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Dezhao Li, Yangtao Ruan, Fufu Zheng, Lijuan Si, Qiang Lin.*
Effect of Taiji post-standing on the brain analyzed with EEG signals

Dezhao Li\(^1\), Yangtao Ruan\(^1\), Fufu Zheng\(^1\), Lijuan Si\(^2\), and Qiang Lin\(^3\)

Abstract—Taiji post standing is a supplementary exercise for Taiji, which aids the internal function of the body and brain. Taiji post standing is usually considered to be helpful for human health. However, few studies have explored the mechanism of this exercise using modern measurement devices. This study for the first time explores the effect of Taiji post-standing on the human brain with participants wearing EEG signal measurement devices. Based on our studies of participants, who were selected to practice three different Taiji posts, the experimental results provide evidence that standing Taiji posts can help people to relax, and they also found it easier to meditate. It is considered that this method of investigation can also be carried out for other Taiji exercises, and it will be possible to gain a greater understanding of the complex health regulation mechanism of Taiji.

Keywords: Taiji post standing, EEG signals, Wearable devices, Significance test

Introduction

Taiji’s popularity has grown dramatically over the past few decades, and it is now identified by UNESCO as part of Chinese national intangible cultural heritage.\(^1\)\(^,\)\(^2\) It is a traditional exercise that has a history of more than one thousand years.\(^3\)\(^,\)\(^4\) The Taiji Post Standing exercise is usually considered as a necessary base that can also operate as a supplementary exercises for Taiji.\(^5\)\(^,\)\(^6\) The earliest record of post standing can be found in Huang Di Nei Jing Su Wen\(^7\) and is a “breathing essence, keeping spirit independently and found in Huang Di Nei Jing Su Wen”\(^8\). It is a traditional exercise that has a history of more than one thousand years.\(^9\)\(^,\)\(^10\) Taiji post standing is an exercise used for aiding the internal function of the body and mind.\(^3\)\(^,\)\(^4\) This is because the practice of Taiji post-standing requires people to cooperate with “imagination”, which is usually considered helpful for the physical and the mental state. However, limited by suitable devices to determine what actual benefits this exercise truly generates, few studies have been undertaken to evaluate its effect on the human mind. It is our belief that understanding the effect of Taiji post-standing on the human brain is of great importance, and it may help reveal the regulation mechanism of Taiji post-standing in human health.

Previous studies have shown that brain function can generate electrical signals.\(^11\)\(^-\)\(^13\) Through measuring these electrical signals, which are commonly named electroencephalogram (EEG) signals, the state of the brain can be assessed.\(^14\)\(^-\)\(^16\) In many studies it has been used to determine emotion, and it is also useful for analyzing issues relating to brain development. However, with the development of wearable electroencephalogram (EEG) devices, the major advantage of this technique is the brain state can be directly measured in real-time, which can be extremely beneficial in sport science.\(^15\)\(^-\)\(^17\) In this study, we carried out a tracking study on a select group of practitioners who undertook three different Taiji post standing exercises. These were directed by a master of Chen Taiji for a period of thirty days. We then analyzed the changes in EEG signals that were caused by different posts, to reveal the influence of this exercise on the human mind. In addition, through comparing the effects caused by different exercises, the characteristics of different standing posts were summarized. This new study can aid Taiji post standing practitioners, to choose the appropriate exercise for their body.

Experiment and methods

A. Participants

With institutional review board approval, three eligible participants were selected for this preliminary study. These participants all had no prior experience of post-standing before this experiment. Three different Taiji posts were selected.

Following the traditional instruction from a master of Chen Taiji, the first post (post-A) shown in figure 1a, requires the participant to keep one foot in front and the other behind, making feet like lunge, holding the arm in front as hugging a tree. Moreover, to ensure the correct posture, the participant should sink their shoulders, hang the elbows, keep the belly in, empty collar, and have a loose waist feeling, like sitting on a stool. The second post (post-B) shown in figure 1b, requires the practitioner to keep the front and back foot disjointed (separated), standing with the back foot pointing 45° forward. Additionally, the participant should stand with knees slightly bent, keep the middle and ring fingers of both hands bent, with empty collar. The third post, (post-C) shown in figure 1c, requires the practitioner to keep their feet a shoulder-width apart, bend their knees, sink shoulders, hang elbows, empty collar, and press their hands as if pressing against a floating board.

B. Procedure

All participants of these three Taiji standing posts were required to practice around 20 minutes every day for one month. Meanwhile, to evaluate the effects of standing Taiji posts, EEG signal tracking measurements were done at 9:00 PM (UTC+8) every day. The EEG measurement experiments were carried out in an electromagnetic shielding room, where the sound and light were also blocked. Additionally, the test environment was clean and tidy, and the temperature and humidity were maintained around 26 °C and 35%–42%, respectively. The measurement experiments were conducted as follows. First of all, the EEG signals of the practitioners were measured for 2 minutes under quiet conditions. Then, 2 minutes EEG signal measurements of standing posts state were followed. After that, 2 minutes of post quiet measurements were done. To exclude the impact from daily effects of the body, average measurement results were used for further feature analysis.

To set up the EEG measurement system, self-developed single-channel wearable EEG devices were applied in this research. According to physical structure and related functions, the brain usually can be divided into four regions, the frontal lobe, parietal lobe, occipital lobe, and temporal lobe. Generally speaking, EEG signals from the prefrontal lobe\(^22\) are mainly used to indicate attention and relaxation.\(^23\)\(^-\)\(^25\) Based on the above theory, EEG signals of the prefrontal lobe were measured for analysis in this study. The EEG measurement diagram used in this study is shown in figure 2.
C. Data analysis

Since the directly measured EEG signal is a type of non-stationary and weak electrical signal with only around 50pV, and the effective frequency range is 0.5~50Hz, it is necessary to analyze the EEG of different frequency bands and extract the characteristics of each frequency band to represent the different physiological activity states of the brain. Previous studies have proven that EEG signals can be classified into different bands, which are related to different states of the human brain shown in Table 1.

To explore the specific effects of different Taiji posts, all these bands are comprehensively considered in this study.

### Table 1 EEG frequency band and its corresponding brain state

<table>
<thead>
<tr>
<th>EEG frequency band</th>
<th>Frequency range (Hz)</th>
<th>Frequency band properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>θ</td>
<td>4-8</td>
<td>Subconscious level, deep meditation, inspiration</td>
</tr>
<tr>
<td>δ</td>
<td>0.5-4</td>
<td>Fatigue, lethargy</td>
</tr>
<tr>
<td>η</td>
<td>2-4</td>
<td>Unconscious</td>
</tr>
<tr>
<td>η1</td>
<td>8-9</td>
<td>Consciousness gradually blurred</td>
</tr>
<tr>
<td>η2</td>
<td>9-12</td>
<td>Physical and mental relaxation</td>
</tr>
<tr>
<td>σ</td>
<td>12-14</td>
<td>Vigilance</td>
</tr>
<tr>
<td>β1</td>
<td>12-16</td>
<td>Relax but concentrate</td>
</tr>
<tr>
<td>β2</td>
<td>16-20</td>
<td>Thinking</td>
</tr>
<tr>
<td>β3</td>
<td>20-28Hz</td>
<td>Agitation and anxiety</td>
</tr>
<tr>
<td>γ</td>
<td>25-50</td>
<td>Meditate and raise awareness</td>
</tr>
</tbody>
</table>

The adopted EEG signal processing flow in this study is shown in figure 3.

First of all, the raw data directly measured by devices usually contain error signals due to the effect of the measurement system. A median filter (which is a kind of data filtering method that can remove the errors mentioned above and retain the integrity of these data) was applied to obtain denoised data. Furthermore, the wavelet packet transform method was used to extract the frequency bands as in Table 1. After that, time-frequency statistical analysis was conducted to get a bird’s-eye view of the influence results. To get more detailed information, a significance test was done using the T-test method with different time-domain features of each frequency band.

### Table 2 EEG features and their calculation expressions

<table>
<thead>
<tr>
<th>Features</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average value (ARV)</td>
<td>$E = \frac{1}{n} \sum_{i=1}^{n} x_i$</td>
</tr>
<tr>
<td>Root mean square (RMS)</td>
<td>$\text{RMS}(x) = \sqrt{\frac{1}{n} \sum_{i=1}^{n}</td>
</tr>
<tr>
<td>Renyi Entropy (RE)</td>
<td>$\text{RE}<em>{\alpha}(x) = -\log \left( \frac{1}{s} \sum</em>{i=1}^{s} P_{\alpha}(i)^{\alpha} \right)$</td>
</tr>
</tbody>
</table>

In this study, three important time-domain features were finally selected and calculated, as shown in Table 2.

### Results

#### A. Time-frequency analysis results for different posts

Through applying the short-time Fourier transform (STFT) to those denoised EEG signals, the amplitude distribution maps in different frequencies and times were plotted for different posts.

**Taiji Post-A**

The time-frequency analysis result of Taiji post-A is shown in figure 4. For Taiji post-A, EEG signal intensity of all frequency bands during the standing process is more balanced than that seen before and after the post standing processes. In addition, during the standing process the intensity for high frequency (>14Hz) is lower than seen in other processes.

**Taiji Post-B**

From the time-frequency analysis result of Taiji post-B shown in figure 5, the balance effect of EEG signal intensity during the standing process is more significant than post-A. Moreover, this effect can last longer after standing process. Obviously, the intensity for high frequency (>14Hz) is also lower during the standing process than in other processes.

**Taiji Post-C**

For Taiji post-C, the EEG signal intensity of low frequency (<14) during the standing process becomes higher than other processes, which is different than other posts. However, EEG signal intensity of all frequencies after post-standing is more balanced.
that the Renyi Entropy values of $\delta^1$, $\sigma$ and $\theta$ are all significantly increased during the standing post-process as shown in Figure 7. In addition, we found that $\delta^2$, $\sigma$ and $\theta$ are all low frequency (<14Hz) bands.

For high-frequency region (>14Hz), the average and root mean square values of $\beta^1$ are significant features. These values all became lower during the post-standing process for all posts.

Discussion

In this study, to analysis, the EEG signals changes caused by standing different Taiji posts, time-frequency and significant tests were carried out. From the EEG intensity of different frequency bands, the change trends caused by standing posts are similar for different posts. This phenomenon may indicate that all posts have a similar ability to relax the human mind. However, the low frequency (<14Hz) bands signals post C increased a small amount, which is closely related to the requirement to imagine pressing a floating board during the practice session. Through significant tests, the Renyi entropy of $\delta^1$, $\delta^2$, $\sigma$ and $\theta$ are all changed in some trends. On one hand, these results indicate three of those parameters can be considered as key parameters to evaluate the effect of standing Taiji posts for humans. On the other hand, since those parameters are usually used to evaluate the meditation and relaxation states of humans, these data show that standing Taiji posts can help people to enter into those states. However, between the different posts, there are differences, which may be caused by slight differences in the practice methods. In addition, many features at other frequency bands are not discussed in this study. Thus, based on this pioneering study other parameters can be used to explore other effects of standing Taiji posts.

Conclusion

Through measuring and analyzing the EEG signals of participants in different processes of standing Taiji posts, this study found evidence that argues Taiji posts can help people to become relax and enter into a meditation state. The Renyi entropy of $\delta^1$, $\sigma$ and $\theta$ bands increased during the standing process for all posts, which indicated those bands are more active. Those frequency bands are usually considered to be related to relaxation and meditation states from previous studies. The average and root mean square values of $\beta^1$ is lower during the Taiji posts standing process. $\beta^1$ is a kind of frequency band that is related to relaxation and concentration, which indicates all participants were relaxed. This study provides a modern measurement method to investigate the effects of standing Taiji posts and some features were shown to change in the same trend for different posts. Based on this method, other feature parameters to evaluate the effects of other posts also can be investigated in the future.

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Biomechanical Analysis of Taijiquan Martial Application

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Abstract—Taijiquan can handle incoming forces with minimal effort and it can overcome hardship with softness. This claim is sometimes viewed suspiciously because ordinary people cannot execute the internal force of Taijiquan. Relaxation can enhance stability and rooting can help facilitate self-defense. This claim often causes confusion because ordinary people are unfamiliar with these concepts. In the following, the author cites ancient Taijiquan Classics and reviews scientific literature to discuss a better way for Taijiquan training for health, and to help reveal an effective way of Taijiquan application for self-defense. Martial application is a complex process and involves converting the mechanically disadvantaged systems in the human body to be more efficient and effective mechanisms. As a martial art for self-defense, Taijiquan is most challenging for practitioners when it comes to quickly receiving a strong oncoming force and effectively launching “Jin” after neutralization. The biomechanical aspects of Taijiquan martial art are evaluated in terms of motion control; the six degrees of freedom in motion; maintaining a central equilibrium; and body kinetic chain manipulation. In this paper, the mysterious “Qi” and “Jin” are scientifically defined, to help users understand the essence of Taijiquan.

Keywords: Taijiquan, biomechanics, martial application, internal force, relaxation, central equilibrium, body integration, biotensegrity, levers, ground reaction force, kinetic chains

Introduction

Taijiquan is a martial art based on the principles of changes (Taoism) and the practice of constant equilibrium (Confacianism). After more than 400 years of evolution, the meditative aspect of Taijiquan is recognized for both maintaining mental and physical health (in terms of relieving stress and maintaining homeostasis), and creating a unique, soft-style martial art. We are fortunate that the ancient Taijiquan masters left us several precious Taijiquan Classics, which cover the underlying Taiji philosophy and methods of practice for martial application. Before the mid-1930s, the Taijiquan Classics were passed down in secret, from generation to generation within individual lineages. Now these Taijiquan Classics are open to the public as the single source of martial arts. Thus, for martial arts, leg training is important. As can be imagined, most of the martial characteristics of Taijiquan from a scientific basis to support the principles of Taijiquan Classics for self-defense.

