai Chi principles it is most readily learned through skilled instruction and dedicated practice.

SECTION FOUR: Breath Fundamentals

Anatomy & Physiology Review

Breath is vital to life and synonymous with "Qi" or universal life source energy.

Human beings breathe on average over 20,000 times per day, highlighting its importance to maintaining life: it is the one distinguishing factor between someone who is dead or alive. Ancient cultures have long considered breathing a method of connecting to higher states of consciousness, linking increased life vitality to being "inspired" or taking in spirit, and of course releasing spirit when we "expire."

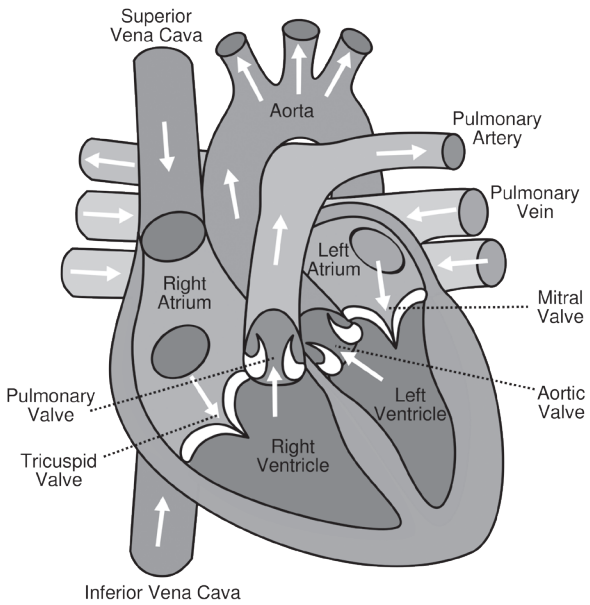
Fully functional breathing stimulates several beneficial physiologic processes including metabolic energy, immune, lymph, and nervous system enhancement.

The cardiopulmonary system feeds life-giving oxygen to the entire body – while it cannot be completely compartmentalized, for present purposes, let's consider the heart, lung, and vascular interface. Adults breathe on average 10-16 times per minute, with a general consensus that less breaths per minute fosters a parasympathetic nervous system shift (6, 11, 12). This simple strategy can easily be implemented clinically by advocating long, slow, smooth, and complete exhalations.

While there are varied opinions on nasal vs. oral inhalation and exhalation breathing, reviewing the pulmonary anatomy can help guide us on purposeful breathing strategies. Inside the sinus passages exist nasal turbinates which act as humidifiers and filters for incoming air. Within these catacomb type structures, mucous and hair trap large particles as well as add moisture to incoming air as it descends towards the lungs. The nasal turbinates are also filled with immune response mechanisms to deal with bacteria and viruses before these pathogens can infiltrate deeper body systems; this becomes readily apparent during common colds when sinuses swell and mucous production increases. For this anatomical reason alone, Rehabilitative Tai Chi practices advocate nasal inhalation as the oral system offers little defensive capabilities for incoming pathogens.

In addition to structural and immune defenses, the nasal turbinates also house nervous system sensors that relay information to the hypothalamus, which modulates autonomic nervous system function. It is has been established that forced unilateral nostril breathing results in specific global autonomic nervous system changes (16). Unilateral left nostril breathing tends to promote a parasympathetic shift while right nostril breathing engenders a sympathetic nervous system shift (6, 16).

As air descends, oxygen is brought into the lungs where gas exchange can take place in the alveoli. Oxygen tends to be diffused into the bloodstream while carbon dioxide is diffused out into the breath cycle. (While once carbon dioxide was considered simply waste, presently science is coming to realize its importance in determining breath rate and blood PH (12).) Once oxygen is exchanged into the blood stream, it is transported towards the heart in the pulmonary vein, where the cycle of circulation can be seen in the figure below.

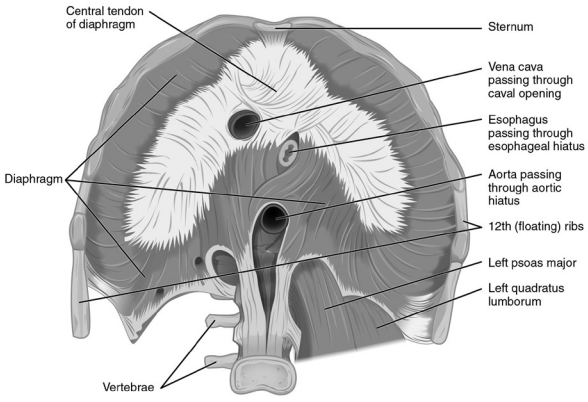


The pulmonary system is intimately tied to the cardiac system and so they are generally considered together. Vital gases brought into the lungs are exchanged into the cardiopulmonary circulation and transported through miles of vascular tissue by the heart. Heart rate and breath rate are also intimately connected with increased respiratory rate resulting in an increased heart rate and vice versa. Breath is both an autonomic and volitional function, meaning that breathing happens when you're not thinking about it, yet you can control and manipulate it at any time. This allows us to manipulate internal cardiac physiology by consciously altering breath patterns (16).

Breath rate is regulated in large part through a series of feedback and autonomic mechanisms triggered by baroreceptors and chemoreceptors in the aorta. Referencing figure 4.1, you will notice that the aorta is the first vessel to receive blood after being ejected from the left ventricle. Like a quality control expert checking products before leaving the factory for distribution, baroreceptors and chemoreceptors feed specific information to the brainstem in order to maintain physiologic balance. Baroreceptors are "stretch" sensitive and relay information to the brainstem regarding how hard the heart is contracting, while chemoreceptors provide feedback information on oxygen, carbon dioxide, and blood PH. The mechanical and chemical information feedback to the brainstem allows the nervous system to adapt to internal conditions and maintain homeostasis. For example, during vigorous exercise, oxygen, carbon dioxide, and blood PH alter; this requires specific neural adaptations to in turn maintain healthy blood gas and PH levels.

While in general our goal tends to be slowing down the respiratory rate to promote a parasympathetic nervous system shift, we also need to consider compensatory hyperventilation, which can occur with hypoglycemia, diabetes, and kidney disease. Blood carbon dioxide and PH levels can alter significantly with the above-noted conditions, resulting in a natural compensatory hyperventilation response. In considering this possibility it is best to move forward cautiously when promoting any volitional breath change strategies, especially if physiologic mal-adaptations like dizziness or nausea are regularly noted.

As mentioned during the introduction of "efficient breathing" in Section Three, the diaphragm is the primary muscle of respiration; viewed from below in figure 4.2, it acts as the roof of the abdominal cavity. The diaphragm is dome-shaped at rest and bowl-shaped during abdominal inhalation. It has connections to the lumbar vertebrae, xiphoid process, and ribs 7-12, which fan outward like a lofted parachute. Returning to our earlier efficient breathing experiential exercise, we recognize that the diaphragm functions best while we assume the Tai Chi posture.



Diaphragm (inferior view)

Natural Breathing Methods

Traditional Qigong and Tai Chi practices generally consider three basic forms of natural breathing, all of which can be observed in children who have no formal breath training practice.

The first natural breath method is *stress* or *survival breathing*, which occurs during the sympathetic nervous system response. (As indicated earlier, the stress response is neither good nor bad; it is simply appropriate or inappropriate for any given condition. In life-threatening situations the stress response becomes important and necessary for survival.)

You may have experienced survival breathing if you've ever been chased by a dog or been involved in a physical or verbal altercation; this breathing method can also be witnessed in children's heaving chests during a crying fit. During the sympathetic nervous system response, breathing shifts rapidly up into the chest in order to ventilate oxygen quickly and expediently. Tension in the neck and redness in the face and head often occur along with this breathing method, indicating accessory muscle breathing and elevated blood pressure.

The efficiency of this method, however, is short lived. Anthropologically the stress response was designed to last for a short period of time, after which normal physiological process would resume. A dysfunction characteristic to modern times is our tendency to suffer from consistent low-level stress states and experience chronic survival breathing patterns, sometimes called upside down breathing. It is also worth mentioning that chronic survival breathing encourages a continued sympathetic nervous system shift creating a negative feedback loop, which can become insidious in nature.

Abdominal breathing, the second natural breath method, can be observed in children quietly at play or resting comfortably in bed. Abdominal breathing is characterized by an apparent expansion and contraction of the abdomen and typically registers a parasympathetic nervous system shift.

This breathing method is the primary breath method during Rehabilitative Tai Chi practice, as will be highlighted in greater detail below.

Reverse abdominal breathing, sometimes called the *bracing breath*, can be seen in infants pulling themselves to standing – their abdominal wall contracts upon inhalation. During reverse abdominal breathing the diaphragm still drops; however, the breath is visualized as going back towards the spine or up into the solar plexus. In essence the breath now has both a horizontal and vertical component: Qigong masters describe visualizing moving a pearl either back and forth or up and down in the abdomen during reverse abdominal breathing (2).

This natural breathing method may seem paradoxical at first; however, it is the primary breath method taught in Chen Style Tai Chi. There is some controversy around the reverse abdominal breathing method, with some Tai Chi experts believing that it is potentially unsafe and unnecessary, while Chen Style Tai Chi masters note that reverse abdominal breathing is the most efficient breath practice.

The Rehabilitative Tai Chi methods primarily use basic abdominal breathing for the majority of practices, but do include reverse abdominal breathing specifically for spine and core stabilization.

Experiential Exercise: Reverse Abdominal Breathing

Assume the Tai Chi stance with feet under hips, knees relaxed, tail settled, and crown lifted towards the sky.

Take a moment to feel the spine lengthen slowly. Notice the natural rhythm of your breath and slowly begin to contract the pelvic floor on inhalation. This will most likely feel foreign at first, as it is the opposite of standard abdominal breathing. Continue contracting the pelvic floor on the inhalation and relaxing on the exhalation.

Once you feel comfortable with coordinating the breath with pelvic floor contractions then include the abdominal draw, contracting with the inhalation and relaxing with exhalation. Imagine moving a pearl towards the spine with inhalation and towards the front with exhalation. Proceed slowly and gently – but notice the degree of core muscle activation with this breathing method.

In Rehabilitative Tai Chi Core and Spine Stability programs, reverse abdominal breathing is coordinated with functional movement patterns.

Abdominal Breathing Effects

The importance of abdominal breathing from a physiological perspective can be explored through four topics, including metabolic energy production, immune function, lymph function, and nervous system activity.

Metabolic Energy

Metabolic energy production takes place in cellular organelles called mitochondria, which primarily employ aerobic respiration (meaning that it involves oxygen; anaerobic respiration is metabolic energy production without oxygen and is much less efficient then aerobic respiration).