Building A Martial Arts Foundation for Six Degrees of Freedom in Motion

There are six traditional lineages of Taijiquan; plus several other standardized styles, which were promoted after 1956 for mainly health purposes. Every postural movement of Taijiquan, especially for those six traditional styles, is intended for martial application. So, if the practice methods are inconsistent with the requirements of the Taijiquan Classics, the practitioner will often perform the moves merely as a type of physical, mechanical exercise, without truly comprehending the skills used in self-defense.

In ancient times, Taijiquan was originally called Thirteen Postures (after the Eight Gates and Five Steps). All movements, in all current styles of Taijiquan, are based on these basic thirteen postures, with slight differences in their arrangements and permutations.

The Eight Gates, which are ward-off (推), roll-back (採), press (挒), push (按), pull-down (採), split (採), elbow strike (採), and shoulder strike (採); all refer to movements of the upper limbs, and express the laws of changes in eight directions (four cardinal and four diagonal).

The Five Steps, which are advance (進), retreat (退), look left (左顧), look right (右顧), and central equilibrium (中定); refer to the lower limbs, and they express the principle of footwork.

Biomechanically, a simple explanation of the “Five Steps” is that the legs are responsible for attacking, retreating, dodging, advancing, and maintaining central equilibrium; and each footwork controls the motions of six degrees of freedom (3 rotational and 3 translational). These then allow for any necessary self-defense actions.

In modern literature, Time Magazine has called Taijiquan “the Perfect Exercise”, and the Cable News Network has described Taijiquan as being “Medicine in Motion”. Taijiquan’s health benefits can be further reinforced when the technique’s martial abilities are achieved by the practitioners.

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Among the basic thirteen postures, central equilibrium is the most important, and all other twelve postures must have the central equilibrium component within them.

Biomechanically, a simple explanation of the “Five Steps” is that the legs are responsible for attacking, retreating, dodging, advancing, and maintaining central equilibrium; and each footwork controls the motions of six degrees of freedom (3 rotational and 3 translational). These then allow for any necessary self-defense actions.

Accordingly, in Taijiquan the priority of leg training should be placed on muscle tone over muscle growth, to maximize the six degrees of freedom in motion. With proper training, the entire body is free to change its position through forward/backward, up/down, and left/right translation in three perpendicular axes, which are then combined with changes in orientation, through rotation about three perpendicular axes (these being yaw, pitch, and roll (see Figure 1)).

Fig. 1 Six degrees of freedom in the lower limbs (hips, knees, ankles, feet) during Taijiquan movements.

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Biomechanically, a simple explanation of the Eight Gates concept is that the arms are an extrapolation on the idea of the insubstantial (Yin) and substantial (Yang) changes, along with the eight types of actions added onto the six degrees of freedom in the legs.

The movements of the upper and lower limbs are coordinated through the body kinetic chain, but the lower limbs control the motion of the upper limbs. Thus, in addition to the power of the legs, a Taijiquan practitioner can use various types of actions to cope with any potential threat (for example, to ward-off a blow in any of the four cardinal directions involving linear momentum and pressure; or to roll-back in any of the other four ordinal directions involving angular momentum and torque).

In Taijiquan, it is critical that the role of the arms is limited to regulating the body’s alignment; and to aiming or reaching out to the target. The arms should not be used to apply piecemeal or unintegrated forces, because all the joints in the arm are considered Class-3 levers, and provide negative mechanical advantages. For these reasons, advanced Taijiquan practitioners don’t apply piecemeal forces from the arms to interfere with the leverage of the integrated ground reaction force (GRF) from the feet. (More discussion on this is provided in later sessions). This is consistent with Master Cheng Man-Ching’s statement that: “Taijiquan is without hands, and hands on is not Taijiquan (太极拳不动手，动手非太极).”

Outsmarting the Response to the Fear of Fighting

In any real situation facing an immediate physical threat, martial artists have all battled against the fears that arise at the beginning of a fight. The result is often a reaction within the amygdala (the part of the brain in the cerebral hemisphere that is involved with experiencing emotions), which is apt to flip individuals into a fight-flight-or-freeze mode, in experiencing emotions), which is apt to flip.

During the height of the fight-flight-or-freeze response, the routine diaphragmatic breathing of the Taijiquan practice can be a powerful tool to take control away from the amygdala, and hand it back to the hippocampus and prefrontal cortex; which can control the fear response in a rational way.

As diaphragmatic breathing slows down the breathing process, and sends signals to the brain that the situation is not alarming; the body stops producing the neurotransmitters and hormones responsible for fear and anger emotions. It has been demonstrated that Taijiquan intervention has a strong effect on neuroplasticity by increasing gray matter volume and the enhancement of functional connectivity. Compared to other regions of the brain, the hippocampus is more susceptible to neuroplasticity. Thus, the neuroplasticity from proper Taijiquan training to acquire a psychological advantage over a bigger and stronger opponent can mitigate the emotional fear response.

Accordingly, Master Cheng Man-Ching indicated that those Taijiquan practitioners who wanted to excel in self-defense must have three characters of fearlessness: (1) fearlessness of enduring the long training required for rooting, (2) fearlessness of suffering losses while investing in yielding, and (3) fearlessness of facing ferocity as softness can overcome hardness. The first two characters are prerequisites to the third character, which is essentially the ability stemming from better relaxation from routine performance of diaphragmatic breathing. The first character of fearlessness entails long-term practice that causes changes to occur in the structure of the brain, which strengthen the neural connections, and improve cognitive skills. Diligent Taijiquan practitioners, with improved neural efficiency, can maintain lower activity levels in the sensory and motor cortex, with less energy expenditure and more effective outcomes. The second character of fearlessness requires the Taijiquan practitioners to learn from prior sacrifices and losses to gain the four crucial keys of Taijiquan techniques: touching (触), sticking (㧲), connecting (粘), and following (随) for effective self-defense.

Enhancing the Neuromusculoskeletal Control by Diaphragmatic Breathing

The traditional Taijiquan training with diaphragmatic breathing affects the whole-body system by not only stimulating the phrenic and vagus nerves for regulating the peripheral nervous system but also strengthens core muscles via an increase of intra-abdominal pressure (IAP) for proper load balancing of the pelvis and spine throughout the body kinetic chain. The Taijiquan movements with mindfulness and relaxation help mediate neuromusculoskeletal responses through activating the parasympathetic nervous system and calming down the sympathetic nervous system.

The Taijiquan Classics indicates: “Effortlessly the Jin reaches the head-top, while letting the Qi (sensation) sink to the Dantien (abdomen) (太极拳顶头，气沉丹田).” This implies that Taijiquan is an effortless action when manifested by diaphragmatic breathing along with correct postural alignment, mindfulness meditation, and rooting in connection with the ground beneath the feet. While the spine and the head naturally held upright as guided by the mind, the diaphragmatic breathing can accelerate the circulation of cerebrospinal fluid. The cerebrospinal fluid plays an essential role in maintaining the homeostasis of the central nervous system.

Accordingly, the triple function (breathing, peripheral nerve regulation, and core stabilization) of the diaphragmatic breathing is a vital part of traditional Taijiquan training. In this case, the core is the muscular cylinder (see Figure 2). While sinking the Qi down to the Dantien, the diaphragm serves as the roof of muscular cylinder, whereas the pelvic floor serves as the floor, and the transversus abdominis and multifidus muscles serve as the wall.

Contraction of the diaphragm downward increases IAP within the muscular cylinder, thus adding to spinal stability. In addition, diaphragmatic contraction increases stability of the trunk by minimizing displacement of the abdominal contents into the thorax and maintaining a hoop-like geometry of the abdominal muscles, which increase spinal stability through tension in the thoracolumbar fascia. Moreover, through the diaphragm’s fascia and connective links, the diaphragmatic breathing can activate the thoracic and lumbar erectors, internal and external obliques, quadratus lumborum in the lower
back, and the posa muscle that crosses the rim of the pelvis to connect the legs to the spine.17

In conjunction, these are all important muscles to stabilize the innermost load-bearing structure—the spinal column. The contraction and strength of these deep muscles are enhanced by the presence of IAP, and the increased pressure provides a stable structure for maximal force production and structural integrity. Therefore, these small and large muscle groups are dependent upon each other for optimum function. From a neuromusculoskeletal perspective, the alignment of the body structure and diaphragmatic breathing have a very direct impact on the function of those core muscles for spinal stabilization.

Exploring the Arts of Receiving

According to the Taijiquan Classics, progressive martial art ability is developed as follows: “From familiarity with the correct pastural postures, one gradually comprehends Jin; from the comprehension of Jin, one can reach wisdom. Without long practices, one cannot suddenly understand it (由著熟而漸悟飈 助)．然非用力之久，不能豁然貫通焉.”18 This means it requires extensive practice of correct postures to become familiar with all the principles of the Taijiquan Classics, and to gain the proprioceptive sense and kinesthetic abilities prior to acquiring Jin.

Proprioception (an awareness of the position and movement of the body) results from sensory receptors in the nervous system and the body, which are mostly located in the muscles, joints, and tendons; whereas kinesthetic sensations are derived from sensory receptors in the muscle, skin, and joints as well as from central signals related to motor output. This means comprehending Jin requires an extensive effort to excel in touching, sticking, connecting, and following an opponent, and then to be able to yield and neutralize their moves with ease, comfort, and least effort. As with many endeavors, there are different levels and stages in comprehension before it is possible to fully understand Jin. Advanced Jin involves deep proprioceptive and proprioceptive awareness, to control both motion and stillness, and to maintain homeostatic conditions in fighting.

Interceptive signals arise from many different physiological systems of the body. So, the comprehension of Jin relates to mastering and applying various kinds of mechanically efficient GRF and torques while engaged in sensing, yielding, controlling, receiving, and launching.

Among all Jins that are developed for use in Taijiquan, for martial applications, the most difficult one to master in free fighting is the receiving Jin (which relates to the ability to absorb an incoming force).19 This can be considered the essential secret of Taijiquan, but it is barely discussed in the Taijiquan literature. One of the few references to this mystery was discussed by Master Cheng Man-Ching, who stated that if your achievement reaches this level of “receiving Jin”, then you do not have to worry about other kinds of Jin.20

His explanation of receiving Jin is analogized as follows. Imagine someone throws a ball to hit another person. If the receiver resists the ball or hits it, it will bounce out. This description is the Jin of colliding, and is not a receiving Jin. The receiving Jin means the receiver is able to catch the ball and then is able to toss it out, regardless of the speed and weight of the ball. This requires the skills of sticking (moving in contact with the opponent to take control), sensing, lifting, and discharging to enable both the catching and discharging to occur almost simultaneously. Since the power can be intensified quickly in a narrow space, it indicates the highest wisdom in free fighting. According to Master Cheng Man-Ching, besides the receiving Jin as the ultimate supreme capability of Taijiquan, there is nothing else.21

So, what is “receiving Jin”? This is when someone attacks with sudden motion, and no matter whether the attacker makes contact with your hands or another part of your body, all you think about doing is nothing but “relaxation.” Regardless of how the attacker feels about the touch of your body, whether it is hard, or soft movement combined with hard, your effort is not piecemeal. You relax to neutralize the incoming attack by forming a biotensegrity framework, and use the support of GRF that runs from your feet through the legs, waist, and chest to the arms.

If the oncoming attack is a force resulting from a Class-3 lever, regardless of its external or internal nature or its source from the arms or from the waist, an advanced Taijiquan practitioner should be able to easily handle it. But if you employ a Class-3-lever in a disjointed manner, you will create resistance that will provide an attacker an opportunity to detect your intention.

In contrast, the biotensegrity framework and GRF plus torques resulting from relaxation has the exact opposite effect and allows you to unload the incoming force, maintain your body stabilization, and strengthen a counterattack.

Moreover, when counterattacking, the GRF and torques exerted on the attacker can have a “sticking” effect to induce and then follow the resistance from the attacker for you to take advantage of the situation for counteracting.

Establishing A Biotensegrity Framework for Defensive Actions

There is no denying that countering the attack may expose the body to a powerful force. Whether or not the oncoming force can be received depends on many factors such as the timing and angle of the attack, the execution trajectory, the amount of the force, and the neutralizing skills. If the opponent's oncoming force is powerful and fast, dodging and retreating should be considered by junior practitioners. Defending and controlling the oncoming force by an advanced Taijiquan practitioner depends on a disciplined state of relaxation and the person’s force sinking abilities; which together form a tactical tensity framework of body integration and equilibrium. In this case, integration means that no one muscle is solely performing just one movement, such as stabilizing one body area for freedom of movement in another body area, but all muscles are working as a combined unit all the time, to reach a stable, but dynamic equilibrium.

Accordingly, there is an impact on one part of the body. A skilled Taijiquan practitioner will start by following the attacker’s strength, so that the impacting force is distributed evenly to the relaxed body as a whole without exposing the center of mass.

In other words, the moment of neuromuscular integration and body equilibrium is to find balance and an ease of motion through oppositional strength; with support of the union of tensioned and compressed parts of the musculoskeletal system forming biotensegrity.22 Biotensegrity is the application of tensity (the tensile behavior of the body) to biological structures such as muscles, bones, fascia, ligaments and tendons; and rigid and elastic cell membranes; which are made strong by the combined action of tensioned and compressed parts.23 During the moment of Jin receiving (receiving a blow), the musculoskeletal system maintains tension through a continuous network of muscles and connective tissues, while the bones provide discontinuous compressive support.24

To sustain the required elasticity for biotensegrity, the matrix of interconnected soft tissues including fascia, muscles, tendons, and ligaments must maintain the right amount of tension. This can be compared to tree roots forming a structural network that holds tension within the earth. If the body is just slightly out of alignment, or the required tension and compression becomes disorganized (or unbalanced), the discrepancy will prevent optimal motion and function of biotensegrity.

However, when the body is relaxed and rooted downward, gravity is pressing the body structure down into the ground. Then a rebounding GRF and torque (rotational force) along with the kinetic chain momentum reverberates up the body structure. The integrated internal movement of multiple joints and muscles helps reduce the impacts of oncoming attacks within the biotensegrity framework.25 Subsequently, a fully developed body proprioception and capacity of sensing body motions are recruited to react to the sudden attacks and to self-correct spontaneously and apparently effortlessly.

Proprioception relies on mechanoreceptors located in deep tissues such as muscles, tendons, and fascia sending detailed messages to the brain about body stabilization and movement. It is evident that martial arts training such as Taijiquan can improve the required proprioception and neuromuscular control.23

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Cultivating the Jin and Recognizing the Qi

What is Taijiquan’s Jin? Rather than using the general term “internal force”, it is defined here as “the integrated GRF and rotational torques launched by the body through a kinetic chain, using mechanically efficient mechanisms.”

Thus, any external and/or internal forces applied by a Class-3 lever are excluded, regardless of their external or internal nature, or their sources, which may be from the arms or from the waist. Taijiquan tactics emphasize simultaneous defense and offense, although neutralization takes priority.

The synchronized transition from a defensive action (receiving the Jin) to an offensive action (launching the Jin) requires both sensing and neutralizing the incoming force, to control the timing and the opportunity before a counteraction. Concurrently, the feet, legs and waist must be fully integrated, in preparation for launching the counteracting Jin. The feeling of integration, derived from sinking (also known as rooting), originates not only from having good balance but also from connecting all parts of the body down to the ground.

This corresponds to the Taijiquan Classics: “When launching the Jin, one must sink and relax completely while aiming at the desired direction (发劲须沉着松, 专注一方); and the power accumulated as drawing a bow and released as an arrow (蓄劲如张弓, 发劲如放箭).”

Thus, the resulting Jin (GRF and torques) for offense depends on the sensitive neuromusculoskeletal control cultivated by routine diaphragmatic breathing, the degree of relaxation and mindfulness to sense the GRF and various torques, and the efficacy of transferring the GRF and torques throughout the body kinetic chain.

For Taijiquan’s closed kinetic chain movement, the Jin is the GRF plus the consequential three-dimensional internal-reaction torques of joints, muscles, and ligaments that synergistically thrust all body segments upward from the feet. Here, the Jin is equal to the change in momentum over the change in time.

Practicing the traditional Taijiquan through awareness, breathing and movement explorations can help foster kinesthetic sensory cultivation, body consciousness, and internal strength enrichment. While cultivating the Qi routinely through diaphragmatic breathing, the Jin will be enhanced over time by integrating body kinetic chain motions, to progressively enhance the neuromusculoskeletal sensitivity. This allows deep-layer core muscles to engage more effectively outside of the inhibiting influence of mobilizing muscles, and thus the kinetic chains can be properly utilized for efficient kinetic energy transfer, from the proximal segments to the distal segments, for launching any Jin.\(^{11}\)

The magnitude of momentum generated by the GRF and torques, and transferred from segment to segment via the kinetic chain, can be sensed, but the kinetic energy as a scalar quantity cannot be felt. To help cultivate the Jin during Taijiquan training for martial arts application, it is necessary to scientifically delineate the Qi here as “kinesthetic sensations of position, movement, and force of muscles, tendons, and joints throughout body segments in kinetic chain motions” to help monitor the progressive sensation of the momentum transfer.\(^{11}\)

**Augmenting Jin from Ground Using Class-2 Lever**

When the lower-body is correctly balanced and the body parts -- particularly the ankles and feet -- are sufficiently relaxed, the gravity sensory feedback from activation of plantar cutaneous mechano-receptors can help manage the torque produced by the forces of gravity and reaction of the ground.\(^{12,13}\) The key movements of the ankle joint complex are dorsiflexion/plantarflexion occurring in the sagittal plane, abduction/adduction occurring in the transverse plane, and eversion/inversion occurring in the frontal plane. Rotation in any given plane occurs about an axis perpendicular to that plane. Moreover, the movements of the ankle joint complex are controlled by the torques due to ground reaction. The vertical GRF, horizontal friction forces, and ankle torque at the time of the plantarflexion movement are shown in Figure 3.

The torque can be estimated by multiplying the body weight by the perpendicular distance of the upward effort from the fulcrum (which is also referred to as pivot point, or center of pressure (CoP)) plus the component resulting from the horizontal friction forces (see Figure 3). In biomechanics, the center of pressure (CoP) is the term given to the point where the GRF vector is applied; whereas the center of gravity (CoG) is the point where the whole weight of the body acts vertically downward. It is important to note that both the CoP and the downward position of the CoG are not static outcome measures because of the dynamic actions of “Five Steps” during the Taijiquan movements.

For example, the CoP is at the ball near the toes at the time of a ward-off or push posture, or it moves backwards to near the heel at the time of a roll-back posture.

Similarly, for the sake of body stability, the downward position of the CoG should be placed at the “bubbling well” (which is a point on the sole of the foot, just in front of the arch and centered side to side) at the time of a ward-off or push posture, or it shifts to below the ankle at the time of a roll-back posture.

More specifically, the “bubbling well” is located one third of the way from the base of the toes to the edge of the heel on the sole of the foot between the metatarsals of the 2nd and 3rd toes.\(^{13}\)

In plantarflexion of the foot, the lower leg acts as a Class-2 lever. A Class-2 lever (e.g., a wheelbarrow) is the only lever that can guarantee that the effort (input force) arm will always be greater than the load (output force) arm.

This arrangement results in a higher effort-arm to load-arm ratio, making this Class-2 lever the most mechanically advantageous. In a calf raise, the effort comes from the calf muscles (gastrocnemius, soleus, plantaris); which is attached to the calcaneus bone. In this case, the load comes from the body weight, plus any extra weight from an opponent, which acts on the lever system through the fibia. Here, the fulcrum (the pivot point) is made up of the metacarpophalangeal joint. In this arrangement, the load is then in the middle, and the effort is furthest from the fulcrum. Therefore, the act of plantarflexion can move much more weight than elbow flexion. This is even if the biceps is just as strong as the calf.

Both GRF and torques are influenced by contraction of lower leg muscles. Thus, contracting the calf muscles occurs when the fulcrum (CoF) is placed at the ball of the foot and the weight (a downward direction of the CoG) is shifted to the “bubbling well” (see Figure 4A), at the time of advancing during the “Five Steps” movements.

Shifting both CoP and CoG forward (towards the toes) can help maximize the vertical GRF and torques by taking advantage of a Class-2 lever system (where the load (CoG) is located between the fulcrum (CoP) and the upward effort). At the time of retreating during the “Five Steps” movements, contracting the shin muscle (tibialis anterior) can occur when both CoP and CoG are shifted backward where the fulcrum (CoF) is placed at the heel and the body weight (CoG) is under the ankle (see Figure 4B). In this case, the advantage of a Class-2 lever system can also apply. Accordingly, the positions of CoG and CoP can be adjusted to maximize the vertical GRF and torques (greater than the body weight) by using the torque of body weight for self-initiated movements or for responses to an external perturbation force. Moving the body weight to exploit the torque of gravity can be performed with great skill, by advanced Taijiquan practitioners.

**Fig. 3 Diagram showing Ground Reaction Forces (GRFs) during the plantarflexion movement along with the resultant ankle torque (which can be estimated by multiplying the GRF components by their respective perpendicular distances).**

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The vertical GRF and torques at the feet as aided by the Class-2 lever of the ankle plantarflexion, or dorsiflexion can be further reinforced by the angular torques firstly at the ankles of the leg segment and subsequently at the hips of the waist segment. In fact, each joint torque can produce linear and angular acceleration of all body segments, due to the dynamic coupling inherent in the interconnected musculoskeletal system. Angular acceleration of the waist and chest segments is principally affected by all the joints of the leg segment with varying degrees of dependency during the gait cycle.\(^\text{16}\) For instance, when the pelvic rotates at the waist segment in the transverse plane, the other joints of the lower limb are involved in rotation as well. In fact, the greater the joint’s distance from the trunk, the greater is the rotation (e.g., the tibial rotation is three times the rotation of the pelvis).\(^\text{21}\)

**Using Only Mechanically Efficient Mechanisms for Offensive Actions**

The human body is composed of a variety of joints; some work biomechanically like levers, others like pulleys, and still others like a wheel-axle mechanism. The synovial joints are moveable and function as lever systems. Most movements in the human body are classified as Class-3 lever systems, which are at a mechanical disadvantage in terms of effort versus load.

In fighting, most of the time, people tend to use unconnected, or unintegrated brute force attack, by using the ends of their limbs. If the physical force is delivered in the arm by moving the hand around the wrist, moving the forearm around the elbow, or moving the whole arm around the shoulder; all these levers are Class-3 type levers with the effort between the resistance (load) and the joint (fulcrum) where the muscle attachments are usually close to the joint. In Taijiquan, the practitioners learn to stabilize those muscle attachments to establish mechanically efficient levers with the GRF and torques rooted in the feet, issued in the legs, dominated by the waist, and delivered to the hands. In other words, using GRF and torques generated from the feet will help convert many inherent Class-3 levers in the human body to either a Class-1 or a Class-2 lever in offense.

The first instance is indicated in the Taijiquan Classics as “The power comes from the spine (力由脊发)”. In this case, the Taijiquan practitioner can place the fulcrum on the moving axial line (spine) between the GRF with torques (effort) and opponent’s body (load) by turning the pelvis around the hip to swing the whole body as a Class-1 lever. It requires very little effort to deliver the Jin from the ground toward opponent’s center of mass.

The second instance is also indicated in the Taijiquan Classics as “The force is borrowed from the opponent (力从人借)”. In this second case, the Taijiquan practitioner can place the fulcrum on an opponent’s forceful arm with the opponent’s body (load) between the fulcrum of the opponent and the GRF with torques (effort) of the practitioner by turning the pelvis around the hip to swing the whole body as a Class-2 lever. This way the Taijiquan practitioner can borrow the incoming force along the direction and momentum of opponent’s arm against the opponent’s body with little effort because the core power is connected to the torso while applying the GRF with torques toward opponent’s center of mass.

Additionally, the Taijiquan Classics indicate “Stand like a balance and rotate actively like a wheel (立如平衡, 运如车轴)” and “The Qi is like the wheel, and the waist is like the axle (气若车轮, 腰如车轴)”.\(^\text{22, 24}\) The rotation of the waist/pelvic region is like turning a wheel on an axle. The hip joints are rotating around the moving axial line (spine) at the angle of elevation of the sacrum. As is well known, the wheel-and-axle mechanism is able to mechanically aid the movement of very heavy loads. Besides, the muscles around the pelvic have high muscle-to-tendon ratios (force producers) while the extremities have relatively much more tendon and elastic structures (force amplifiers). In a correctly aligned body, a small movement of the waist along with the Jin from the

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ground can produce very large amounts of force elsewhere in the body.

The Taijiqian Classics indicate that: “Use a force of four ounces to deflect a thousand pounds (擒晃两千金)”.

This is the level that all serious Taijiqian practitioners are keen to attain. The prerequisite of using four ounces to deflect a thousand pounds is the ability of receiving the Jin while neutralizing the incoming force by following its direction of movement. To induce the opponent's attacking force to emptiness, the point in contact must naturally rotate and the arc of rotation must be aligned in accordance with the direction of the incoming force. Regardless of the magnitude of a force coming to attack, the impact is zero in its tangential direction at the target point. As a result, only a small amount of friction force is required to achieve the effect of “deflecting a thousand pounds with four ounces of effort.” The key lies in sensing the incoming force and inducing the opponent to a tangential direction effortlessly.

Taijiqian is an interesting and effective martial art like playing American football with specific defensive and offensive strategies. In defense, the Taijiqian practitioner is relaxed, forming a stable biontensegrity framework. In offense, the Taijiqian practitioner is efficient and can powerfully use mechanically efficient levers (within a living fulcrum) along with the efficient wheel-and-axle mechanism. This study provides an extensive review of the structure, function, and motion of the biomechanics of Taijiqian and offers a scientific clarification that may help martial art achievement. The mysterious Qi and Jin are scientifically defined, to help understand the essence of Taijiqian.

As the fundamental step to develop the martial ability, the lower limbs should have six degrees of freedom to help control the eight types of actions of the upper limbs. To overcome the initial fear of fighting, the routine diaphragmatic breathing can be a powerful tool to take control away from amygdala hijack. Diaphragmatic breathing can further enhance neuromusculoskeletal control to help maintain the central equilibrium of the body.

In defense during free fighting, the most difficult action is to receive and neutralize the oncoming force. This requires training on relaxation, proprioceptive and interoceptive awareness, as well as the basic skills of touching, sticking, connecting, and following. Additionally, establishing a biontensegrity framework in the body from relaxation and alignment are necessary to help disperse incoming forces for defensive actions.

Synchronizing a quick switch from defense to offense requires a sensitive neuromusculoskeletal control as cultivated by routine diaphragmatic breathing to allow effective transfer of GRF and torques upward throughout the body kinetic chain. The sensational feeling of Qi can help monitor the momentum transfer. The powerful Jin (GRF and torques) of Taijiqian is augmented at the feet using a Class-2 lever. The way to apply the augmented Jin from the ground naturally and with agility is by reducing the dependence on local muscle strength (avoiding Class-3 levers) and using whole-body power efficiently (enabling Class-1 and Class-2 levers and wheel-and-axle mechanisms).