The aerobic respiration process is basically described in the Krebs cycle as:

$$C_6H_{12}O_6 + O_2 + BMR = CO_2 + H_2O + ATP$$

Or in other words, glucose plus oxygen plus metabolic enzymes equals carbon dioxide plus water plus energy.

Oxygen is a primary substrate in metabolic energy production and the aerobic respiration process is dose dependent, meaning that if we add more oxygen then more glucose and metabolic enzymes will be called upon to produce more carbon dioxide, water, and energy. Low metabolic energy states are consistent with feelings of fatigue, lethargy, and depression, which act as barriers to the rehabilitation processes. Increasing normal and healthy oxygen levels are paramount to our success as rehabilitative professionals – and it is simply a breath away.

As described above, dysfunctional upside down breathing becomes habituated and creates a diminishing return on investment from a breath efficiency standpoint. Inefficient chest breathing takes place primarily in the top of the pyramid-shaped lungs, whereas complete abdominal breathing empties the lungs completely (including a one-third-reserve capacity that is rarely turned over). In fact, in terms of oxygen capacity, chest breathing has been shown to be five to seven times less efficient than abdominal breathing (6, 12). Chest breathing perfuses roughly five ounces of oxygen per breath, while a complete abdominal breath exchanges thirty-two ounces. Considering adults breathe between 20-22,000 times per day, taking a complete breath just 1% of the time would mean an additional 200-220 liters of oxygen each day.

As dysfunctional upside down breathing becomes habituated, consciously altering breath patterns may become more difficult. Rehabilitative Qigong and Tai Chi methods focus on long, slow, smooth, and complete exhalations in order to stimulate and natural abdominal breath. Recall from Section Three the experiential exercise on efficient breathing where a complete exhale in the Tai Chi stance resulted in an effortless inhalation. With the addition of extra energy to the physiologic system as a result of complete abdominal breathing, internal resources including immune and brain function become enhanced.

Immune & Lymph Function

Immune function is largely dependent on the internal actions of oxygen and resultant ATP (energy). Long

term research on cardiopulmonary risk factors conclude that breath capacity plays a vital role in disease generation and early mortality (13). Similarly, a thirteen year longitudinal study of cardiac risk and lifestyle concluded that vital breath capacity was a more important indicator of early death and disease than levels of blood insulin, blood cholesterol, or tobacco use (14).

The lymph system is key in systemic detoxification and circulates fluid through the body in four ways: gravity, muscle contractility, smooth vessel wall elasticity, and breathing. Tai Chi practices inherently include all four of the lymph circulation processes, further lending efficacy to its ability to promote wellness and healing.

There is no dedicated lymph heart such as with the cardiopulmonary system. Of the four primary lymph circulation processes, breathing is the single most potent lymph pump. Abdominal breathing positively affects lymph circulation via two primary mechanisms: aerobic and mechanical propulsion.

Recalling the Krebs cycle below, notice that increased oxygen will also result in more water output.

$$C_6H_{12}O_6 + O_2 + BMR = CO_2 + H_2O + ATP$$

Mitochondria inside the cell produce water as a byproduct of aerobic respiration, which in turn is diffused outside of the cell when cellular water capacity is met. As water exits the cell metabolic byproducts are carried into extra cellular spaces, meaning that an increase in intracellular water production results in greater cellular detoxification (6). This is known as aerobic propulsion.

Mechanical propulsion includes the natural action of the diaphragm during abdominal breathing. The increased extracellular fluid, as a result of aerobic propulsion, is taken up by lymph vessels and transported to primary lymph chambers including Cisterna Chyli and Thoracic Duct.

Cisterna Chyli resides in the abdomen where upon deep abdominal breathing it is compressed by the diaphragm and its lymph contents are mechanically squeezed vertically into the Thoracic Duct (imagine a bag of fluid on the ground with a pipe sticking vertically out the top; if you step on the bag, the fluid is projected upward through the tube). The Thoracic Duct, located in the chest, is compressed as the lungs descend during abdominal breathing, once again mechanically moving lymph up into the subclavian vein.

Once in cardiopulmonary circulation, metabolic byproducts can be excreted primarily through the breath and skin, with breath affording 70% of the body's cellular detoxification (10). By observing fragile and discolored skin in conditions such as Chronic Obstructive Pulmonary Disease (COPD) we see evidence of poor systemic detoxification occurring through the breath.

Nervous System Activity

As touched upon earlier, autonomic nervous system function is highly dependent on breath quality, with slower, deeper breaths engendering a parasympathetic nervous system shift.

Imagine flipping a light switch up and down, on and off respectively. The breath, acting in a similar manner, shifts the autonomic nervous system from sympathetic to parasympathetic (essentially on and off), creating an environment conducive to healing – recall that in Section One, we explored the physiologic effects associated with both sympathetic and parasympathetic shifts, and recognized that cellular healing takes place primarily during parasympathetic dominance.

Breath Fundamentals: A Summary

In summary, natural abdominal breathing elicits a parasympathetic shift through autonomic feedback mechanisms, stimulates cellular energy production, enhances cellular detoxification, and activates robust immune function.

Clinically, abdominal breathing is best taught through exhalation focus and in combination with gentle movement.

Experiential Exercise:
Coordinated Breathing with Flowing Motion

Stand in the Tai Chi stance with knees relaxed, tail settled, and crown lifted towards the sky.

The movement pattern for Flowing Motion is simply to raise hands, palms facing up, to the front until they reach shoulder height and then turning hands palm down and dropping them down past your hips, slightly behind the center of gravity.

Begin moving very slowly in the Flowing Motion pattern. Deeply inhale as arms raise and completely exhale as they lower. Move as slowly as you can and pace your movement with your breathing. Focus on making the exhalation long, slow, smooth, and complete.

Does the inhale want to rush in after complete exhalation? Notice the body's tendency to want to gulp air and slow the inhalation to match the rate of exhalation. Find a comfortable pace of movement and continue coordinating inhalation-up and exhalation-down.

This simple exercise is profoundly shifting internal psychological, emotional, and physical physiology.

SECTION FIVE: Vision & Visualization

Functional Vision

For humans, sight has easily become our most relied upon sense – often this means that we take it for granted as well as depend on it too much.

We of course associate seeing with the eyes; however, the eyes are simply portals of information into the brain where all central processing takes place and from where responses are generated. Our brains are constantly reorienting body alignments based on information conveyed through visual pathways. These adjustments are generally reflexive in nature and so occur below our level of conscious awareness.

Tracing the optic nerve, the first synapse on the visual pathway is in the thalamus. The thalamus acts as a primary routing center for all sensory information coming into the brain from the periphery, with initial routing to the limbic system, otherwise known as our "emotional brain." Incoming sensory information take about 8 milliseconds to reach these emotional centers. After leaving the thalamus, optic information is routed to neuro-motor reflexive areas in the midbrain as well as the visual cortex. (All incoming sensory information is processed in the limbic system before the cortex, meaning that, as humans, we are always emotional first and rational second – we "feel" before we "think.")

Neuro-motor reflexive responses occur prior to object identification and are consistent in supporting the direction of gaze. For example, have you ever been working in the yard and caught something in your peripheral vision which caused you to reflexively jerk away only to discover that it posed no direct threat? If so, you have experienced a reflexive response prior to object identification. This idea of using the visual system to affect neuro-motor reflexive responses can be very helpful in guiding clients to achieve specific functional tasks: in other words, where the eyes go the body tends to go.

Research on muscle activation reveals that gaze direction has a direct effect on cervical muscle recruitment (3).

Experiential Exercise: Gaze Direction

Sit in a chair while assuming the Tai Chi Posture with feet on the floor, tail settled, and crown of the head lifted towards the sky.

Look directly ahead and then move only your eyeballs to the left. While keeping your eyeballs left, turn your head to the left and assess the relative effort this movement requires. Now return to looking directly ahead and once again move only your eyeballs to the left. While keeping your eyeballs left, this time turn your head to the right and assess the relative effort this movement requires.

Which direction is easier to turn?

The above exercise usually reveals that cervical rotation occurs more easily in the direction you're looking; likewise, it's been shown that in normal subjects, patterns of cervical muscle recruitment are predictable with directional gaze (3). In contrast to normal subjects, people suffering from whiplash-related disorders show higher and more variable levels of overall cervical muscle activation with gaze directed rotation. These findings further highlight a functional relationship between gaze direction and cervical muscle activation as well as suggest the basis for clinical symptom reporting of visual disturbance and postural control dysfunction in whiplash clients (4).

In addition to cervical muscle function, visual gaze focused at peripheral targets has also been shown to heavily affect motor systems responsible for moving the feet (6): in other words, where your eyes go your feet go. On a gross motor level, direction of gaze markedly affects physical performance; consider skiing and bicycling, where staring at something that you don't want to hit can often result in its actually occurring.

Visual gaze also has a profound effect on both proprioceptive and vestibular function in reorienting automatic postural reactions (7). The proprioceptive system is responsible for conveying joint position information to the central nervous system so that postural adjustments can be made to maintain balance. In a similar manner, the vestibular system conveys information from the inner ear regarding how level the head is being held. This research has shown that both proprioceptive and vestibular input is processed in context to visual control and a horizontal frame of reference. Clinically this is seen in clients with cervical torticollis or a rigid, laterally tipped neck: in order to return to a horizontal gaze, they often side bend the spine and inadvertently cause spinal pain and dysfunction.

In a study of patients with Vestibular Hypo-function, both traditional vestibular rehabilitation (VR) and Tai Chi were shown to improve functional balance measures, but via different mechanisms; the traditional VR group improved via vestibular-ocular reflexes while the Tai Chi group showed improved lower extremity neuromuscular patterns (8). (In contrast to the Rehabilitative Tai Chi body, breath, and vision principles focus, the Tai Chi group in this study did not include visual scanning as part of practice. We can only wonder what results a combined Tai Chi and traditional VR group may produce.)

While implementing visual focus as a key Rehabilitative Tai Chi principle, we take advantage of gaze and automatic neuro-motor responses as described above. These automatic responses tend to support direction of gaze, mediate the proprioceptive and vestibular systems, as well as enhance balance function.

Visualization & Mental Imagery

It's been said that the body can't tell the difference between what the mind sees when the eyes are open or closed. In other words, the body has a physiologic response both when it sees something in the objective world and when it's imagined. Recall a time when you had an argument with someone: how does the memory make you feel? If the answer is "tense and upset," it's most likely because you are still imagining the argument.

Visualization can be categorized into three basic types: mental imagery, mental practice, and visuo-motor behavioral rehearsal (VMBR). Mental imagery is simply imagining something like a bird, horse, or car. Mental practice is the act of visualizing a specific action or technique like hitting a golf ball or riding a bike. VMBR is similar to mental practice however adds in a kinesthetic component where the action is not only visualized but also "felt" in a first person perspective.