More research in the topic areas is recommended, and it is clear that new advances in science can empower us with new ways to further comprehend the Taijiqian martial capabilities and help reveal Taijiqian’s martial insights. It is highly recommended that future research on both the health and martial aspects of Taijiqian should recruit those who have acquired certain Jin from the ground and can demonstrate Taijiqian’s soft-style martial arts. Further scientific research studies on Taijiqian’s Jin (GRF and torques) are certainly needed, including direct measurement via kinematic data analysis and indirect estimation via computer modeling.

References


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Research on the Belt and Road Initiative and the International Communication of Health Qigong

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Abstract—Under the background of the Belt and Road Initiative, this paper studies the international communication of Health Qigong by a combination of historical materialist dialectics and logic analysis. Health Qigong has the characteristics of both education and instruction that spans across many centuries and world regions. Based on the Belt and Road Initiative, the communication strategy of Health Qigong should include: strengthening scientific research; widening channels of communication and enhancing the radiant power of culture; boosting international exchange outreach, and promoting a deeper expansion and diffusion of Health Qigong culture. With the continuous advancement of the construction of the Belt and Road and the enhancement of soft power by China, Health Qigong will play a role in carrying forward the traditional culture of China, and help strengthen the exchange of sports between China and foreign countries, and promote the development of local society and economic development.

Keywords: The Belt and Road Initiative; Health Qigong; International Communication

1. Research Background

The Belt and Road Initiative was initially put forward by General Secretary Xi Jinping and it became a major strategic decision by the CPC Central Committee and the State Council to coordinate both domestic and international affairs. Due to its size and reach, it has substantial potential for realizing China’s desire to open up to the outside world, and to promote the growth of the Chinese economy and culture. At its base, the primary aim of the Belt and Road Initiative was to employ the historical symbolism of the ancient Silk Road, to develop economic partnerships with the countries that lie along its route; and to then build upon various shared common interests, with the aim being to generate mutual trust, common economic growth and cultural inclusiveness.1 With the deepening of China’s Belt and Road Initiative, this study looks at the effect of strengthening research in the communication of Chinese traditional sports and Chinese traditional culture, within the countries located along the New Chinese Silk Road.

As is common, the aim of many national governments is to promote friendship and cooperation between countries, and in this respect, China is no different. Health Qigong is an integral part of Chinese traditional culture. It employs body and mind control over limb movement, breathing, and psychological adjustments; and it also contains the spirit of Chinese culture, which is often described as the Harmony between Heaven and Man, and the need for Internal and External Harmony. This reflects a traditional way of keeping healthy in China, and it is deeply loved by many practitioners, both within and outside China. Therefore, led by the Belt and Road Initiative, it is important to research cultural methods to assist the spread of Health Qigong worldwide.
within countries to know each other better, and to live together in harmony. For this, a good political environment, featuring mutual trust, mutual benefit and a concept of common, shared development, not only reduces the risk of unwelcome conflict, the international communication of Health Qigong also makes it easier for people around the world to obtain better physical and mental health, mainly because of the respect and inclusiveness shown to foreign cultures, under an improved political environment.

2.2 the International Influence of Health Qigong Culture

As is well known, with the rapid development of modern science and technology, the concept of distance and time has greatly narrowed, and exchanges between people around the world have become far more frequent and convenient. This has led many people to now compare the world to a global village, and in this case the village is very large.

As of 2022 there are more than 60 countries along the route defined by the new Belt & Road Initiative, and the current population, within these countries, is calculated to be 4.4 billion; generating a substantial 21 trillion US dollars annually. This accounts for 63 percent of the world’s populations and 29 percent of the world economy.

Because there is only one earth, it is clear the world’s common interests outweigh any potential differences. It is clear that the whole of mankind faces the same results from global economic instabilities and ecological crisis, and the threat of nuclear weapons, extremism and many other risks.

Through deeper international economic cooperation, many believe that it is possible to reduce these risks, and it will be possible to improve people’s lives, by increases in connectivity and improvements in efficiency in the transportation of goods. Thus the Belt & Road Initiative will facilitate more trade, which will result in increased investment in what was previously considered difficult to reach, poor transportation areas.

And with increases in people’s workload, it is important to note that Taiji, can ease stress, and sport-based activities can improve worker’s health.

Relief of stress can also be psychological. For example, something as simple as a person’s pride in a countries achievements can result in the person working with a happier mindset. This can also be activated by a person’s connection to a specific culture, or to a shared group activity.

The flourishing of culture is a distinctive symbol and it is strongly supported by many different governments. For example, General Secretary Xi Jinping stressed in his report to the Nineteenth National Congress of the Communist Party of China (CPC) that “Culture is the soul of a country and a nation. Without a high degree of cultural self-confidence and prosperity, there will be no great rejuvenation of the Chinese nation.”

In this context, it is important to note that Health Qigong international communication is not the only way for the international community to understand China. It, however, can be considered unique, among sports, in being open to all people, irrespective of their age and their physical ability.

There are various sports and health preservation methods, such as the Yi Jin Jing (the changing tendon exercise), Wu Qin Xi (five mimic-animal exercise), Liu ZiJue (the six-character formula), and BaDuanJin (eight-sectioned exercise), and their simplicity creates a pathway for the international community to begin to understand the traditional cultural spirit that China has inherited over thousands of years.

Through the international component of the Belt and Road Initiative, and the greater spread of Chinese culture in the media, there has been an increase in awareness around the world of Chinese traditions, and as these traditions are quickly absorbed into new cultures, these new interactions may slowly create a shared common destiny. Here, the vision of the Belt and Road is to act towards both mutual benefit of a shared common destiny. For example, the economic and trade ties and the current population, within these countries, is calculated to be 4.4 billion; generating a substantial 21 trillion US dollars annually. This accounts for 63 percent of the world’s populations and 29 percent of the world economy.

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2.3 The Macro Strategy of Belt and Road Provides a Wide Opportunity for the International Communication of Health Qigong

The Belt and Road Initiative has clearly accelerated the pace of opening up between China and the international community. With its multi-field, multi-level and all-round cooperation, and its integration in the fields of economy, trade, transportation, culture, education, information, tourism, science and technology, the internationalization of Qigong has been reinforced.

Health Qigong international communication is a huge cross-cultural communication activity. Rational cross-cultural communication must be like a dialogue, and the dynamic way of communication features mutual respect and understanding. Therefore, it is necessary to actively promote the international academic exchanges of Health Qigong in order to create an opportunity for mutual understanding. Through a series of academic research activities, it is possible to aid communication, and to help researchers learn and collaborate with each other, and also they can provide support for the dissemination of Health Qigong at the academic level.

Health Qigong international communication is a unique physical and mental exercise method that originates from the ancient Chinese way of health preservation (which in English can be referred to as Preventive Care), but despite some recent advances there is still little known about the process from a modern scientific view point. This argues that there is a strong needs for more modern scientific research.

With many fitness mechanisms, fitness effects and cultural connotations, and the socialization of sport, there are many topics that are open to research, and

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perhaps many new fields can be explored and practiced - especially in the face of different cultural backgrounds and life styles. It is thus important for historians and Qigong researchers to continue to explore the fitness values, cultural values and social values of Qigong in order to make it more scientific and effective, to allow more people in the world to improve their life through Qigong.

To this end, the International Health Qigong Federation now holds Scientific Forums on Health Qigong every two years, to promote scientific research and international dissemination of Qigong. The first three forums were held in the United States, New York, Paris, and at the Hague Peace Palace in the Netherlands, in September, 2017.

3. The Features of Health Qigong International Communication

3.1 Education: Symbol Dissemination and Entity Dissemination

It is well known that the construction and dissemination of culture are based on symbols. Symbols are the carriers of information and are used to refer to specific things which are different from the things they signify, or to the characteristics of things. Video, picture, book, film and television are symbols of movements. But the real fitness effects of Qigong must be understood by symbols. Videos, pictures, books, films and television can be used to teach and distribute Qigong information.

With the development of film and television technology, movements can be taught by means of reproduction of entity communication. Actual things in the world are constantly transmitting information of their own existence and movement, and all the information transmitted by symbols comes from physical things.

In Chinese traditional culture Health Qigong contains the sum total of both spiritual civilization and material civilization. This involves not just fitness, but also a concern for life, and the pursuit of life. If we say that the various exercises of Qigong are the explicit "skills" to help study disease prevention, physical fitness and life health in symbolic communication, then the cognitive thinking mode, and the values and health concepts with unique Chinese characteristics, can be considered the physical "ways" of communication of Qigong.

Both skill and Tao are interrelated and have their own characteristics. However, in the international communication of Qigong, it is necessary to let the exercisers both understand the "skill" of Qigong and to feel the "Tao" of Qigong culture as well.

3.2 Spreading Space: Across the Boundary of Space-time

Within a scientific context, cultural space can be described as a place with specific cultural significance, which is specially reserved for certain cultural activities, during which traditional cultural activities, or events will be held periodically or irregularly according to the occurrence of a particular event. Cultural space can be thought of consisting of three distinct elements: time to carry out the activity, the space to do the endeavor, and culture (a term which covers many different elements; and, as stated previously, can be related to mental pride). Pride can be strongly linked to happiness, and is thus an important component in health.

Health Qigong not only contains knowledge of preventative health, it also contains profound cultural heritage. It carries a vast and rich knowledge in its oral traditions, and folk knowledge, which prompt many to seek a large amount of space and time to practice this knowledge, and concepts. At the same time, due to the small average site requirements, coupled with its gentle movements, Qigong has gained popularity among fitness enthusiasts, both in China and abroad.


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Acknowledgments

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Wang Zongyue's Taijiquan Discourse: The Biomechanics of Dongjin

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Abstract—We present in this following paper a verse-by-verse translation of the Taijiquan Discourse, with annotations in the framework of biomechanics. In the text, dongjin 懂勁 is the "comprehension of jin" crystallizes as a central concept. Dongjin can be viewed as how the body comprehends, and interacts functionally with force. While the body relates to force by its strength and functionality, the Taiji body, is considered to be instilled with dongjin, and perceives the force associated with jin (貢) as "soft" (rou) and "hard" (gang), which correspond to the vector quantities of the force, namely, direction and magnitude. In most cases the common response to an attacking force is to fight back, in a direct force-against-force interaction, which creates a "double-weighted" conditions (shuangzhong 双重) that tenses up, and traps the body from being able to maneuver. This renders the body vulnerable. Dongjin enables the body to respond to the incoming force by making postural adjustments to receive force at an angle, at the moment of impact, thus deflecting and mitigating it. In other words, the body uses the rou component (softness) to absorb and neutralize the incoming force. Also, dongjin accords liveliness and spontaneity in the response of rou and gang, which is a fundamental feature of martial skills. Dongjin is more comprehensive than perceiving force as a vector; it is considered to be a core classic in the art of Taijiquan. Within it, the principles that govern Taiji motion are well articulated, but they are expressed in archaic, traditional terms that do not easily link to modern scientific descriptions.

Despite this, the body relates readily to the central concept of the Discourse, dongjin ("comprehension of jin"), and the associated traditional concepts of gang (hardness), rou (softness), and jin ("internal force") as they manifest in the musculoskeletal framework.

We can parse them, as well as the meaning of "Qi sinking to the Dantian," and "double-weightedness" (shuangzhong) in the context of biomechanics. Indeed, by viewing Taijiquan as an art of body motion, we eschew the esoteric and bring out the science in Taijiquan.

Such an approach may seem to diminish the role of traditional Taiji theory, but to the contrary, what is revealed is the wisdom of the traditional theory in resolving the fundamental issue in Taijiquan: How to discipline motion at the myriad joints of the body, when they are subject to varying multiple internal muscle forces and multiple external forces.

The significance of exploring the science behind Taijiquan is that one can employ biomechanics to try to better understand the meaning of the art. More importantly, with science we can attempt to better gauge the progress made in one's practice, in what can be a very long journey. The science gleaned from the Taiji methodology can thus be ported to Sports Science, which shares many similar issues in training.

Our review of the Discourse is organized by theme, corresponding to the related stanza in the text. It should be noted that this is not a literary exercise to appreciate the poetry of the original work, but rather an essay into the Scientific Thought behind Taijiquan. The full text of the Discourse in Chinese is given in the Appendix with pinyin for the reader's convenience. This is divided into 8 stanzas.

1. The Ideal Taiji Motion

The practice of Taijiquan is a discipline of body motion with the movement made in accord with the Taiji principles of Yin and Yang.

Taiji, born without limits,
Engine of motion, the Mother of Yin-Yang.

Movement separates, stillness unites.
Not over and not under, it takes the bends and straightens.

太极者，无极而生，
动之则分，静之则合。

无过不及，随曲就伸。

1.1 Taiji Theory

Taiji, the Theory of Grand Extremes, is not limited in scope in the Chinese discourse of all things, from the microscopic to the cosmic scale. Inherent in the theory is the concept of an engine that drives the motion of life—the principle of Qi, the life-force energy, that is the animating agent of all things (dong zhi zhe jin 动之则分，静之则合). Since ancient times, Chinese thinkers have used the Grand Theory in the study of geomancy, fengshui, medicine, etc., and, of course, Taijiquan.

The motion engendered by the engine has the operational effects of “motion separating, stillness uniting” (dong zhi ze fen, jing zhi ze he 动之则分，静之则合). States that evolve by this engine of motion have two distinguishable characteristics, the Yin or the Yang. Taiji, thus, is the Mother of Yin and Yang.

The dynamics is governed by the Yin-Yang Principles towards harmony; at the heart of which is this Yin-Yang balance.

Taijiquan motion is a product of discipline, guided by the Principles of Yin-Yang balance that integrate the forces acting on the body in balance. Externally are the forces of gravity and the interactions that occur with other bodies, and internally are the tensile forces of muscle contractions, stretched tendons, ligaments, and fascia connective tissues of the musculoskeletal structure. This defines a comprehensive balance of our bipedal functionality with all the Yin-Yang nuances.

The metaphysics of Yin-Yang balance is captured fully with all its dynamics and multi-dimensionality in the ubiquitous Taijitu (太极图) or Taiji Diagram (Fig. 1). This is the circular image of two-halves, each in the form of a Yin or Yang fish. Within the Yin fish is an eye of Yang, and within the Yang fish, an eye of Yin, with each flowing into the other in harmony within the circle. The ideal Taiji motion is elegantly depicted in the Diagram.
1.2 The Dao of Seeking Balance

The structure of our bipedal framework is inherently unstable, and the body is constantly adjusting its balance. To keep upright, the body relies on the interaction between the inner ear, body proprioception, and visual clues, to constantly adjust the body.

Normally these processes occur in the background, and we are unaware of the number of actions that our body takes to keep us upright. However, when we undertake an artistic movement of the body, we become conscious of postural balance, as we have to generate various motions to form the desired posture. Intriguingly, in creating these movements, even though many moves must now be considered, we still do not need to make mental calculations to determine how to allocate muscle forces to maintain good posture. So, how do we get to the right combination of muscle forces for postural balance?

Seeking the solution of balance is to find a unique point in a range of imbalances, which in practice is impossible to pinpoint exactly. Taiji skirts around the concept by finding the exact solution and trains the body to recognize what is overextended (this being described in Taiji as excessive) or what is under-expressed (this being described as deficient). These are cognized as errors and expressed in the text as wuguo buqi 无过不及. Thus, in Taiji, the focus is not on balance, per se, but on perceiving “what is over, or what is under” as sensed by the body.

It can be said that the attentiveness to these processes, through exercise, forges into the body a cognitive sense of the postural and stay in the middle ground within the margin of errors. This prescriptive exercise carves a solution-practice path which continually refines and sharpens the process, thereby reducing the error margins towards balance. In Chinese philosophy, this is the art of seeking balance without seeking it, the Dao of doing without doing (wei wu wei). The task of resolving for balance will be discussed in Section 3.

2. How does the body relate to force and dōngjīn?

The concept of force is implied in the “engine of motion” (dōngjīnn jī ji 动静之机). Force is defined in physics as the product of mass and acceleration. Normally we think of weight as mass and only consider it to be a force after we study gravity. As a result, we, usually, do not sense the weight of our arm, but we relate much better to the functional effect of the force of our hand hitting someone, where the collision of the hand with a person results in a change of momentum (mass x velocity).

We can also relate this to the mass factor in the force of a car crash, which at high speeds can be fatal, and compare that to the forces experienced in a push cart that is moving at a slower speed.

We also know that a stone dropped on our head can result in serious injury, but not a football of the same mass, which demonstrates the less obvious but important factor surrounding the time duration in the collision. The cushioning effect of the football provides a longer time duration for the change. These factors are expressed mathematically in Newton's Second Law:

\[ \text{Force} = \frac{\text{Change in Momentum}}{\text{Time duration}} \]

The body can learn to relate to the Law governing the changes in momentum caused by the forces of muscle contractions. Muscle force can only do one thing. It produces body motion.

While force is well-defined in physics, how does the body comprehend this force? In this case Taijiquan's answer lies in the concept of dōngjīn 動靜 (the comprehension of jīn-force).

The Discourse introduces two factors that do not seem to be scientific. These are gang 松 ("soft") and rou 硬 ("hard"), which are used in basic Taiji vocabulary in all discussions of the application of force. However, it turns out that these terms can be described by physics and they are just Taijiquan's perception of force as a vector, with the terms related to magnitude and direction.

2.1 The Functional Effects of Force Vector

To hardness, I respond with softness to “walk-follow,”

I follow his movements as he attacks to “adhere.”

If swift, I respond swiftly; if slow, I follow slowly.

Changes are innumerable, the same principle applies.

人刚我柔谓之走, 人柔我刚谓之粘, 人刚我柔谓之走.

动急则急应，动缓则缓随。虽变化万端，而理唯一贯。

The force of an attacker's strike is lessened if it is received on impact at an angle rather than directly. One can alter the magnitude of an incoming force by deflecting it, to avoid a direct impact, or by moving out of the way.

One can make postural changes to alter the angle of impact, thus the directional component of the attacking force is modified, to mitigate its damaging effects. Taijiquan does this by accessing the rou component (softness), by addressing the changeability of one's posture, to respond to the magnitude, the gang or hardness, of the strike.

At the same time, one can also access the gang component of one's response-action to keep one's posture in balance. This is depicted by the eye of gang-Yang in the rou-Yin half of the fish in the Taiji Diagram. Thus, in the rou response the body is neutralizing, walking, and following the attacking force. "To hardness I respond with softness to walk-follow." (Ren gang wo rou wei zhi zou 人刚我柔谓之走).

There is another important quality in the response of rou. When pushed, the usual response is to push back. This is to keep one from being pushed off one's base.

In such a situation, the pushing-back action is directed straight at the push. If one is not as strong as the person who initiated the push, there is only one possible outcome. One will be pushed off their base.

Also, in this force-against-force response, the result is the defender tenses up, and his or her body will become locked in posture, which restricts the person's ability to maneuver.

In contrast, if the defender responds with rou (softness), this gives the defender the ability to access the vector properties of rou and gang to maintain maneuverability and balance. This rou response is a recurring theme in the Taijiquann Discourse.

This application of physics to Chinese martial arts texts now provides the rationale of how Taijiquan uses 'softness to overcome hardness' (yi rou ke gang 以柔克刚) through responding with rou; one can absorb, neutralize, follow, stick, and stay with the opponent's body in the adhering action of rou 貴 to the opponent's attacks (Xi xun ren bei wei zhi zhan 我顺人身背之粘). This limits the opponent's opportunity to strike until he falters. One can immediately read his faltering momentum from the sensitivity of one's zhan-adherence to his body, upon which a gang counterstrike can then be launched.

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instantaneously.

The zhan-adherence to an attacker’s body is more than a touch or sticking sensation. The zhan establishes a contact connectivity with his body so that one can decipher his motion and his intention. This establishes a strategic advantage of the zhan-adherence, which is based on rou.

However, to maintain a zhan-adherence, one must continually follow the opponent’s body motion, to flow with it. If his movements are swift, one must also be swift, if slow, one must be slow to keep the connectivity. (“If swift, I respond swiftly; if slow, I follow slowly.”) Dong ji ze ji ying, dong huan se huan sui. (动荡则急应，动荡则缓随). At this point a student may ask what will happen if I am not as swift as the opponent? In this case zhan can still be maintained at a contact point closer to his center of motion. For example, one can keep adherence at the arm closer to the elbow or shoulder without being as fast as the hand. If his action is manifestly slow, and not a nudge for a hidden kick or strike to emerge suddenly, then of course, it does not mean that one should not proceed with gang to dispose of him!

Therefore, respond with rou to walk-follow and flow with his body to zhan-adhere to maintain contact and connectivity. This is the meaning behind: “Changes are innumerable. The same principle applies.” (Sui bianzhe wu wu, er li xian yi guan 虚化万端，而理惟一贯). In this way, the body gains familiarity of the functionality of force as a vector; or the body comprehension of force, dongjin.

2.2 The Body Comprehension of Force, Dongjin

As training matures, one gradually comprehends force,

Poised thus, one ascends to the spiritual plane,

But unless one puts in the time and effort;

The insight of wholesome mastery cannot arise.

Jin is Taijiquan’s concept of force vector as perceived by the body as gang and rou, corresponding to the vector quantities of magnitude and direction. The concept embodies body comprehension and functionality in application.

In the Taijiquan form practice, the body constantly adjusts muscle forces against gravity to retain postural balance, by engaging the dynamics of gang and rou. The attentiveness to practice these movements in slow motion instills the vector principle through the body sensing the gang and rou, cultivating dongjin 勤劲, the body comprehension of jin.

In push-hand drills, the body is adjusting gang and rou against both gravity and the external forces generated by a partner, which together reinforces the comprehension of jin.

Implicit in the experiential cultivation of dongjin is that the body is also enabled to access the gang and rou of jin to maneuver, or reposition itself to retain constant balance; and “As training matures, one gradually comprehends force.” (Yinkaishengdongjin 由着熟而渐悟懂劲).

In application, dongjin renders jin as a highly refined force, which is distinguished from li (力), the colloquial term for force. To emphasize this distinction, jin is often referred to as neijin 内劲, which means “internal force”, to point to the amount of “internal” work involved in training gang and rou. This hallowed neijin is developed as the body’s core strength in Taijiquan. The amazing martial feats of Taijiquan are attributed to the force of neijin.

Indeed, poised on the comprehension of jin, one’s practice ascends to the spiritual plane that represents a unity of mind and body. (“Poised thus, one ascends to the spiritual plane.” You dongjin er jie ji shenming 由勤劲而阶及神明). The immediate import of this elevation is that the body’s response in an encounter will be spontaneous, and the body will immediately apply the right force vector.

However, like growing a plant, the nurturing of this dongjin cannot be rushed; it is a process of time and effort in study and training, which is the meaning of Kungfu (功夫). There are no shortcuts and no limits in Taijiquan. Unless one puts in the effort to practice Kungfu, one cannot attain wholesome mastery (武侠). In other words, without putting in the time and effort, the fruits of mastery cannot be attained (Ran fei you li zhi jiu, huneng huoruan guan yang 然非用力之久，不能豁然贯通也).

3. Fangsong, Qi and Balance

Point the crown up without stretching, Qi sinks to the Dantian

虚领顶劲，气沉丹田

Xia ling deng jin, Qi chen dantian

It is uncanny how well these few characters encapsulate the genre of the art. Though some find it had to believe it, the whole practice of Taijiquan to develop neijin is distilled in this one short verse. In fact, one can find a lot of science by unpacking the role of Dantian (丹田) and Qi (气). Qi, is the ubiquitous vital life-force energy, and is a whole subject by itself, but we can take it as given in Traditional Chinese Medicine, or the reader can find a review of Qi in the author’s prior paper, Science in Qi.

The practitioner’s comprehension of jin grows by experiential development from the dynamics of gang and rou, that is grounded in biapedal balance. As mentioned, this discussion has relied on the body’s senses, to convey to the brain what is in excess or what is deficient in imbalance, as well as of the gang and rou. In this complex equation, Qi comes in as the sensation transduced from the body senses to gauge the Yin and Yang. The nurturing of Qi in Taijiquan practice is to cultivate the Qi cognition of the body senses to facilitate the goal of Yin-Yang balance.

Yin-Yang balance goes beyond physical balance; it incorporates the functionality of balance. For example, there is balance in the posture of a person standing at attention before a sergeant in a drill. With the chest braced up, the air in the abdomen hollows, rendering the body top-heavy, and can be easily toppled with a gentle nudge. The tensing of the chest...
muscles affects the functionality of the posture while the physical balance remains.

In another example. If you stretch out your right arm horizontally to the side and hold it for a few minutes, there is a varying combination of the muscle forces of the arm and shoulder supporting the limb’s weight in balance. In this action, what is a preferred combination of muscle forces? After a while, the effort to maintain the physical balance makes the arm tense, giving you some ache and discomfort, which affects the arm’s functionality. This elicits a response of relaxation that eases the tenseness, bringing some relief. This “relaxation” turns out to be a rudimentary operation of fangsong (放松), “relaxing by letting go,” which lets the body settle into a better state of balance with less stress. The body experiences a sensation of ease, by the fangsong adjustment of the posture, which Taiji attributes to a Qi sensation. That is, fangsong induces a preferred state of balance, which is associated with a better Qi state.²

As a final example, in the same arm position, now extend your fingers and keep them stretched. With the fingers stretched, you find that you cannot flex the fingers unless you relax the hand to regain its functionality. Likewise, if the wrist, elbow, or shoulder joints are tensed up, the arm’s functionality is compromised while still in physical balance. Fangsong relaxation at the joints settles the arm in a better state of balance, cognized as a better Qi state, and facilitates the arm’s functionality.

To recap, in Taijiquan, we can view Qi as a sensation of balance, cognized as a better Qi state, and facilitates the transmission of muscle tensions from the shoulder to the hand through the elbow. In this way, the Qi in fangsong utilizes the medium of fascia tension to discipline the arm’s motion.