Visualization research supports the idea that mental imagery affects physiology, and has been proven in the areas of motor recruitment, skill performance, balance, skin temperature, and immune function.

Various studies focused on visualization and motor function show that mental imagery subjects consistently increase strength and power output in visualized muscle groups, and in some cases outperform actual physical practice subjects (9, 10, 11).

Skill performance studies have focused attention both on positive and negative mental practice. Research on putting accuracy divided subjects into three groups including physical practice, positive imagery, and negative imagery. Following six consecutive days of actual putting practice, the physical practice group improved accuracy 9.9%. The positive imagery group, focused on the mental practice of sinking puts improved 30.4%. The negative imagery group, focused on the mental practice of missing puts had an accuracy decrease of 21.2% (12). In a similar study of dart throwing accuracy, a positive imagery group improved accuracy 28%, while the negative imagery group decreased accuracy 3% (13). Each of these studies highlights that in affect our physiology consistently acts to support our most consistent mental practices regardless of whether or not they are desired.

Immune function is another important area of mental imagery research. A study on the effects of guided imagery on surgical stress and wound healing revealed that visualization subjects had less anxiety, lower cortisol levels one day after surgery, and less surgical wound erythema than the control group (14). A critical review study of the effects of guided imagery on the immune system showed that cell specific imagery affected corresponding white blood cell counts, neutrophils, and lymphocytes (15).

Therapeutic application of mental imagery in rehabilitation settings has shown positive results with strokes, intractable pain, brain activity, cancer, and sports rehabilitation (16, 17).

While various studies follow different parameters of visualization practice, five components of effective mental practice have been identified:

The first component is to create a clear and vivid image of the practice task; this may include well-defined objects borders and bright colors.

The second component is to add action or movement to the image; this may include performing a specific task like hitting a golf ball or imagine white blood cells gobbling up a tumor.

Next, adding a kinesthetic component is valuable, which may include imagining the feeling a golf club in your hands or a warm sensation in the tumor area that the white blood cells have devoured.

Symbolic imagery has also been shown to alter physiologic function and performance. This may include visualizing a rail between the golf ball and hole on which the golf ball rides or having the cancer tumor change from a putrid, black mass into a bright white light.

Finally, visualizing the desired outcome is critical to successful mental imagery. As seen in the above skill performance studies, outcomes are more likely to manifest with consistent visualization even if that particular outcome isn't desired. In other words, even if all the other components are in place to support wining the golf game, if you imagine missing the putt, your body will alter its physiology to support missing the putt.

In Rehabilitative Tai Chi both vision and visualization play a key role. Visual tracking is included in the majority of Rehabilitative Tai Chi gestures to enhance vestibular function, directional muscle activation, spine range of motion, balance, and foot coordination. In addition to functional vision practices, Tai Chi is rich with symbolic imagery to evoke specific physiologic states.

Experiential Exercise: Cloud Hands Visualization

Assume the Tai Chi posture in sitting.

Begin performing Cloud Hands as we practiced earlier by holding your left hand approximately 18 inches away from your body at shoulder level and looking at your palm while your right hand is at waist level with palm facing the floor. Slowly turn your body to the left and when you have turned as far as comfortable switch hands by lowering the left and raising the right. When the right hand is at shoulder and the left at waist heights slowly turn your body to the right again reaching the comfortable end of rotation and switching hands. Continue turning from the waist slowly side to side.

Now focus vision on your upper hand as it crosses your visual field. Follow it all the way across the body until your hands switch places. While your hands switch, focus your vision as far in the distance as possible, outside a window or against a far wall. When the hand switch is completed once again focus your vision on the upper hand and follow it all of the way across the visual field until the hands switch again. When the hands switch, once again focus on a point in the far distance.

This process of focusing from near to far encourages convergent and divergent muscle activity in the eyes and improves both vestibular function and eyestrain.

(Another variation is to imagine that your hands are clouds. As your hands drift back and forth across the visual field image you are watching clouds float across the sky. Allow your hands to relax, become soft, and drift effortlessly.)

SECTION SIX: Painless Rehabilitation & Movement

The philosophy of Tai Chi emphasizes moderation and balance in all things, including the way we approach healing and rehabilitation. Often the expectation is that the healing process must become faster and follow the established guidelines of care set by third party payers; however, the body pays allegiance to no such authority. In one of life's great paradoxes, the body heals fastest when we intentionally slow down.

Rehabilitative Tai Chi principles likewise follow the philosophy of moderation with regards to pain and movement during the healing process.

Our new understanding of contemporary pain science has been greatly influenced by the work of David Butler and Larimer Moseley as outlined in their book *Explain Pain*. The graded and imagery-based treatment approaches advocated in *Explain Pain* further substantiate the ancient Qigong and Tai Chi methods of meditative movement with moderation (say that three times fast).

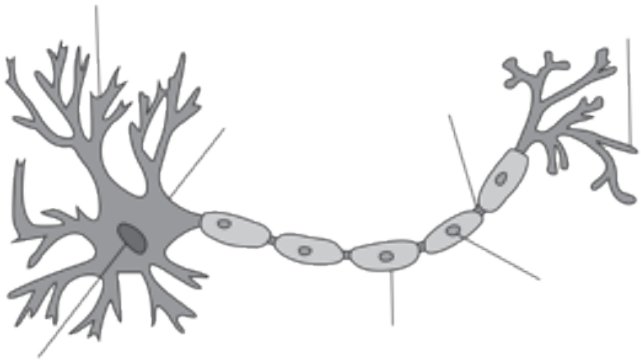
Pain Physiology

In Section One, we highlighted the differences between the somatic and autonomic nervous systems, which we will continue to expand upon below.

Somatic	Autonomic
Receptors	Sympathetic
Peripheral Nerves	Parasympathetic
Spinal Cord	Glands
Brain	Hormonal
Volitional	Perceptual

The Role of Peripheral Receptors

At the end of every sensory nerve there is a receptor that receives input from the environment.



There are four basic types of peripheral receptors: mechanical, temperature, chemical, and nociceptive. Input may come in the form of pressure, touch, temperature changes, or changes in the PH balance.

When someone shakes your hand, thousands of pressure and touch receptors are activated sending an electrical signal to the brain via the spinal cord. It is obvious that many of these receptors are found in the skin; however, muscle and joints are densely packed with them as well. There are also free nerve endings called nociceptive receptors located throughout your body, capable of receiving input from multiple sources. It is important to understand that these receptors don't send pain signals to the brain, but rather information about the environment: these receptors are not processing centers, they are receiving points. It is up to the brain to decide if something is painful.

It is also interesting to note that these receptors often have specific thresholds of activation: the brain will generate a painful response long before actual tissue damage can occur.

As an example for mechanical receptors, take your right index finger and slowly bend it backwards as far as possible using your left hand. At a certain point you will most likely experience some pain and release the stretch. You have just stimulated stretch receptors in the joint sufficiently to cause great concern in the brain, which in turn gave you the experience of pain to lead you to stop the activity. Of course even after doing this, your finger works just as well as before; no damage was caused to any tissues, yet pain was still experienced.

Temperature sensors can be tested in the same way. Remember the last time you placed your hand accidentally on a hot stove and jerked your entire arm away in response. This time your temperature receptors were stimulated, and if you moved your hand quickly enough no tissue damage resulted.

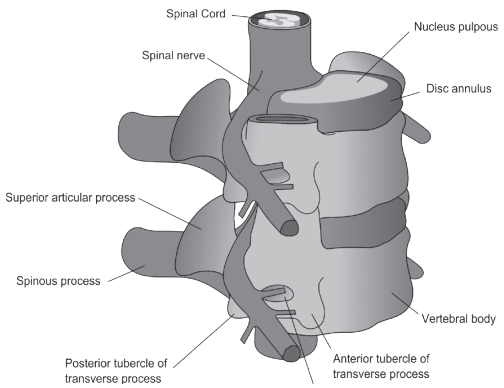
Lastly the chemical sensors can be tested. Have you ever diced hot peppers without gloves and then unintentionally touched your eye? Again, intense pain, most likely with no resulting damage.

What a fantastic nervous system we have; it actually protects us by generating pain **before** anything gets damaged. This is important because during rehabilitation, especially in the later stages, the amount of pain you are experiencing does not necessarily equate to tissue damage (this of course does not give us the right of way to push through pain just because tissues may not be getting damaged). Receptors have the ability to become more sensitive over time to consistent stimulus, and the nervous system has the ability to generate more receptors so that the entire region may become more sensitive and efficient in sending that stimulus to the brain. This may contribute to the Water Torture technique being so painful: one wouldn't think that having a single drop of water landing on the forehead would be painful at all; however, over time as the skin adds receptors and becomes more sensitive, every single drop of water would become more excruciating.

These changes in receptor number and sensitivity aren't necessarily permanent; however, because of cascading events up the neurological chain to the brain via the spinal cord, heightened pain perceptions can be a struggle to overcome.

Role of the Spinal Cord

The spinal cord acts as a functional gateway between the peripheral and central nervous systems, which means that it must be imbued with certain features to help with the transfer of both incoming and outgoing information. Sensory signals, such as those coming from receptors, enter in the back or dorsum of the spinal cord; while motor signals to cause muscle contraction or vascular changes exit from the front or ventral side of the spinal cord.



Practically all the sensory information coming through the back of the spinal cord will cause some type of motor response, and much of this activity happens as a monosynaptic reflex. In other words, the spinal cord has the ability to cause muscle contraction to occur as a direct result of some stimulus without first sending that information to the brain. In addition to this the spinal cord has the ability to amplify that motor response up to twenty times greater than the incoming sensory signal (6).

Let's use the example of placing your hand on a hot stove to clarify. When the sensors in your skin detect a rapid temperature change, that information is sent quickly to the spinal cord before going to the brain. Because the stimulus is of heightened intensity the spinal cord routes a signal immediately down the motor fibers, which will act to jerk your hand away from the stove. Almost always you are moving away from danger quickly before you even know what the threat actually is; your body is moving reflexively even before your brain can assess the problem. This is the way our physiology consistently acts: sensory information in and motor activity out.

So how do large areas of the body respond simultaneously to a relatively small area of incoming stimulus?

The spinal cord branches into 31 pairs of spinal nerves, which communicate with the entire body including over 700 muscles, 206 bones, and multiple organ systems. Considering this large disparity in spinal nerves to peripheral structures, obviously some communal innervation must occur, where on average each spinal nerve is responsible for approximately thirty muscles. We recognize this feature with dermatome and myotome distributions where spinal nerve compression will affect wide areas of sensation and multiple muscle groups. With regards to monosynaptic reflexive responses, with sufficient input the spinal cord will amplify the incoming sensory information up to twenty times and cause an excessive motor response, which will spill over into the muscles that share the spinal nerve of the threatened region.