We can extend the discussion of the dynamics of the arm to the dynamics of all the segments of the body. By working on fangsong of all the joints, we can extend the tensile connectivity of the arm to the whole body, forming a fascial tensional network. In this way, Taiji cultivates the cognition of the tensional network as Qi, thereby building the Qi-connectivity bodywide, which is harmonized in disciplined body motion to center on the principles of Yin-Yang balance. More discussion on fascia tension and Qi can be found in the author’s paper.³

3.2 “Qi sinking to the Dantian”

The power in sport actions comes from the waist, but successfully applying it is quite another matter, which is why most weekend golfers find it hard to improve their drive. Knowing the physics, that greater momentum is generated with more speed or mass, is easy, but engaging the body segments to move in well-aligned momenta requires a lot of discipline. What makes it more difficult is that, habitually, our torso does not turn as a whole. In our walking, the chest turns in one direction, while the abdominal region twists in the opposite direction. Doing so cancels out the angular momentum, an action facilitated by the curvatures of the spine.⁴

To tap the full potential of waist power, it is necessary that the torso and pelvic girdle must rotate as a whole, while supported by the base below, turning in the opposite orientation. This is the discipline of the transmission of forces at the triangle of joints, consisting of the hip joints and the sacroiliac joint (SIJ). Taijiquan has a specific term for the waist, called the kua (胯), to describe the complex of the pelvis and the triangle of joints. The kua serves as the junction of force transfer between the upper and lower body, channeled from the ground.⁵

Recognizing its pivotal role in force transmission, Taijiquan practice revolves around the discipline of the kua, namely, the fangsong of the kua at the triangle of joints. The Dantian, which is the point located three-fingers below the navel, and a third of the way in, serves as the functional center of the kua. The Qi nurtured through fangsong at the kua is sensed as filling the pelvic bowl and concentrating at the Dantian center, which is cognized as “Qi sinking to the Dantian” (Qi chen dantian 气沉丹田). However, the balance at the triangle of joints is not localized. It is integrated with the other joints of the body due to the tensile integrity of the body frame. This means that balancing at one joint can affect another, requiring a re-calibration, which makes the task of balancing a many-joint system quite intractable. The fangsong process bypasses this complex issue by working on the correspondence between pairs of body’s major joints. The fangsong of the shoulder and hip-joints disciplines the motion of the torso as a whole, which consolidates the fangsong of the kua and reinforces the force-transference role of the kua. The fangsong process can then be extended to the elbow-knee and hand-foot pairs, to systematically resolve the balance of the matrix of joints via the fascia tensional network.⁶

Operationally, the fangsong of the matrix of joints is also resolving the balance at each joint relative to the Dantian center, thus nurturing the Qi to sink to the Dantian repeatedly. This consolidates the Qi-connectivity body-wide, centered at the Dantian, as Qi is harmonized in the discipline body motion. This defines the centrality of the Dantian. The mastery of the art of Taiji is thus ingeniously reduced to the actualization of the role of Dantian centrality in Qi-connectivity. The actualization of Dantian centrality is articulated by Chen Xiaowang as Dantian wei hexin de xing cheng 丹田为核心的行成. This is further discussed in the author’s prior essay.⁷

3.3 Xu ling ding jin

Crucial to fangsong of the kua is the balance of the head. Straightening the head may keep it from nodding, but to engage its balance with the kua requires tensional connectivity between them. This is facilitated by ding jin (顶劲), pointing the crown of the head up as the torso settles by its weight into the kua. However, the action of pointing may inadvertently cause the neck to be stretched, which introduces tenseness. Xu ling 虚领 comes in to modify it with “empty leading” or without the active pushing or stretching to negate any cause of tenseness. This is emulated by imagining the head being suspended at the crown and bending slightly at the knees to let the body drop but not the head, which actions involve eccentric muscle contractions. The dropping action induces the torso to settle at the kua, generating tensional connectivity along the spine with the balance of the head via the thoracolumbar fascia and the mual fascia. This augments the body-wide fascia tensional network from the head to the feet.

The tensional network provides the medium for dongjin to transmit jin-force between the ground and the upper body. The action of the jin-force of waist-power transmits from the kua up the torso to the shoulders, through the elbows to the extremities, and the reaction jin-force pushes down through the knees to the feet, to anchor solidity onto the ground.

The continual settling of Qi in the Dantian not only builds, consolidates and refines its role of centrality, but the Qi nurtured also provides a measure of how well the practice is progressing in the body’s comprehension of the Yin-Yang balance. Indeed, the beguiling mantra of Xu ling ding jin, Qi chen dantian 气沉丹田 captures fully the practice theory of Taijiquan, foregazing the benefit of the details of muscle anatomy. That both Qi and Dantian are not scientific

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With the liveliness accorded by the principles of Yin-Yang and dongjin, the Taiji body responds spontaneously with the right force vector to accommodate the opponent’s action. The maneuvers in Taijiquan thus appear to be magical to the opponent. His slightest error would be picked up by the sensitivity of Taijiquan's consummate balance, and a counterattack would be launched instantaneously by dongjin to send him flying.

5. Taijiquan’s Consummate Balance
A feather cannot be added, a fly cannot alight.
People cannot gauge me, but I can read them.
Such heroes have no peers, forged thus by these principles!

一羽不能加，轻飘不能落
人不知我，我独知人
英雄所向无敌，盖由此而及也！

The Sanddorn Balance act is often considered to be a spellbinding demonstration of the balance of 14 palm leaf ribs and a single feather. Starting with the balance of a feather on a branch, it is then balanced freely on the next, then on the next, one by one until the last branch. The elaborate structure stands freely in mesmerizing balance. Then upon the removal of the feather, the branches fall one by one, demonstrating dramatically the delicate support of the single feather in the balance.8

The allure of a feather to convey the delicacy of balance appears in the verse: A feather cannot be added, a fly cannot alight (Yi ye beneng jia, ying chong huneng jia —一羽不能加, 轻飘不能落). However, while our bipedal structure is inherently unstable, the reference to balance in Taijiquan includes a functional factor. The body can withstand piles of kilos without collapsing. It has muscle engines generating forces to dynamically balance external forces. Taiji balance is more; it incorporates the crucial functionality of lively changeability to maneuver. Not only does the Taiji body adjust to changes in load, but, more significantly, it is also extremely sensitive to subtle load changes in the balance.

The arduous training process of faungong to settle the Qi in the Dantian is continually infusing the body with the principle of balance in ever greater refinement. This cultivates the sensitivity of feather-weight changes critical to maintaining the advantage of martial functionality in balance. Accorded with this feather-weight sensitivity, the subtle responses of the Taiji body are almost undetectable, or magically invisible, while the same sensitivity can decipher an opponent’s slightest change in motion, as conveyed in the verse: People cannot gauge me, but I can read them (Ren baazi wo, wo da zhi ren 人不知我, 我独知人).

The body comprehension of jin is also consolidating the feather-weight sensitivity in the dynamics of gang and ron in the refinement process. Thus, as the Taiji expert ascends the rarified heights of mastery, he can find no one to match his skills: Such heroes produced can find no peers, forged thus by these principles! (Yingshong suoxiangwudi, gai jie you ci ji ji ye 英雄所向无敌, 盖由此而及也!).

6. Touting the Superiority of the Art of Taijiquan
Uncharacteristic of the Chinese culture of humility, the next few verses tout the superiority of the art of Taijiquan. Taijiquan regards itself as standing above the other martial arts systems, which it critiques as relying primarily on the advantages of superior speed and strength to prevail.

Branches of martial arts abound; they may differ in characteristics,
Most are about the strong subduing the weak, and the slow yielding to the fast!
A stronger force beating a weaker, a slower hand losing to a faster,
These are of the natural order, not from innovative mechanics!

斯技旁门甚多，虽有区别，概不外乎壮欺弱，慢让快耳！
有力打无力，手慢让手快，总是先天自然之能，非关学力而有为也！

The charm of Taijiquan is that it offers a way to overcome the shortcomings of being weaker or slower to defeat one who is stronger and faster. This is borne out in the much touted Taiji skill of “four ounces repelling a thousand pounds” which is most demonstrative that superior strength is not the only deciding factor in winning. The verse after describes the situation of Taijiquan elders beating back a besieging crowd; the oldies are clearly not as fast or as strong.

Four ounces repel a thousand pounds” shows not only strength can win!

Witness elders driving back a throng, where is the speed advantage?

察四两拔千斤之句，显非力胜！
观老耋御众之形，快何能为?

We, of course, can attribute to the mechanics of lever, the skill of these martial feats. However, to move a thousand pounds placed at 3 inches from a fulcrum with 4 ounces, the lever arm would have to be over 1000 feet! Our anatomy is too constrained to effect such a setup! Still, the reference in the verse is not meant to be metaphorical either, but to highlight a Taiji Kungfu skill of the highest order.

The leverage applied is not linear, but rather like the torque of a screwdriver. If you held the handle, while the opponent holds the tip, no matter how great his strength, you could control the dynamics with little effort. The key is to exert control of the kua as the handle of a screwdriver. With the leverage, the torque generated at the kua can easily overcome a grip on your arm. Also, by turning minutely at the kua, you can divert the pressure away from the body. This involves the body’s rotational motion, which is disciplined in the practice of “silk-reeling” motion or chansigong (缠丝功).9

Speed may not be the only deciding factor, but at the normal range of fighting, speed is of critical advantage in delivery. The strikes of the fist, or foot can come from unexpected angles. So, speed is also critical in defense. However, the advantage of speed is diminished in close quarters, which limit the

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extension of the limbs. The swiftest speed of the fist or foot at delivery is reached only through full extension. In situations when fighters are grappling, the advantage of speed is blunted. Moreover, the Taiji body has the advantage of dongjin, the comprehension of jin, which can decipher the opponent's relative speed in motion and intercept a faster hand at a point on the arm with lesser speed.

However, this by no means implies invincibility. The sacrosanct belief of Taiji's superiority was given a rude awakening when a MMA fighter floored a self-styled Taijiqian master in a matter of seconds. The fighter's fast punch easily found its way to the head of the so-called Taiji master! Great theory is one thing, but comprehensive mastery is quite another. The mastery of dongjin is an experiential development of the Yin-Yang art.

7. Double-weightedness and Yin-Yang

Stand poised in balance, ever-ready, lively as a wheel.

Yield and sink to follow, "double-weightedness" will stagnate.

Often, after years of dedication, still unable to neutralize

Rather, be controlled by others; the flaw is "double-weightedness."

立如枰准备, 活似车轮。偏沉则随, 双重则滞。

每见数年纯功, 不能运化者, 即是双重病也。

To avoid this illness, comprehend Yin and Yang

To adhere is to walk-follow, to walk-follow is to adhere,

Yin and Yang mutually aid in change, then comprehension of jin is achieved.

8. Art of Self-cultivation

Once you grasp jin, the more you train, the more refined it will be.

Contemplate and study, gradually the body will do as you wish.

Give up self to follow, avoid erring in the near, the goal is distant.

It is said, a minute error can cascade to a miss by a thousand miles.

Students must not fail to make this fine distinction! This is the Theory.

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T’aijiquan motion is not based on form appearance only. As long as the motion is in accord with the Yin-Yang principles, the force that arises will be jin, of the right force vector.

9. Conclusion

Although we have reviewed the central concept of dongjin by the perspective of biomechanics, and related the gang and rou of jin to the vector values of the associated force, they are, nevertheless, not scientific constructs, as they incorporate aspects of functionality in application. We do not calculate the forces that move the hand to touch the nose, like we compute the planetary trajectories from differential equations derived from gravitational forces. Although the muscle forces that generate body motion, too, obey Newton’s Laws of Motion, the hand’s motion involves many skeletal muscles, each made up of contractile subunits. These forces cannot be expressed in terms of computable variables, unlike gravitational forces which depend only on the distances between the planets. Moreover, we do not relate directly to the muscle forces. We do not connect to the biceps or triceps per se. That is why body motion is not studied by the classical formulations of Newtonian mechanics.

The Taiji solution relies on what the body can sense or relate to, namely, on the concept of dongjin by the formulation of gang and rou, and on Qi-cognition to resolve postural balances based on the non-axiomatic soft logic of Yin and Yang. This is the prescription of nurturing Qi that resolves imbalances, which process is distilled to sinking the Qi to the Dantian. Amazingly, the very practice carves a solution-path that leads to Yin-Yang balance, generating the ideal motion of Taijiquan. The upshot is that the response that ensues from the ideal Taiji motion is of the right force vector in application. The jin-force itself arises from the ideal motion by virtue of Newton’s laws and of Yin-Yang balance.

However, the practice of Taijiquan today is motivated more for its health and therapeutic efficacy. In Traditional Chinese Medicine, a measure of health well-being is a good store of Qi in circulation. Indeed, the Taiji methodology draws on the Qi energetics of the ancient art of daoisin tuna, which promotes the Qi harmony of the “Five Internal Organs” (Wazang). We find the harmonizing effects of Qi permeating via the body-wide fascial tensional network, which envelops all the internal organs. Taiji practice, then, contributes to the homeostasis of the body’s organ systems, the passport to health. For an overview of Taiji health, see the NIH Fact Sheet. Finally, it is noted that the practice of Taijiquan is more than a physical exercise. The self-cultivation process embodies a meditation component. The operation of fangsong-relaxation that resolves imbalances entails attentiveness to the practice, hence the slow-motion methodology. The attentiveness keeps the mind from wandering to stay in focus, and to sharpen in refinement. The meditation component develops mindfulness and tranquility that ascends to spiritual clarity and insight (shenming 伸明).

Appendix

Wang Zongyue Taijiquan Discourse

朗读王宗岳《太极拳论》

1. 太极者，无极而生，动静之机，阴阳之母也。
   Tàijí zhě, wújí ér shēng, dòngjìng zhī jī, níngyáng zhī mǔ yè.

2. 则约而精，动之则分，静之则合。
   Zé yuē ér jīng, dòng zhī zé fēn, jìng zhī zé hé.

3. 无过不及，随曲就伸。
   Wú guò bù jí, suí qū jiù shēn.

4. 合抱之木，生于毫末。
   Huòbào zhī mù, shēng yú háo mò.

5. 角力不如巧，务期周到。
   Jiǎojié bù rú jiǎo, wùqī zhōudào.
Yīngxióng suǒxiàngwúdí, gài jiē yóu cǐ ér jí yě!