The spinal cord doesn't only act this way with high intensity stimulus but also low intensity, consistent stimulus. This helps explain the common occurrence of chronic muscle pain and those hard knots in muscles called "trigger points." Those knots are areas of localized muscle contraction and inflammation and are perpetuated by a reflex response. These "trigger points" are initially formed by physical trauma, emotional stress, posture or movement dysfunction, and exposure to harsh environments. Once formed, the PH balance of these muscular trigger points turns acidic secondary to high levels of inflammatory chemicals, and mechanical sensors are stimulated because of constant low-grade muscle contraction. These sensory signals are sent up the chain to the spinal cord which sorts and amplify the signal into a motor response causing a further increase in the local muscle contraction. This reflex loop essentially becomes a vicious cycle of irritation causing muscle contraction and muscle contraction causing further irritation.

When a signal enters the spinal cord through the dorsal root ganglion for sorting, the peripheral nerve synapses, or jumps a gap, to another nerve so that the signal can get propagated up to the brain. At the synapse the incoming electrical signal is transformed into neurochemical information where it is transferred across to once again become electrical. It's like a pony express rider carrying a message until he reaches a river: at the river he hands the letter to the ferry man who paddles across the river and hands it in turn to another rider.

Normally whatever message is being brought to one side of the river should be the same as the other side. In other words we have to trust that the ferry man will deliver the letter intact and unadulterated.

With this in mind, the ferry man also has to be sure to deliver the message to the correct rider on the other side. If he receives a message written in a certain language, say French, then he must be sure to deliver it to a French rider on the other side. Delivering it to someone who only speaks English wouldn't work.

Recall that physiologically, the electrical signal being carried from the peripheral receptors will contain either mechanical, chemical, temperature, or nociceptive information, and that the nerve endings on the far side of the synapse will also have these specific receptors to receive those specific signals. This is important to know because at the level of the spinal cord, when a message carrying information about mechanical changes (like finger position) arrives, it can only be interpreted accurately by the brain if it is carried by a nerve that speaks mechanical signals.

Essentially, on the other side of the river, many options exist for the ferry man. He has to choose between receptors for mechanical, temperature, PH, or nociception (which carry noxious or threat signals).

In cases of chronic pain, two common problems occur specifically at the river.

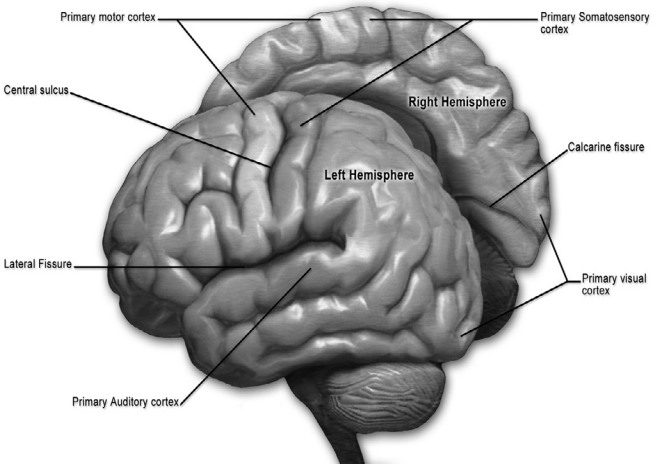
Sometimes the ferry man changes the content of the letter and makes it a bit more urgent. For example, maybe the letter originally says, "Dear Aunt Millie, your favorite sister had the sniffles but is feeling much better." However, after the ferry man gets ahold of it, he changes it to, "Dear Aunt Millie, your favorite sister is near death and won't last the night!" You can imagine Aunt Millie's reaction to this awful news: it will undoubtedly be out of proportion to the original message. When this happens in the spinal cord it is called hyperalgesia. Your brain receives a signal out of proportion from the original message and will create a pain experience equal to its perception of the events.

Another problem at the river crossing is when the ferry man does indeed deliver the message to the wrong rider on the other side. Most often this happens in the case of a mechanical stimulation message being delivered to a nocioceptive or threat nerve. When a mechanical message is delivered to mechanical nerve, the brain receives accurate information about joint position or muscle stretch. When a mechanical message is delivered to a nocioceptive nerve, the brain receives the sensation of being threatened because that is the only information those nociceptive nerves know how to carry. This explains why in chronic situations relatively simple and benign movements can be interpreted as being painful by the brain. This is called allodynia.

These two situations may occur in the rehabilitation setting when the patient with chronic back pain has difficulty with even simple trunk movement (hyperalgesia) and post surgical patients have excessive pain even with light touch around the surgical site for several months after surgery (allodynia). Once again, these changes in the spinal cord may not be permanent, but are certainly persistent.

Role of the Brain

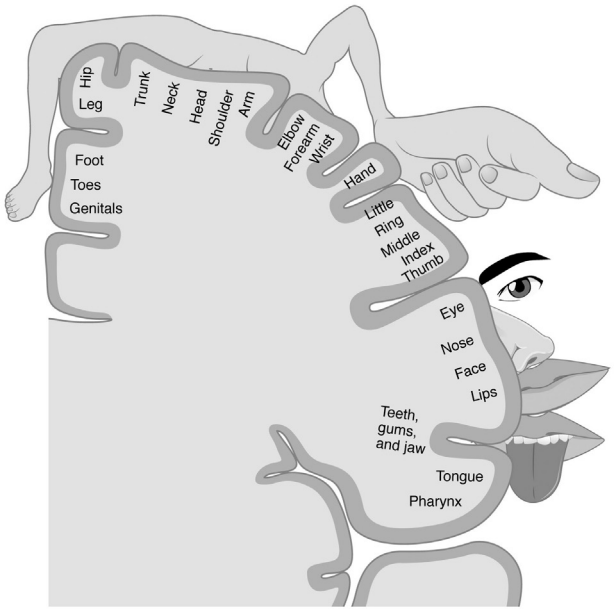
In addition to its gateway and reflexive activity, the spinal cord acts as a conduit for information traveling both to and from the brain.



As seen in the image above, the brain contains both a primary somatosensory and motor cortex. Incoming sensory information eventually lands in the somatosensory strip while outgoing signals are generated in the motor cortex. Notice how these primary cortexes are located both on lateral and superior medial brain surfaces as if they were a door hanging that wraps over the top of the door and hooks on the inside.

The homunculus acts as the brain's virtual map of the body with the amount of nerve tissue denoted to specific body regions related to the size of homunculus structures. For example, notice that the homunculus hand is larger than its foot relating to us that more brain resources are allocated to hand function than foot function.

The figure below highlights the homunculus where the brain is imaged from the front.



Once again notice how peripheral regions associated with the lower extremities are represented on the medial aspect of the cerebral cortex.

In normal situations, information coming in from peripheral receptors travels up nerves to the spinal cord, which in turn relates that information up to the brain with the information terminating at its represented area on the somatosensory strip. During functional MRI's, when a subject's index finger is stimulated, the somatosensory area relating to the index finger lights up with well defined borders.

Chronic pain has been associated with a process known as neural "smudging," where sensory stimulus at a peripheral region results in undefined borders in corresponding somatosensory regions. For example, if the index finger were consistently stimulated with noxious input, then the spinal cord would be more likely to amplify the ascending information as described above. This ascending information would continuously bombard the homunculus region associated with the index finger, and over time neural adaptations would result such that neural tissue would expand to accommodate the increased level of input – supply and demand, so to speak. Notice on the homunculus that the thumb and middle finger lay adjacent to the index finger. In this case of consistent heightened ascending stimulus a functional MRI would indicate that the brain lights up in the middle and thumb regions as well, explaining why chronic pain seems to spread into areas apparently uninvolved body regions.

The brain in fact has no direct experience of the outside world, and actually receives all of its information second hand, as every incoming sensory channel has at least one synapse. It may be considered the CEO of a huge company – it never gets to leave the office, and must receive all of its information from employees running in and out of the room. Even with this apparent liability, the brain makes trillions of decisions a second, 95% of which occur below conscious awareness.

With regards to pain, the brain takes into account a summary of incoming sensory information, plus our emotional states, thought patterns, and memories. Recall that there are no specific "pain sensors" in the periphery; this option is left up to the brain. In short, pain is *output* and only if the brain decides that the summary of incoming and stored information is *threatening* will it create an experience of pain.

Evidence of this can be seen with phantom limb pain: clients who have had a leg amputated often complain of pain in the foot that is no longer there, in the space where the foot was (not on the end of the amputation). If pain sensors existed in the body, how could this be possible? The painful input is no longer present.

Delay in core muscle activation is well known in subjects with chronic spine pain. Studies on the physiologic effects of anticipating pain reveal that subjects with no history of back pain experience a delay in core muscle activation when expecting back pain (9). Additionally, research has been done showing that people rate pain as being higher when in the presence of loved ones, and that violinists rate finger cuts as being more painful than dancers do (1).

Each of these studies indicates that emotional perceptions and underlying belief systems affect pain perceptions and physiologic responses.

Autonomic Influence

The autonomic nervous system also makes contributions to pain physiology and our resultant pain perceptions.

In general, sympathetic nervous system activation will heighten peripheral receptor sensitivity and heighten pain perceptions. In reverse order, consistently pushing receptors past reasonable thresholds will in turn activate a sympathetic nervous system response.

A parasympathetic nervous system shift has been associated with a release of endogenous endorphins, which decrease pain perceptions.

Sympathetic	Parasympathetic
heightens pain experience	endogenous endorphins
increases sensitivity	descending inhibition
increases muscle tension	decreases muscle tension
immune system deregulation	optimal immune function
cortical shut down	higher cortical activation
vasoconstriction improves	circulation
protective movements*	creative movements*

Neuromuscular Compensations

When the brain determines that incoming sensations are threatening, a pain perception is created.

Included in this pain response are automatic neuromuscular recruitment patterns designed to protect the body from further harm. These patterns of recruitment are intended to be short-lived emergency responses, not long-term functional strategies; however, often in the case of chronic pain they persist.

In general, muscles can be categorized into two types: mobilizers and stabilizers. The features of each are listed below.

Mobilizers	Stabilizers
fast twitch	slow twitch
anaerobic	aerobic
produce torque/power	maintain joint balance
concentric function	eccentric/isometric function
fatigue easily	fatigue resistant
often superficial	often deeply placed
small proprioceptive role	major proprioceptive role
tighten & shorten*	lengthen & weaken*

From the lists above we can see that during pain perceptions the sympathetic nervous system activates, which is associated with protective movement strategies. In addition, following pain and injury the mobilizing muscles tend to tighten and short while the stabilizers will lengthen and weaken (2). (There is also an agonist/antagonist relationship between these groups, with the mobilizers tending to inhibit the stabilizers.)