6. Sī jì pángmén shén duō, suī shì yǒu qūbié, shì jiè xiāntiān zìrán zhī néng, fēi guān xuělì ér yǒu wéi yě。

7. Lì rú píng zhǔnbèi, huó shì chēlún, piān chén zé suí, shuāngchóng zé zhì.

8. Dǒng jìn hòu yù liàn yù jīn, mò shí chuǎimó, jiàn zhì cóngxīnsuǒyù.
"Cardio Taiji for Wellness"
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US Collegiate Taiji Federation

Abstract—The concept of Taiji (Tai-chi), consisting of Yin and Yang, originates from the ancient Yijing (I-ching), the Book of Changes. It is the traditional metaphysical Law of China, and has been described as Dao (Tao) or "The Way." Two years ago, in December, 2020, Taijiquan (the fighting system of Taiji) was recognized and accepted as an Intangible Heritage of Humanity by the United Nations Educational, Scientific and Cultural Organization (UNESCO). This study reviews the Taijiquan technique for assisting in life and wellness, and presents a brief review of the effect of Cardio Taiji on blood pressure.

Keywords: Yin & Yang, Balance, Holistic Healing, Wellness Continuum, Security, Cardio Exercise, Harmony, Tao/Dao, The Way

Introduction
For centuries, Taiji theories have been widely applied as a vehicle for the cultivation of the body, mind and spirit (Figures 1 & 2). Thus, the current trend of study on Taiji has been directed towards measurable Cardio Taiji for fitness and Therapeutic Taiji for integrative medicine. This includes preventive medicine and rehabilitation.

Cardio Taiji is a relatively new Taiji exercise which is considered safe and benefits cardiovascular function. In 2002 a debut performance was given at the IDEA Annual Conference in San Diego; a workshop was conducted at the 2005 AAHPERD Conference in Chicago, and Cardio Taiji was added as a new event in the 2003 International Kungfu Tournament in Rio de Janeiro. It was also exhibited at the 2006 First World Tai Chi Chuan Championship in Taipei, and at the International Tai-chi-chuan Tournament at San Jose State University.¹

The work-out presented in this paper, which has been shown to aid blood pressure in participants, integrates traditional Taiji with a high intensity interval training method. This exercise is considered useful in helping people maintain general health, who have only limited time to exercise.

Cardiovascular fitness and high intensity intervals have been proven to be effective exercises for health maintenance. Taiji movement has also been studied by many scholars and has become more and more popular around the world. The integration of high intensity cardio exercise and traditional Taiji is a new contribution to the world of sport and medicine.

What is The Eight Dimensions of Wellness?

Fig. 1 Overview of the Integration of Tai Chi and Aerobatic Exercise designed by the author Chi-Hsiu Weng.

Fig. 2 The way of pursuing Taiji.

Fig. 3 Examples of Taiji techniques classified for sport prescription purposes.

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Taiji as an essential activity

There are many negative influences that have become apparent and been exacerbated under the shadow of COVID 19. The problem of lack of time and space to exercise is one of the problems that occurred after lock-down in many cities of the world. According to psychological research by the Department of Psychiatry at the University of Oxford, Dr. Diamond Rowan said, “During this pandemic, there are likely to be additional barriers to increasing activity at the very time it may be most beneficial in alleviating physical and psychological stresses. For example, anxiety about leaving the house, the closure of gym facilities, and less opportunity to exercise with others.” Therefore, finding a healthy exercise, after the pandemic phase has passed, is an urgent need.

Cardio Exercise has been emphasized for health maintenance

The WHO has recommended that adults between 18–64 years old should do at least 150 minutes of moderate intensity aerobic physical activity throughout the week, or 75 minutes of vigorous intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity. Aerobic activity should be performed in bouts lasting at least 10 minutes duration. The 2008 Physical Activity Guidelines for Americans also states: “People who do moderate or vigorous-intensity aerobic physical activity have a significantly lower risk of cardiovascular disease than do inactive people. Regularly active adults have lower rates of heart disease and stroke, and have lower blood pressure, better blood lipid profiles, and fitness.”

There have been many positive results in the research of Tai Chi and general health. According to the study of a review of literature by Taylor-Piliae: “Simplified forms of Tai Chi are ideal for people with impaired health conditions, including those with heart disease and the elderly.” Consistent findings were also observed in the significant reduction in blood pressure reported over multiple studies, especially when Tai Chi practitioners were compared to inactive control groups. After the study of the comparison of the effectiveness of Tai Chi versus people who went on brisk walks, it indicates that the Cardiopulmonary benefits of Tai Chi may partially be explained as a response to aerobic exercise.

Definition of Taiji and Kungfu

Tai Chi Kung Fu is one of the great health exercises of the ancient world. Dr. Peter M. Wayne, author of “The Harvard Medical School Guide to Tai Chi” explains, “Though these roots are thousands of years old, the formal name Tai Chi Chuan was coined as recently as the seventeenth century as a new form of kung fu, which integrates mind-body principles into a martial art and exercise for health.” Dr. Wayne also described Tai Chi Chuan as the “manifestation or integration of these philosophical concepts into the body.” “One reason Tai Chi is popular is that it is adaptable and safe for people of all ages and stages of health,” he points out. “Recent Tai Chi forms have even been developed for individuals to practice in wheelchairs. And although few formal medical-economic analyses have been conducted, Tai Chi appears to be relatively cost-effective.” Even though there are many benefits of Tai Chi practice, the questions regarding scientific evidence are still to be answered. According to Dr. Wayne’s research, “Tai Chi can increase the heart rate to between 50 and 74 percent of the maximum, depending on the type and intensity of Tai Chi and your age. Importantly, Tai Chi is highly adaptable to your heart’s capacity for exercise because you can modulate the intensity.”

Designing Cardio Taiji

“Numerous studies have shown that Tai Chi can be considered an aerobic activity of low-to-moderate intensity, depending on your training style, how deep you sink into the postures, how fast you move from one posture to the next, and the duration of your practice.” It is possible to modify the Tai Chi exercise into an aerobic exercise. Cardio Tai Chi is one of the effective physical activities which integrates aerobic exercise and traditional Tai Chi Kung Fu. This exercise was created by the co-author of this paper, Dr. Chi-Ihsiu Weng, and was developed in response to the urgent need for a cardiovascular workout that did not put the joints, ligaments, and muscles at risk. This being important for participants who have poor general health.

According to Dr. Weng’s design, “Cardio Tai Chi maintains a high energy level while remaining less aggressive. In this way, there is a much less possibility of hyper-extension of the joints or pulled muscles when training.” There are several highlights of this Cardio Tai Chi exercise: 1. Simplicity: The design is based on the principle of simplicity so that anyone can easily learn it, while having fun, without the frustration that is often involved in memorizing the sequence of complex Tai Chi forms. 2. Efficiency: It is an efficient form of cardio fitness training combined with coordination skills of martial arts which reaches the standard of aerobic exercise. 3. Adaptability: It can be practiced simultaneously with any current martial arts or even dance training. 4. Flexibility: The distance and speed of training can be adjusted and tailored to each individual. 5. Applicability: It is a practical Kung Fu for self-defense and even qualifies for kickboxing competitions. For first effects to be seen, it has been found that it is possible to undertake as few as 10 Cardio Tai Chi course over a period of 10 weeks. Each class consists of several Tai Chi stances at three different levels of increasing intensity as the course progresses. Each level has two Tai Chi stances selected for fast movement as high intensity interval training and one stance chosen for low intensity at a slower pace. Two specific stances are separately selected as transitional motions (see Figure 4).

There are three repeated sections in level one, four sections in level two and five sections in level three. The high intensity movement of each stance gradually transitions the body from moderate speed to higher speed within 90 seconds in each section.
Scientific support of Cardio Taiji

Many have questioned whether the Cardio Tai Chi has any effectiveness on cardiovascular fitness. For example, in 2017, around 160 research papers were submitted by hundreds of international scholars to The International University Sports Federation summer conference in Taipei City. Among those papers, only one topic was related to the effectiveness of Tai Chi. This being “The Study of the Effectiveness of Cardio Tai Chi for Cardio-respiratory Fitness: A Pilot Study.” The study was based on twenty-eight participants who were enrolled in the Cardio Tai Chi classes; only 9 participants completed the classes and thus were considered for the data analysis. A significant difference of means (-6.7 L/min) was observed on pre-post VO2max. In Fig. 4, the image shows a selection of slow, fast and transitional stances used in Cardio Tai Chi. This involved an exercise regime where the participants undertook a daily group of exercises.

For the purpose of this test this involved a 3 to 5 minute warm up period, which was then followed by the participants undertaking 8 cardio exercises, which are commonly known as grasping bird tail, golden rooster standing on one leg, white crane spread wings, waving hands like a cloud drifting by, playing the fiddle, frog kick, open the window to view the moon, and parting wild horse mane. This was then followed by a 5 minute cool down period where the participants did two exercises. These being carry the tiger back to the mountain and brush knee twist step.

Conclusions

The conclusion of the initial study showed that Cardio Kung Fu with the practice of Tai Chi techniques has benefits for the Cardiopulmonary system. Although traditional Tai Chi is an ancient healthy exercise for longevity, Cardio Tai Chi is a modern healthy exercise for both wellness and longevity.

References

1. For more information on the Cardio Taiji course, please refer to www.collegiateTaiji.org US Collegiate Taiji Federation.

The research on the coupling relationship between human skeleton and fascia in Taiji from the perspective of spatial structure

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Abstract—This paper analyzes the spatial structure and movement characteristics of bones in Taiji movement, and puts forward the viewpoint that the human body forms a “rigid and flexible” coupled movement force system with the bones and fascia during Taiji movement, and this relates to the structural forces experiences by the human body in Taiji movement. In Taiji movement, the fascia wraps and connects bones in series. This forms a rigid flexible coupling prestressed force system in the human body. It is believed that to understand the ancient process of Taiji scientifically, it will be required to undertake a combined study of fascia science, fluid mechanics, spatial structure mechanics, modern kinematics, with other research disciplines.

Keywords: Tai Chi; Fascia; space structure

1. Analysis on the spatial structure and movement characteristics of bones in Taiji movement

1.1 Frame – The spatial structure of the bone system in Taiji movement

The general meaning of frame in Taiji is a frame composed of lines. In traditional Chinese texts, Tai Chi is a movement of “round outside and square inside. The square inside of Tai Chi is reflected by the body, which is the frame, where the trunk of the human skeleton, and the internal frame is the square. However, because flesh and blood, fascia and skin are attached outside this hard frame, the human body presents a soft body, where its shape is flexible.

The body’s internal and external performance can be summarized in Fig. 1. In this figure, the inner square is like the white frame in the figure, and the outer circle is composed of black. In this way, bones are local frames, where (1) the bone is the component of the whole structure and the executor of action; (2) The functions of bone are linked to the fulcrum, the force point, and the transmission and transformation of force directions; (3) The rigidity of bone (its tenacity, flexibility and cushioning are all important); and (4) bones do not exert force, but can only receive and transmits force.
Fig. 1. shows the abstract structure of the "inner square and outer circle" of the human body. However, in terms of structural loads, the human skeleton system is not uniform and it can be divided into two main parts: the central axis (where the spine is the central axis) supporting the skeleton; and the appendages (the limbs), which together form a complex structure with a central axis and cantilever, that creates a three-dimensional frame structure that is able to move left and right, up and down, front and back (Fig. 2).

1.2 Rigidity and flexibility - the difference between the spatial structure of this frame in Taiji movement and ordinary force movements

Integrity, coordination and for most people the building of strength are very similar pursuits in Taiji and many other sports, but one of the major differences between Taiji and other sports lies in the different way the internal structure forms.

In Fig. 2 the movement mode of the internal structure in ordinary (muscle/strength building) exercises is shown, and in Fig. 3 and 4 this is compared to the movement mode of the internal structure in Tai Chi exercise.

Between the two, the major differences can be seen in the distribution in node forms of the internal structure, and the transformation space of flexible nodes is different.

Fig. 2 A three-dimensional frame structure with the combination of real and virtual human body.

In addition, in Tai Chi the Tai Chi nodes are more flexible. Each node can flexibly transform (move) and coordinated in the overall spatial structure, in a larger range of flexible space for accumulating strength (building muscle), emitting this stored strength, and deflecting the strength behind a blow. The internal structure of Tai Chi shows that the movement space range is large and the movement direction is flexible. In other words, the local torque can be large. This links to how the body in Tai Chi can change in close range, can “sacrifice” itself, and respond to the movement of others, and also attack others with the help of the other person’s strength, which when combined together create many advantages in close combat.

1.3 The key to flexibility -- the function and characteristics of bone joint in Tai Chi

The key to the flexibility of the whole-body bone system is mainly reflected in the structure of the bone and joint.

In Tai Chi, as in many sports, there is great importance in the process of warming up and relaxing the joint, and in undertaking regular active exercise that strengthens the function of the joint. However, the advantages of Taiji's internal structure and movement are mainly reflected in how the bone and joints are trained, and after clarifying this principle, it is possible to understand many specific principles of Tai Chi that are often difficult to understand from reading classical Chinese texts. A brief summary is as follows:

1. In the "frame" system of the human body, bony joints not only play a role in connection, but also the role of transformation, Fig. 5.

2. The human body's meridians run through the whole body and connect various bone joints in series. While the bone joints are flexible, the meridians are exercised and elongated.

3. Filament winding force plays a unique role in the process of relaxation of bone joints, and spiral winding movement stretches the joint.

4. Internal Qi takes the meridians as the channel. In the operation of internal Qi, bone joints are also the key nodes. If the bone joints are flexible, Chinese tradition states the internal Qi operates rapidly and in large quantities.