These imbalances tend to perpetuate long after cellular healing has taken place and contribute to chronic pain experiences (1, 2). An example of this occurs in core musculature following spine injury. Spinal movement is initiated by mobilizing muscles including erector spinae, rectus abdominis, and external obliques. In subjects with no history of back pain, the deep core muscles (transverse abdominis, pelvic floor, multifidus, and diaphragm) will activate prior to spinal movement in order to stabilize vertebral segments in advance; in subjects with chronic back pain, the core muscles delay their firing until after spinal movement has taken place (9).

The Rehabilitative Tai Chi method addresses on multiple levels the physiologic processes associated with pain generation, restoring function to a troubled nervous system.

Movements that push through pain are known to cause further sensitization at peripheral receptors, amplified responses at the spinal cord, and functional changes in brain tissue (1). For these reasons, the "no pain, no gain" philosophy becomes invalid. In contrast, it is also known that maintaining artificial patterns of protection to avoid physical discomfort result in muscle atrophy, poor joint circulation, lymph pooling, and connective tissue thickening.

The Rehabilitative Tai Chi methods naturally advocates a "middle way" in which movement patterns are graded to mobilize dysfunctional body regions without causing threat to the nervous system. In addition, Rehabilitative Tai Chi naturally evokes a parasympathetic nervous system shift where elevated endorphins decrease pain perceptions and immune function is optimized. Considering neuromuscular compensations, activating the parasympathetic nervous system allows stabilizing muscles to engage more effectively outside of the mobilizing muscles inhibiting influence and thus functional joint balance can normalize more effectively.

Cross Mapping

Cross education, or contralateral limb training, has been shown to improve function in an injured extremity when the uninvolved limb is exercised.

> In a study of twenty-three females performing right ulnar deviation 4x/week for 6 weeks, strength in both the trained and untrained arm improved over 40% (18). In a cast immobilization training study, 14 subjects were randomized into free limb exercise or non-exercise groups. Participants who trained the free limb maintained pre-intervention strength in the immobilized extremity while the non-exercise group showed an 11% strength loss (19).
>
> Cross education has also shown potential in neurological rehabilitation, with a study of subjects with hemiplegia following stroke focused on exercising exclusively the uninvolved extremity. Study results included, "…this study demonstrates that high-intensity resistance training of a non-paretic upper extremity muscle group can enhance voluntary muscle activation and force-generating capacity of a severely paretic muscle group after stroke. There is also preliminary evidence that corticospinal adaptations may accompany these gains (20)."
>
> Finally, single leg coordination training involving ankle discs and balance trainers has been shown to significantly improve coordination abilities of both lower extremities following 4 weeks of training (21).

Again, research has shown that unilateral upper and lower extremity exercise focus has a therapeutic effect on the corresponding contralateral limb. Many Qigong and Tai Chi gestures involve mirror image bilateral or alternating upper extremity movements, and Rehabilitative Tai Chi specifically applies mindful awareness of what "is" working to guide what is "not working" during rehabilitative movement. As dysfunctional compensatory neuromuscular patterns are predictable in regional injuries, conscious focus can be directed at symmetrical muscles to activate normal patterns of muscle recruitment in a process coined "cross mapping" by the author.

An effective "cross mapping" process depends on five steps of implementation:

1. Perform gestures bilaterally in mirror in symmetrical or alternating fashion
   a. The use of Tai Chi gestures is ideal when considering ease of movement during investigation phase of cross mapping.
2. Identify differences between the sides (i.e. Strength, ROM, sensation)
   a. The mindful aspect of Tai Chi practice allows more ease in identifying subtle functional differences between opposing sides.
3. Focus on the desired outcome on the "good" side
   a. Rehabilitative Tai Chi gestures naturally engage healthy patterns of movement, which can be readily identified on the "good" side. Bringing attention to that which is desired or positive thought patterns utilizes the affects of visualization as described in earlier chapters.
4. Exaggerate desired outcome on the "good" side
   a. Following identification and focus on the positive function of the "good" side, conscious exaggeration of muscle contraction or range of motion is employed. Cross education research reveals that greater degrees of unilateral muscle contraction create adaptations in the "sensorimotor cortex… that subserve semantic memory for movement (18)." The cross education effect therefore not only increases motor unit excitability on the involved side but also the likelihood that effective motor learning will also occur on the involved side when "good" side practice is performed.
5. Cross map desired outcome to injured side
   a. With knowledge of effective strength in key musculature on the "good" side, the client can now "cross map" the somatic memory of productive muscle contraction to inhibited musculature on the injured side. Clinically this is most effective during simultaneous mirroring gestures with visual focus on injured side and kinesthetic focus on "good" side as supported by mirror therapies practiced with clients suffering from phantom limb pain (1).

Painless Rehabilitation: A Summary

Our modern scientific understanding of pain generation has revealed more complex processes than simply being a victim of incoming painful stimuli. Peripheral receptors, the spinal cord, brain, and autonomic nervous system all play a role in pain perception and resultant physiologic adaptations. Heightened pain perceptions commonly act as a barrier to physical rehabilitation, and transcending them demands a compassionate and consistent approach.

Rehabilitative Tai Chi employs a multifactorial approach to pain including a parasympathetic nervous system shift, which results in improved circulation, decreased inflammation, endorphin release, decreased muscle tension, and immune system optimization. In addition, the slow and graded movements inherent to Tai Chi have been shown to normalize sensory-motor processes and lessen the fear of painful movement, called kinesiophobia (5). It is also well known that pain contributes to dysfunctional compensatory movement patters, which in turn contribute to chronic pain states (2). Rehabilitative Tai Chi emphasizes painless, therapeutic movement patterns designed specifically to re-educate regional agonist/antagonist relationships and create more efficient global movement strategies.

CONCLUSION

Groundbreaking work in energy medicine research has revealed that connective tissue is simultaneously structural, energetic, and vibrational. Posture, movement, and breathing contribute to the quality of information carried through this connective tissue matrix, having a profound effect on cellular healing and the efficiency of global physiologic processes. Cellular healing occurs most effectively when the autonomic nervous system is balanced and the bio-energetic field is coherent.

Rehabilitative Tai Chi principles are known to encourage postural alignment, breathing, visual, and movement methods consistent with engendering bio-energetic coherence, parasympathetic nervous system dominance, and highly efficient global movement patterns. Health and rehabilitation-related research confirms the efficacy of Tai Chi as a safe and effective method for multiple conditions including balance enhancement, COPD, diabetes, cancer, chronic pain, osteoarthritis, psychological related disorders, and heart disease.

In our present health care climate of fiscal over-burden, Rehabilitative Tai Chi offers a low-cost, high-return option to simultaneously speed patient healing and markedly decrease professional caregiver stress related issues.

REFERENCES

Rehabilitative Tai Chi Introduction: Section 1

1. Benson, Herbert MD. *The Relaxation Response*. New York: HarperCollins, 1976
2. Cohen, Kenneth. *The Way of Qigong*. New York: Random House Publishing Group, 1999
3. Jahnke, Roger OMD. *The Healer Within*. San Francisco: HarperCollins, 1999
4. Jahnke, Roger OMD. *The Healing Promise of Qi*. New York: McGraw Hill, 2002
5. Jahnke, Roger OMD. *The Most Profound Medicine*. Santa Barbara: BCH, 2011
6. Selye, H. *The Stress of Life*. New York: McGrawHill, 1956. Rev. ed. 1976.
7. Deane Juhan. *Job's Body*. Station Hill Barrytown, LTD Copyright 1998
8. Wayne, Peter. *The Harvard Medical School Guide to Tai Chi*. Boston, Mass: Shambhala, 2013
9. Janice k Kiecolt-Glaser, Phillip T Marucha, William B Malarkey, Ana M Mercado, Ronald Glaser. 1995 "Slowing of Wound Healing by Psychological Stress". *The Lancet* 346
10. Gouin, Jean-Philippe, and Janice K. Kiecolt-Glaser. "The Impact of Psychological Stress on Wound Healing: Methods and Mechanisms." *Immunology and allergy clinics of North America* 31.1 (2011): 81–93. PMC. Web. 4 Jan. 2015
11. Ching Lan, Ssu-Yuan Chen, Jin-Shin Lai, and Alice May-Kuen Wong, "Tai Chi Chuan in Medicine and Health Promotion," Evidence-Based Complementary and Alternative Medicine, vol. 2013, Article ID 502131, 17 pages, 2013
12. Boyatzis, R.E. and McKee, A. (2005), Resonant Leadership: Renewing Yourself and Connecting with Others Through Mindfulness, Hope, and Compassion, Harvard Business School Press, Boston, MA.
13. Inflammatory Markers and Depressed Mood in Older Persons: Results from the Health, Aging and Body Composition Study, Brenda W.J.H. Penninx et all, Society of Biological Psychiatry 2003;54:566-572
14. Hempel, S, Taylor, S L, Solloway, M, Miake-Lye, I M, Beroes, J M, Shanman, R, Shekelle, P G. Evidence Map of Tai Chi. VA-ESP Project #ESP 05-226; 2014
15. Exploring the basis for Tai Chi Chuan as a therapeutic exercise approach. S. L. Wolf, C. Coogler, T. Xu Arch Phys Med Rehabil. 1997 August; 78(8): 886–892
16. Roger Jahnke, OMD,1 Linda Larkey, PhD,2 Carol Rogers,3 Jennifer Etnier, PhD,4 and Fang Lin5. "A Comprehensive Review of Health Benefits of Qigong and Tai Chi". *Am J Health Promot*. 2010 JUL-AUG; 24(6): e1–e25.
17. Yang G-Y, Wang L-Q, Ren J, et al. Evidence Base of Clinical Studies on Tai Chi: A Bibliometric Analysis. Scherer RW, ed. *PLoS ONE*. 2015;10(3):e0120655. doi:10.1371/journal.pone.0120655.
18. Medical College of Wisconsin (2009, November 17). Transcendental Meditation helped heart disease patients lower cardiac disease risks by 50 percent. *ScienceDaily*. Retrieved June 4, 2010, from http://www.sciencedaily.com / releases/2009/11/091116163204.htm
19. Kabat-Zinn, Jon. *Full Catastrophe Living*. NY, Dell Publishing, 1990
20. Molly M. Schleicher, Lauren Wedam & Ge Wu (2012): Review of Tai Chi as an Effective Exercise on Falls Prevention in Elderly, Research in Sports Medicine, 20:1, 37-58.

BodyMind Foundations: Section 2

1. Gerber, Richard. *Vibrational Medicine*. Rochester, VT. Bear & Company, 2001
2. Hanna,Thomas. *Somatics*. Cambridge MA: Da Campo Press, 1988
3. Jahnke, Roger OMD. *The Healer Within*. San Francisco: HarperCollins, 1999
4. Jahnke, Roger OMD. *The Healing Promise of Qi*. New York: McGraw Hill, 2002
5. Jahnke, Roger OMD. *The Most Profound Medicine*. Santa Barbara: BCH, 2011
6. Lipton, Bruce. *The Biology of Belief,* CA, Mountain of Love/Elite Books, 2005
7. Myers, Thomas. *Anatomy Trains*. London, UK: Churchill Livingston, 2002.
8. Oschman, James. *Energy Medicine: The Scientific Basis*. London, UK: Churchill Livingston 2000
9. Pert Candace B. *Molecules of Emotion*. New York: Touchstone, 1997
10. Cuddy, Amy J.C., Caroline A. Wilmuth, and Dana R. Carney. "The Benefit of Power Posing Before a High-Stakes Social Evaluation." Harvard Business School Working Paper, No. 13-027, September 2012.
11. Davis D, Dina T, Patronas N, Wiesel S. Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects. A prospective investigation. J Bone Joint Surg Am. 1990 Mar;72(3):403-8.
12. Boden S, McCowin P, Davis D, Dina T, Mark A, Wiesel S Abnormal magnetic-resonance scans of the cervical spine in asymptomatic subjects. A prospective investigation. J Bone Joint Surg Am. 1990 Sep;72(8):1178-84.
13. Jensen M, Brant-Zawadzki M, Obuchowski N, Modic M, Malkasian D, Ross J Magnetic resonance imaging of the lumbar spine in people without back pain. N Engl J Med. 1994 Jul 14;331(2):69-73.
14. Jarvik M, Brant-Zawadzki M, Obuchowski N, Modic M, Malkasian D, Ross J Magnetic resonance imaging of the lumbar spine in people without back pain.N Engl J Med. 1994 Jul 14;331(2):69-73.
15. Alberto Foletti, Settimio Grimaldi, Antonella Lisi, Mario Ledda, Abraham R. Liboff. Bioelectromagnetic medicine: the role of resonance signaling. Electromagn Biol Med. 2013 December; 32(4): 484–499.
16. Sung-Eun Jo, Myoung-Soo Kim, Min-Ki Kim, Hong-Lae Kim, and Yong-Jun Kim. Human Body Heat Energy Harvesting Using Flexible Thermoelectric Generator for Autonomous Mircosystems. School of Mechanical Engineering, Yonsei University, Republic of Korea.
17. R. McNeill Alexander. Tendon Elasticity and Muscle Function. Comparative Biochemistry and Physiology Part A 133 (2002) 1001-1011. School of Biology, University of Leeds, Leeds LS2 9JT, UK
18. Victoria G, Petrisor B, Drew B, Dick D. Bone stimulation for fracture healing: What's all the fuss? *Indian Journal of Orthopaedics*. 2009;43(2):117-120. doi:10.4103/0019-5413.50844.
19. Levin, Steven. Tensegrity: The New Biomechanics. Published In Hutson, M & Ellis, R (Eds.), Textbook of Musculoskeletal Medicine. Oxford: Oxford University Press. 2006
20. Donald Ingber, Ning Wang, Dimitrije Stamenovic. Tensegrity, cellular biophysics, and the mechanics of living systems. Reports on Progress in Physics. 2014 Vol 77, Number 4.

21. K. J. Pienta, D. S. Coffey. Cellular harmonic information transfer through a tissue tensegrity-matrix system. Med Hypotheses. 1991 January; 34(1): 88–95.

22. Hammerschlag R, Levin M, McCraty R, et al. Biofield Physiology: A Framework for an Emerging Discipline. *Global Advances in Health and Medicine*. 2015;4(Suppl):35-41. doi:10.7453/gahmj.2015.015.suppl.

23. Muehsam D, Ventura C. Life Rhythm as a Symphony of Oscillatory Patterns: Electromagnetic Energy and Sound Vibration Modulates Gene Expression for Biological Signaling and Healing. *Global Advances in Health and Medicine*. 2014;3(2):40-55. doi:10.7453/gahmj.2014.008.

24. Hawkins, David MD, PhD. Power vs. Force: The Hidden Determinants of Human Behavior. Carlsbad CA: Hay House Publishing, 2002

25. Julienne E. Bower, Michael R. Irwin. Mind-body therapies and control of inflammatory biology: A descriptive review. Brain Behav Immun. 2016 January; 51: 1–11

26. Ching Lan, Ssu-Yuan Chen, Jin-Shin Lai, and Alice May-Kuen Wong, "Tai Chi Chuan in Medicine and Health Promotion," Evidence-Based Complementary and Alternative Medicine, vol. 2013, Article ID 502131, 17 pages, 2013

27. Hendricks Luke, Bengston William, Gunkelman Jay. The Healing Connection: EEG Harmonics, Entrainment, and Schumann's Resonances. Journal of Scientific Exploration, Vol. 24, No.3, pp. 419-430, 2010

28. Gross Melissa, Crane Elizabeth, Fredrickson Barbara. Effort-Shape and kinematic assessment of bodily expression of emotion during gait. Human Movement Science. Volume 31, Issue 1, February 2012, Pages 202-221.

29. Angelo Compare, Cristina Zarbo, Edo Shonin, William Van Gordon, and Chiara Marconi, "Emotional Regulation and Depression: A Potential Mediator between Heart and Mind," *Cardiovascular Psychiatry and Neurology*, vol. 2014

Body Focus Principles: Section 3

1. Brown, Stuart. Play: *How it Shapes the Brain, Opens the Imagination, and Invigorates the Soul*. New York, NY. Penguin Group, 2009

2. Cohen, Kenneth. *The Way of Qigong*. New York: Random House Publishing Group, 1999

3. Jahnke, Roger OMD. *The Healer Within*. San Francisco: HarperCollins, 1999

4. Jahnke, Roger OMD. *The Most Profound Medicine*. Santa Barbara: BCH, 2011

5. Myers, Thomas. *Anatomy Trains*. London, UK: Churchill Livingston, 2002.

6. Oschman, James. Energy Medicine: *The Scientific Basis*. London, UK: Churchill Livingston 2000

7. Yang, Yang. *Taiji Quan: The Art of Nurturing, The Science of Power*. Champaign, ILL: Zhenwu, 2005

8. Deane Juhan. *Job's Body*. Station Hill Barrytown, LTD Copyright 1998

9. Wayne, Peter. *The Harvard Medical School Guide to Tai Chi*. Boston, Mass: Shambhala, 2013

10. Levin, Steven. Tensegrity: The New Biomechanics. Published In Hutson, M & Ellis, R (Eds.), Textbook of Musculoskeletal Medicine. Oxford: Oxford University Press. 2006

11. Hanna,Thomas. *Somatics*. Cambridge MA: Da Campo Press, 1988

12. Sakatani K, Ohta T, Shimo-Oku M, Conductivity of dorsal column fibers during experimental spinal cord compression and after decompression at various stimulus frequencies. Cent Nerv Syst Trauma. 1987;4(3):161-79

13. Cuddy, Amy J.C., Caroline A. Wilmuth, and Dana R. Carney. "The Benefit of Power Posing Before a High-Stakes Social Evaluation." Harvard Business School Working Paper, No. 13-027, September 2012.

14. C Wang, D R Eyre, R Clark, D Kleinberg, C Newman, A Iranmanesh, J Veldhuis, R E Dudley, N Berman, T Davidson, T J Barstow, R Sinow, G Alexander, and R S Swerdloff, Sublingual testosterone replacement improves muscle mass and strength, decreases bone resorption, and increases bone formation markers in hypogonadal men--a clinical research center study. The Journal of Clinical Endocrinology & Metabolism 1996 81:10

15. Mortimer JA, Ding D, Borenstein AR, et al. Changes in Brain Volume and Cognition in a Randomized Trial of Exercise and Social Interaction in a Community-Based Sample of Non-Demented Chinese Elders. *Journal of Alzheimer's disease : JAD*. 2012;30(4):757-766.

16. Luders E, Toga AW, Lepore N, Gaser C. The underlying anatomical correlates of long-term meditation: Larger hippocampal and frontal volumes of gray matter. *NeuroImage*. 2009;45(3):672-678.

17. Fuzhong Li, K. John Fisher, Peter Harmer, Dainis Irbe, Robert G. Tearse, Cheryl Weimer. Tai chi and self-rated quality of sleep and daytime sleepiness in older adults: a randomized controlled trial. J Am Geriatr Soc. 2004 June; 52(6): 892–900

18. Moseley GL, Nicholas MK, Hodges PW. "Does anticipation of back pain predispose to back trouble?" Brain. 2004 Oct;127(Pt 10):2339-47. Epub 2004 Jul 28.

19. Hashim HA, Hanafi@Ahmad Yusof H. The Effects of Progressive Muscle Relaxation and Autogenic Relaxation on Young Soccer Players' Mood States. *Asian Journal of Sports Medicine*. 2011;2(2):99-105.

20. Yunping Li, Ranran Wang, Jingqun Tang, et al., "Progressive Muscle Relaxation Improves Anxiety and Depression of Pulmonary Arterial Hypertension Patients," Evidence-Based Complementary and Alternative Medicine, vol. 2015, Article ID 792895, 8 pages, 2015.

21. PATHAK, Pragya et al. Progressive Muscle Relaxation: An adjuvant therapy for reducing pain and fatigue among hospitalized cancer patients receiving radiotherapy.. International Journal of Advanced Nursing Studies, [S.l.], v. 2, n. 2, p. 58-65, apr. 2013.

Breath Fundamentals: Section 4

1. Benson, Herbert MD. *The Relaxation Response*. New York: HarperCollins, 1976

2. Cohen, Kenneth. *The Way of Qigong*. New York: Random House Publishing Group, 1999

3. Farhi, Donna. *The Breathing Book*. New York, NY. Henry Holt and Company. 1996

4. Jahnke, Roger OMD. *The Healer Within*. San Francisco: HarperCollins, 1999

5. Jahnke, Roger OMD. *The Healing Promise of Qi*. New York: McGraw Hill, 2002

6. Jahnke, Roger OMD. *The Most Profound Medicine*. Santa Barbara: BCH, 2011

7. Oschman, James. *Energy Medicine: The Scientific Basis*. London, UK: Churchill Livingston 2000

8. Yang, Yang. *Taiji Quan: The Art of Nurturing, The Science of Power*. Champaign, ILL: Zhenwu, 2005

9. Deane Juhan. *Job's Body.* Station Hill Barrytown, LTD Copyright 1998

10. Wayne, Peter. *The Harvard Medical School Guide to Tai Chi.* Boston, Mass: Shambhala, 2013

11. Sovik, R. (2000). The science of breathing – The yogic view. Progress in Brain Research, 122 (Chapter 34), 491-505.

12. Novotny, S., & Kravitz, L. (2007). The science of breathing. IDEA Fitness Journal, 4(2), 36-43.

13. Gordon, T., Kannel, W.B. *The Framingham Study. An Epidemiological Investigation of Cardiovascular Disease. Sections 1-26,* Bethesda MD: National Heart and Lung Institute, 1970

14. Cullen, K., et al. *Multiple Regression Analysis of Risk Factors for Cardiovascular Disease and Cancer Mortality in Brusselton, West Australia: A 13 Year Study.* Journal of Chronic Diseases 36:371-377, 1983

15. Chaitow, Leon. *Muscle Energy Techniques*. London: Churchill Livingston, 1996

16. Bhavanani AB, Madanmohan, Sanjay Z. Immediate effect of chandra nadi pranayama (left unilateral forced nostril breathing) on cardiovascular parameters in hypertensive patients. *International Journal of Yoga.* 2012;5(2):108-111. doi:10.4103/0973-6131.98221.

Vision & Visualization: Section 5

1. Anees A. Sheikh & Errol R. Korn. *Imagery in Sports and Physical Performance*. New York: Baywood Publishing Company, Inc. 1994

2. Wayne, Peter. *The Harvard Medical School Guide to Tai Chi.* Boston, Mass: Shambhala, 2013

3. Effect of gaze direction on neck muscle activity during cervical rotation. Catharina S. M. Bexander, Rebecca Mellor, Paul W. Hodges Exp Brain Res. 2005 December; 167(3): 422–432.

4. Cervico-ocular coordination during neck rotation is distorted in people with whiplash-associated disorders. Catharina S. M. Bexander, Paul W. Hodges Exp Brain Res. 2012 March; 217(1): 67–77.

5. Priming of head premotor circuits during oculomotor preparation. Brian D. Corneil, Douglas P. Munoz, Etienne Olivier. J Neurophysiol. 2007 January; 97(1): 701–714.

6. A new paradigm to investigate the roles of head and eye movements in the coordination of whole-body movements. Mark A. Hollands, Nausica V. Ziavra, Adolfo M. BronsteinExp Brain Res. 2004 January; 154(2): 261–266

7. Ivanenko YP, Grasso R, Lacquaniti F. Effect of gaze on postural responses to neck proprioceptive and vestibular stimulation in humans. *The Journal of Physiology.* 1999;519(Pt 1):301-314.

8. McGibbon, Chris A et al. "Tai Chi and Vestibular Rehabilitation Improve Vestibulopathic Gait via Different Neuromuscular Mechanisms: Preliminary Report." *BMC Neurology 5* (2005): 3.

9. From mental power to muscle power--gaining strength by using the mind. Vinoth K. Ranganathan, Vlodek Siemionow, Jing Z. Liu, Vinod Sahgal, Guang H. Yue Neuropsychologia. 2004; 42(7): 944–956

10. Mind Over Matter: Mental Training Increases Physical Strength. Erin M. Shackell and Lionel G. Standing. Bishop's University

11. Benefits of motor imagery training on muscle strength. Florent Lebon, Christian Collet, Aymeric Guillot J Strength Cond Res. 2010 June; 24(6): 1680–1687

12. The Effects of positive and negative imagery on motor skill performance. Woolfolk, Parrish, and Murphy. JOURNAL OF SPORT PSYCHOLOGY, 1985, 7, 191-197

13. GRAHAM E. POWELL (1973) NEGATIVE AND POSITIVE MENTAL PRACTICE IN MOTOR SKILL ACQUISITION. Perceptual and Motor Skills: Volume 37, Issue , pp. 312-312.

14. Effects of relaxation with guided imagery on surgical stress and wound healing. C. Holden-Lund Res Nurs Health. 1988 August; 11(4): 235–244

15. The effects of guided imagery on the immune system: a critical review. Trakhtenberg EC. International Journal of Neuroscience. 2008 Jun; 118 (6): pages 839-55

16. Motor Imagery in Physical Therapist Practice. Ruth Dickstein and Judith E Deutsch. PHYS THER. 2007; 87:942-953.

17. Mental imagery and its potential for physical therapy. L. Warner, M. E. McNeill. Phys Ther. 1988 April; 68(4): 516–521

18. Mulder T. Motor imagery and action observation: cognitive tools for rehabilitation. *Journal of Neural Transmission.* 2007;114(10):1265-1278

19. MacIver K, Lloyd DM, Kelly S, Roberts N, Nurmikko T. Phantom limb pain, cortical reorganization and the therapeutic effect of mental imagery. *Brain.* 2008;131(8):2181-2191

20. Strength Gains by Motor Imagery with Different Ratios of Physical to Mental Practice Mathias Reiser, Dirk Büsch, Jörn Munzert Front Psychol. 2011; 2: 194.

Painless Rehabilitation & Movement: Section 6

1. Butler, David. Moseley, Lorimer. *Explain Pain.* Adelaide: NOI Group Publications, 2003

2. Chaitow, Leon. *Muscle Energy Techniques*. London: Churchill Livingston, 1996

3. Cohen, Kenneth. *The Way of Qigong*. New York: Random House Publishing Group, 1999

4. Kabat-Zinn, Jon. *Full Catastrophe Living*. NY, Dell Publishing, 1990

5. Wayne, Peter. *The Harvard Medical School Guide to Tai Chi.* Boston, Mass: Shambhala, 2013

6. Deane Juhan. *Job's Body.* Station Hill Barrytown, LTD Copyright 1998

7. Sarno, John. *The Mindbody Prescription.* New York, NY. Warner Books, 1998

8. Sarno, John. *The Divided Mind.* NY, Harper Collins, 2007

9. Moseley GL, Nicholas MK, Hodges PW. "Does anticipation of back pain predispose to back trouble?" *Brain*. 2004 Oct;127(Pt 10):2339-47. Epub 2004 Jul 28.

10. Burns, John W. et al. "Suppression of Anger and Subsequent Pain Intensity and Behavior among Chronic Low Back Pain Patients: The Role of Symptom-Specific Physiological Reactivity." *Journal of behavioral medicine* 35.1 (2012): 103–114.

11. Michele Sterling, Gwendolen Jull, and Anthony Wright. "The Effect of Musculoskeletal Pain on Motor Activity and Control". *The Journal of Pain,* Vol 2, No3, 2001

12. Neuro-physiological adaptations associated with cross-education of strength. Farthing JP, Borowsky R, Chilibeck PD, Binsted G, Sarty GE. Brain Topogr. 2007 Winter;20(2):77-88.

13. Wang C, Schmid C, Hibberd P, Kalish R, Roubenoff R, Rones R, McAlindon T. "Tai Chi is Effective in Treating Knee Osteoarthritis: A Randomized Controlled Trial". *Arthritis Rheum* 2009. 61(11): 1545-1553

14. Lee EN, Kim, YH, Lee MS. 2008 "Tai Chi for Disease Activity and Flexibility in Patients with Ankylosing Spondylitis—A Controlled Clinical Trial". *Evid Based Complement Alternat Med.* 2008 December; 5(4): 457–462

15. Tibor Hortobágyi[1], Janet L. Taylor[2], Nicolas T. Petersen[2], Gabrielle Russell[2] and Simon C. Gandevia[2]. "Changes in Segmental and Motor Cortical Output With Contralateral Muscle Contractions and Altered Sensory Inputs in Humans" *J Neurophysiol* 90: 2451-2459, 2003

16. Chenchen Wang, MD, MSca. "Tai Chi and Rheumatic Diseases". Rheum Dis Clin North Am. 2011 February; 37(1): 19-32

17. Michele Sterling, Gwendolen Jull, and Anthony Wright. "The Effect of Musculoskeletal Pain on Motor Activity and Control". *The Journal of Pain*, Vol 2, No3, 2001

18. Neuro-physiological adaptations associated with cross-education of strength. Jonathan P. Farthing, Ron Borowsky, Philip D. Chilibeck, Gord Binsted, Gordon E. Sarty. Brain Topogr. 2007 Winter; 20(2): 77–88.

19. Changes in functional magnetic resonance imaging cortical activation with cross education to an immobilized limb. Jonathan P. Farthing, Joel R. Krentz, Charlene R. A. Magnus, Trevor S. Barss, Joel L. Lanovaz, Jacqueline Cummine, Carrie Esopenko, Gordon E. Sarty, Ron Borowsky. Med Sci Sports Exerc. 2011 August; 43(8): 1394–1405

20. Urbin MA, Harris-Love ML, Carter AR, Lang CE. High-Intensity, Unilateral Resistance Training of a Non-Paretic Muscle Group Increases Active Range of Motion in a Severely Paretic Upper Extremity Muscle Group after Stroke. *Frontiers in Neurology.*

21. The contralateral effect after a single-leg coordinative training program Oehlert Oehlert K. K Dr. Universitätsklinikum Schleswig-Holstein, Campus Kiel, Klinik für Orthopädie, Kiel katharina. Heine Heine J. J Kiel. Krause Krause H. H Kiel. Varoga Varoga D. D Kiel. Rieckert Rieckert H. H Kiel. Hassenpflug Hassenpflug J. German Medical Science Düsseldorf, Köln 610

22. Song R, Lee EO, Lam P, Bae SC. "Effects of a Sun-style Tai Chi exercise on arthritic symptoms, motivation and the performance of health behaviors in women with osteoarthritis". *Taehan Kanho Hakhoe Chi*. 2007 Mar;37(2):249-56.

23. Skoglund L, Josephson M, Wahlstedt K, Lampa E, Norbäck D. "Qigong training and effects on stress, neck-shoulder pain and life quality in a computerised office environment". *Complement Ther Clin Pract*. 2011 Feb;17(1):54-7

24. Rendant D, Pach D, Lüdtke R, Reisshauer A, Mietzner A, Willich SN, Witt CM. "Qigong versus exercise versus no therapy for patients with chronic neck pain: a randomized controlled trial". *Spine* (Phila Pa 1976). 2011 Mar 15;36(6):419-27.

25. Lansinger B, Larsson E, Persson LC, Carlsson JY. "Qigong and exercise therapy in patients with long-term neck pain: a prospective randomized trial". *Spine* (Phila Pa 1976). 2007 Oct 15;32(22):2415-22

26. Tsai P-F, Beck C, Chang JY, et al. The Effect of Tai Chi on Knee Osteoarthritis Pain in Cognitively Impaired Elders: Pilot Study. *Geriatric nursing (New York, NY)*. 2009;30(2):132-139

27. Wang C, Schmid CH, Rones R, et al. A Randomized Trial of Tai Chi for Fibromyalgia. *The New England journal of medicine*. 2010;363(8):743-754.

28. Yan J-H, Gu W-J, Sun J, Zhang W-X, Li B-W, Pan L. Efficacy of Tai Chi on Pain, Stiffness and Function in Patients with Osteoarthritis: A Meta-Analysis. Milanese S, ed. *PLoS ONE*. 2013;8(4):e61672.

THE SCIENCE OF REHABILITATIVE TAI CHI

(4 CE Hours)

FINAL EXAM

1. **Rehabilitative Tai Chi, _____ Qigong principles, adapts and applies Tai Chi for the specific purpose of physical rehabilitation.**
   a. Contrary to
   b. Holding true to
   c. Improving upon
   d. Replacing

2. **The sympathetic response is adaptive in nature and includes a cascade of consistently reproducible physiological responses, such as increased muscle tone, decreased cortical function, and _____.**
   a. Blood sugar drops
   b. Decreased heart rate
   c. Heightened sensory perception
   d. Slow, deep breathing

3. **Clinically, chronic and persistent stress has _____ tissue healing rates.**
   a. Been shown to dramatically slow
   b. Been shown to dramatically speed
   c. No impact on
   d. Statistically insignificant impact on

4. **An important correlation supporting Rehabilitative Tai Chi is the fact that positive psychological and emotional markers like hopefulness, support, and relaxation are associated with both _____ and consistently reported experiences during Qigong and Tai Chi practice.**
   a. Decreased rates of cellular decay
   b. Decreased rates of cellular healing
   c. Increased rates of cellular healing
   d. Increased rates of cellular decay

5. ***A Comprehensive Review of Health Benefits of Qigong and Tai Chi*** **(Janhke, Larkey, Rogers, Etnier, Lin, 2010) identified numerous outcomes with varying levels of evidence for the efficacy for Qigong and Tai Chi, including _____.**
   a. Bone weakness
   b. Cardiopulmonary stress and related biomarkers
   c. Falls prevention and balance
   d. Vocabulary retention

6. **The bodymind rehabilitation paradigm considers individuals as holistic beings with the body and mind functioning _____ all human activity.**
   a. In opposition to
   b. Inseparably with
   c. Separately to resist
   d. Separately to support

7. **The inflammatory response after a ligament sprain, where the local area typically becomes red, swollen, and "hot," is an example of the human body's capacity to produce _____ energy.**
   a. Elastic/Kinetic
   b. Piezoelectric
   c. Sound
   d. Thermal

8. **Following up on electrical field research, magnetic fields were subsequently discovered around the heart and _____ respectively in 1963 and 1972.**
   a. Brain
   b. Lungs
   c. Spine
   d. Stomach

9. **"Generative" cells, including _____, act to repair and heal the body and are specifically activated or deactivated by piezoelectric information.**
   a. Fibroblasts
   b. Osteoclasts
   c. Both A and B
   d. Neither A nor B

10. **The term biotensegrity was coined by _____ as a way to describe how biological structures like bone, muscles, ligaments, and tendons are made stronger through compression and tension.**
    a. Buckminster Fuller
    b. Donald Ingber
    c. Dr. Stephen Levin
    d. Thomas Myers

11. **Specific to cellular repair and healing, our physiology naturally becomes most balanced when in the presence of electromagnetic frequencies that are _____.**
    a. Coherent
    b. Comprehensive
    c. Congruent
    d. Incongruous

12. **Per Amy Cuddy's research on posture, emotions, and physiology, follow up blood samples drawn from a group asked to stand tall with hands on hips for two minutes showed a rise in the confidence promoting hormone testosterone and a drop in the stress hormone cortisol, while samples from a group asked to fold forward showed _____.**
    a. Drops in both hormones
    b. Exactly the opposite effect
    c. Exactly the same effect
    d. No postural impact

13. **The most primary Tai Chi principle is _____.**
    a. Obtaining an upright yet relaxed spinal posture
    b. Rounded movement
    c. Slow, graceful movement
    d. Spiraling movement

14. **In looking at *Experiential Exercise: The Tai Chi Posture*, "_____," so to speak, opens and distracts the lumbar spine in the caudal direction. This specific imagery method has proven very effective in teaching pelvic neutral to even the most physically unaware patients.**
    a. Lowering your brows
    b. Raising your crest
    c. Rooting your knees
    d. Settling your tail

15. **The _____ rule essentially states that the nervous system is only able to receive and quantify incoming information in relationship to the total amount of information entering the system: for example, easily seeing a flashlight on a dark night while during a sunny day you may not know the flashlight is on even when looking directly at it.**
    a. Dantien
    b. Levine
    c. Weber Fechner
    d. Yang Yang

16. **The _____ exercise illustrates that the human nervous system doesn't compartmentalize its effects in separate body regions: when the hands carry excessive tension, so does the entire body, in particular the upper half.**
    a. Cloud Hands
    b. Flowing Motion
    c. Silk Reeling
    d. Standing Pole

17. **Progressive muscle relaxation exercises, such as those employed with Rehabilitative Qigong and Tai Chi lymph pumping, have NOT been shown to _____.**
    a. Decrease anxiety and depression as well as improve quality of life markers in cardiopulmonary patients
    b. Decrease fatigue and pain in cancer patients
    c. Enhance mood states in young athletes
    d. Increase muscle tension

18. **Sensory input from fast movements is _____ for the brain to process and adapt to, especially when new learning is required.**
    a. Easier
    b. Impossible
    c. More difficult
    d. More efficient

19. **Tai Chi practice places great emphasis on _____ weight shifting initiated from the Dantien or center of gravity (COG), which is referenced frequently in balance related research.**
    a. Mindful and controlled
    b. Rapid and frequent
    d. Sudden and swift
    d. The elimination of

20. **Traditional Qigong and Tai Chi practices generally consider three basic forms of natural breathing. _____, the second natural breath method, can be observed in children quietly at play or resting comfortably in bed.**
    a. Abdominal breathing
    b. Circle breathing
    c. Reverse abdominal breathing
    d. Stress or survival breathing

21. **Which of the following is NOT a result of natural abdominal breathing?**
    a. Activates robust immune function
    b. Elicits a parasympathetic shift through autonomic feedback mechanisms
    c. Enhances cellular decay
    d. Stimulates cellular energy production

22. **Various studies focused on visualization and _____ show that mental imagery subjects consistently increase strength and power output in visualized muscle groups; and in some cases outperform actual physical practice subjects.**
    a. Biofeedback
    b. Meditation
    c. Mental function
    d. Motor function

23. **While various studies follow different parameters of visualization practice, _____ components of effective mental practice have been identified, including "creating a clear and vivid image of the practice task" and "visualizing the desired outcome."**
    a. Four
    b. Five
    c. Six
    d. Seven

24. **Cross education or contralateral limb training has been shown to improve function in an injured extremity when the uninvolved limb is exercised. In a study of twenty-three females performing right ulnar deviation 4x/week for 6 weeks, strength in _____ improved over 40%.**
    a. Both the trained and untrained arm
    b. Only the trained arm
    c. Only the untrained arm
    d. The shoulders

25. **The slow and graded movements inherent to Tai Chi have been shown to _____ sensory-motor processes and lessen the fear of painful movement.**
    a. Augment
    b. Irritate
    c. Normalize
    d. Shut down

ANSWER SHEET

First Name: _____ Last Name: _____ Date: _____

Address: _____ City: _____

State: _____ ZIP: _____ Country _____

Phone: _____ Email: _____

License/certification # and issuing state/organization _____

Clinical Fellow: Supervisor name and license/certification # _____

Graduate Student: University name and expected graduation date _____

** See instructions on the cover page to submit your exams and pay for your course.

By submitting this final exam for grading, I hereby certify that I have spent the required time to study this course material and that I have personally completed each module/session of instruction.

The Science Of Rehabilitative Tai Chi
Final Exam

1. Ⓐ Ⓑ Ⓒ Ⓓ	6. Ⓐ Ⓑ Ⓒ Ⓓ	11. Ⓐ Ⓑ Ⓒ Ⓓ	16. Ⓐ Ⓑ Ⓒ Ⓓ	21. Ⓐ Ⓑ Ⓒ Ⓓ
2. Ⓐ Ⓑ Ⓒ Ⓓ	7. Ⓐ Ⓑ Ⓒ Ⓓ	12. Ⓐ Ⓑ Ⓒ Ⓓ	17. Ⓐ Ⓑ Ⓒ Ⓓ	22. Ⓐ Ⓑ Ⓒ Ⓓ
3. Ⓐ Ⓑ Ⓒ Ⓓ	8. Ⓐ Ⓑ Ⓒ Ⓓ	13. Ⓐ Ⓑ Ⓒ Ⓓ	18. Ⓐ Ⓑ Ⓒ Ⓓ	23. Ⓐ Ⓑ Ⓒ Ⓓ
4. Ⓐ Ⓑ Ⓒ Ⓓ	9. Ⓐ Ⓑ Ⓒ Ⓓ	14. Ⓐ Ⓑ Ⓒ Ⓓ	19. Ⓐ Ⓑ Ⓒ Ⓓ	24. Ⓐ Ⓑ Ⓒ Ⓓ
5. Ⓐ Ⓑ Ⓒ Ⓓ	10. Ⓐ Ⓑ Ⓒ Ⓓ	15. Ⓐ Ⓑ Ⓒ Ⓓ	20. Ⓐ Ⓑ Ⓒ Ⓓ	25. Ⓐ Ⓑ Ⓒ Ⓓ

Accessibility and/or special needs concerns?
Contact customer service by phone at (888) 564-9098
or email at support@pdhacademy.com.

Refund and general policies are available online at
http://pdhacademy.com/policies/

THE SCIENCE OF REHABILITATIVE TAI CHI

(4 CE HOURS)

COURSE EVALUATION

Learner Name: _____

	Disagree				Agree	
Orientation was thorough and clear	1	2	3	4	5	
Instructional personnel disclosures were readily available and clearly stated	1	2	3	4	5	
Learning objectives were clearly stated	1	2	3	4	5	
Completion requirements were clearly stated	1	2	3	4	5	
Content was well-organized	1	2	3	4	5	
Content was at or above entry-level knowledge	1	2	3	4	5	
Content was substantiated through use of references, footnotes, etc.	1	2	3	4	5	
Content reflected stated learning objectives	1	2	3	4	5	
Exam assessed stated learning objectives	1	2	3	4	5	
Exam was graded promptly	1	2	3	4	5	
Satisfied with learning experience	1	2	3	4	5	
Satisfied with customer service (if applicable)	1	2	3	4	5	n/a

What suggestions do you have to improve this program, if any?

_____

_____

What educational needs do you currently have?

_____

_____

What other courses or topics are of interest to you?

_____