2. Coupling Relationship and Stress Analysis of Skeleton and Fascia in Taiji Exercise

2.1 Human Motion Structure System from the Perspective of Spatial Structure

The human body consists of nerve, muscle, bone, fascia, tissue fluid and many other elements, which can show characteristics of "multiphase flow" (multi-component flow) and "fluid-solid coupling".

From the perspective of solid phase spatial structure, the structure of its motion system is mainly embodied in three motion stress systems that are linked to the muscle system, the skeleton system and the fascia system, see Fig. 6 which shows a schematic diagram of three motion force systems on a human body.
In general, western kinesiology attaches great importance to strengthening and developing the muscular and skeletal systems, while Taiji, which represents the characteristics of Chinese martial arts, attaches the importance to the skeletal and fascia systems of the human body. The fascia system is the generalized meridian system, including the fascia tissue and skin of the whole body. The skeleton system is an integral hinged rod motion system consisting of a relatively rigid skeleton and a relatively flexible universal joint, and the muscle system and the fascia system are attached to the thin hinged rod motion system, to form an integral space structure stress system which combines rigidity and flexibility and has the characteristics of a tension hinge, see Fig. 7.

2.2 Rigid-flexible coupling prestress system of human body in Taiji movement

As mentioned above, the human body is composed of a muscle system, a skeletal system, and a fascia system, which are rigid-flexible coupling and have the characteristics of a tension hinge. In this system, research, in both the East and the West, pay attention to the exercise of the skeletal system.

However, the difference between the two views of exercise is western fitness exercises emphasize muscle exercise, whereas Taiji exercise, under oriental wisdom, emphasizes the relaxation of muscle groups. After the relaxation of muscle groups, the function of resisting gravity is transferred to the fascia system. Taiji exercise involves the skillful use of gravity to relax large muscle groups and to place the weight of the whole body on the fascia system.

As shown in Fig. 8, the fascia system connects the human skeleton in series to form a whole stress system, just like the prestressed reinforcement connecting each cantilever component in series in the prestressed cantilever bridge structure. When the human body is standing and in general motion, the body weight is converted into gravity. This is mainly resisted and borne by skeletal and muscular tissues. In the state of Taiji, the muscle tissue of the human body is relaxed, and the weight of the human body falls on the rigid-flexible coupling system formed by the "fascia" wrapped in series with the skeleton to form the overall prestress, which is traditionally called "strength". This is the main feature of the overall force in the state of Taiji movement.

3. Health preserving principle of fascia

3.1 Health preservation principle of fascia

According to modern fasciology, meridians and collaterals are also part of the fascia, which relates to the connective tissue within the human body. Fascia includes meridians and collaterals and is larger than meridians. As for the health preserving principle of the fascia, modern fascia science is completely consistent with the traditional meridian theory, and it is believed that the health preserving principle is embodied in two aspects: one is that by exercising and "dredging" the meridians (fascia), diseases can be prevented; The second is to strengthen the meridians (fascia) is beneficial to prolonging the life span of people. The function of preventing diseases is mainly achieved by activating and strengthening the function of meridians (fascia) to conduct "Qi". The principle of prolonging life is that the meridian (fascia) system can provide metabolic supplement cells for other functional systems of the human body.

In traditional Chinese medicine, it is said that Qi moves through the meridians. In other words, Qi moves through the whole body, and its running line moves between the meridians (fascia) of the human body, where its running nodes are found in acupoints and joints. In the case of lack of exercise and amongst people of older age, the fascia tissue tends to become rigid, showing that the fascia tissue becomes disorderly, its tissue fibers become rough and its elasticity decreases. At this stage the ability to conduct "Qi" is gradually weakened, and a person’s ability to prevent diseases is also weakened.

In the state of Taiji exercise, the meridian (fascia) tissue is often stretched and relaxed, the fascia tissue is exercised and the fascia fibers become smooth and elastic, the ability to conduct Qi is then strengthened, and it is said that the human body's Qi circuit is gradually made smooth and vigorous, and the sense
of Qi is gradually enriched and steadfast. The movement of internal Qi is continuous in the process of movement, forming a whole within the body, which becomes a "defensive qi", that aids the ability of human body to prevent diseases.

As for the statement that "one inch of muscle prolongs life for ten years", it has also been explained more scientifically in the theory of fascia. The fascia is the support and reserve system of the human body and is linked to fat cells, fibroblasts, and stem cells. The human fascia has the important functions of repairing damaged cells and tissues, regulating life renewal and it is linked to the functional metabolism of specialized cells. The specialized cells of the nine major functional systems of the human body have only a short life cycle, ranging from a few days (such as epidermis) to a few months (for bone cells), but through continuous proliferation and differentiation, the fascia is continuously transformed into functional cells to repair and renew the functional system, thus ensuring the growth of each system. In this way it not only maintains the stability of the life process, but it also prolongs the survival time (the life span) of the human body.

3.2 The Specific Mechanism of Taiji Exercise on Strengthening Fascia

3.2.1 Strength is the basic force to strengthen the fascia

As mentioned above, in the state of Taiji, the weight of the human body falls on the rigid-flexible coupling system formed by the fascia wrapped around the skeleton, forming the overall prestress, which is traditionally called "strength" in a more general sense.

In the process of Taiji movement, traditional instructions state we should pay attention to "not losing the top", which can be translated to mean that we should always keep our strength and never lose it. That is to say, the prestress that is acting on the fascia system should not be allowed to dissipate, and this basic prestress is the basic force to relax the fascia of the human body.

In the Taiji state, when the large muscle groups of the body are relaxed, under the action of gravity, the tissue fluid held within the tough skin that makes up the human body shows an overall trend to loosen. At the same time, it acts on the fascia system to relax the human fascia and lengthen the limbs, so as to achieve the effect of loosening joints and strengthening tendons. Therefore, long-term correct practice of Tai Chi is bound to have the effect of strengthening tendons, (Fig. 9).

3.2.2 Action mechanism of stake standing stretching fascia

Another example is the use of stake standing exercise, which has a positive effect on the fascia tissue at the intersection of the bones between the human spine, crotch and thigh. As shown in Fig. 10, when the human body is upright, the traction force between the spine, crotch and lower limbs is in the same vertical plane, and the force in the three directions is mainly pressure. The fascia tissue between the bones does not bear shear force.

When the human body is in the position of standing pile, the forces in the three directions of spine, crotch and lower limb are not in the same vertical plane, the supporting effect of lower limb bones on the spine is weakened, and the shear force at the force point is enhanced, and combined with the state of relaxing leg and crotch muscles, in addition the gravity felt on the upper body spine produces strong traction on the ligament and fascia between the crotch and thigh. This can effectively stretch the
fascia tissue with this part of the body. Therefore, the standing pile exercise is an effective form of exercise that skillfully uses gravity to stretch and exercise the fascia between the hips, see Fig. 10.

3.2.3 The use of spiral winding wire in fascia stretching

As shown in the Fig. 11, the force of winding wire is a winding movement distributed throughout the body, which acts in the same way as twisting a towel. The force of winding wire twists and lengthens the body motion curve, lengthens the extension distance of muscles and fascia of the whole body, and skillfully uses the tension and pressure generated by torque to stretch and massage the fascia. While stretching and massaging the fascia with the spatial motion curve of the force of “winding silk”. In traditional theory this forces stability and order in the movement of body fluid and Qi and blood in the human body, making Qi and blood more unobstructed. Therefore, it not only has the effect of exercising the fascia, but it also plays a role in maintaining the elasticity and health of blood vessels.

Conclusions

Based on ten-year experience of Tai Chi, this study draws lessons from the theories of modern fascia, space and structural mechanics and kinematics, and it examines the traditional meridian theory from a new perspective. It is proposed that in Tai Chi, the human body forms a rigid yet flexible coupling motion force system that employs bones and fascia; A new viewpoint on the problems of relaxation of force and “liveliness” in Taiji is presented. In Taiji, the fascia wraps the skeleton in series to form a rigid flexible coupling prestressed stress system. In Taiji, the relaxation of force in the human body is linked to the muscle tissue of the body, and the “liveliness” activates the fascia tissue of the human body. Future multidisciplinary collaborative research will be useful in aiding the understanding of the scientific fitness and health preservation mechanism of Taiji. On the basis of explaining the health preservation mechanism of Tai Chi by fasciology, we can explore more concise and effective ways of Tai Chi practice, and health preservation that are easy to be accepted by the public.

Fig. 11 Schematic diagram of stress route of human spiral winding wire.

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An Experimental Study of the Interventional Effects of Qigong Exercise on College Students with Different Personality Types

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Abstract—This paper explored the effects of practicing Qigong, a traditional Chinese fitness method which includes the imitation of the Five-animal exercise, on the psychological adjustment of college students with different personality types. Through the study of 220 college students aging from 19 to 22 a study of the responses made on the Eysenck Personality Questionnaire (EPQ) and Symptom check list-90 (SCL-90) provided scientific data that supported the idea that Chinese traditional health preservation exercises can improve the mental health of college students. Specifically, after 12-week Qigong exercise, the total symptom index, interpersonal sensibility, obsessive-compulsive, paranoid-anxiety, depression, psychoticism and anger-hostility of the participants significantly differed from baseline. There were also significant differences in somatization and anxiety. In the female participants in the experimental group, there was a very significant difference in terms of paranoid-anxiety, depression, and interpersonal sensibility. The results provided scientific data that physical exercises have a direct regulating effect on mental health and can improve mental health through the cultivation of the emotional regulation of self-efficacy and emotional adjustment strategies. The relevant studies showed that 40% of psychological studies adopted the Symptom check list-90 (SCL-90) questionnaire21 to assess mental health and the Eysenck Personality Questionnaire (EPQ) to evaluate personality traits and emotions.22,23 As a traditional Chinese sport, Qigong has been favored by people for thousands of years. The Qigong exercise we used in this experiment was mainly adapted from Five-animal exercise (FAE), which is the imitation of the movements and expressions of five animals (the tiger, deer, bear, ape and bird), to achieve psychological states, such as practicing yoga and Baduanjin exercise for extended time periods, which can promote women sleep quality during pregnancy, relieve tension24 and have regulating as well as mediating effects on mental health.41 Moreover, Baduanjin exercise has a better regulating effect on college student’s mental health than many other sports. At the same time, an increasing number of studies have discussed the mediating effect of different intensity and frequency of exercises on emotional adjustment and strategies.44 Domestic studies have further confirmed that physical exercises have a direct regulating effect on mental health44 and are also effective, applicable and feasible for college students with depression.45 It was also found that the mental health status of people who participate in aerobic exercise was better than that of people who do not exercise regularly. The relieving effect of aerobic exercise on negative psychological symptoms was proved to be significant.41 At present, it is widely recognized by researchers that physical exercise has a direct regulating effect on mental health and can improve mental health through the cultivation of the emotional regulation of self-efficacy and emotional adjustment strategies. The relevant studies showed that 40% of psychological studies adopted the Symptom check list-90 (SCL-90) questionnaire21 to assess mental health and the Eysenck Personality Questionnaire (EPQ) to evaluate personality trait tendencies and emotions.22,23 However, there is still a lack of research on the effect of FAE on the psychological adjustment of college students with different personality types. For this experiment, this study recruited 220 college students with ages ranging from 19 and 22 to practice FAE for 12 weeks as an interventional method, and was aimed at observing and revealing emotional adjustments on various college students with different personality types. The results provided scientific data and a theoretical basis to support the idea that schools should offer FAE courses to enhance the emotional adjustment of the college students and alleviate their mental problems.

2. Materials and Methods

2.1 Participants

The participants were undergraduate students from freshmen to senior students at Inner Mongolia Normal University who were between 19 to 22 years old and were taking various majors other than physical education. The participants voluntarily chose one of the physical education courses through the university course selection platform. The 136 students who selected the Qigong exercise course constituted the experimental group. Another 113 students took part in regular physical education course and were taken as the control group.

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Inclusion criteria: (1) Participants enrolled in the Qigong exercise course voluntarily; (2) Participants had never attended Qigong exercise or other systematic intervention exercise before; (3) Without major physical diseases or disorders of consciousness; (4) Without past medical history of mental illness.

Exclusion criteria: (1) Physical disability; (2) Returned to school after suspension due to mental problems; (3) Unable to participate in intense sports due to trauma or chronic disease; (4) The occurrence of any negative events over the previous two months, including divorce of parents, the death of relatives, family financial difficulties, emotional frustration and other factors.

2.2 SCL-90 and EPQ

The self-rating SCL-90 translated by Wang Xiangdong (1999) was adopted as the psychological questionnaire. Due to its objectivity, simplicity and convenience, this scale has gradually been combined with other psychological scales to operate in many research fields such as public psychology, clinical psychology, education and physical education. In this experiment, the participants filled in the questionnaires based on self-perception generated recently or within a week. By scoring from 1 to 5, any factor scored greater than 2 was regarded as positive.

EPQ is a self-report inventory developed by the British psychologist H. J. Eysenck which is an objective scale for personality surveys, and has been widely used in various fields. The adult questionnaire is used in this study, which includes 85 questions. The four subscales are the introversion and extroversion scale (E), neuroticism scale (N), mental quality scale (P), and cover-up scale (L). According to the total scores obtained by the participants on each scale, the standard T-score (T=50+10×(X-M)/SD) was calculated according to the norm, and the personality characteristics of the participants were analyzed.

2.3 Interventions

The participants in the experimental group were randomly assigned to a teaching class and none of them had any former experience of Qigong exercise. The teaching material was Qigong (adapted from FAE), and the participants were taught by the teachers who had the skills. The participants were taught in one class. The participants were required to do the Qigong exercise twice a week for 12 weeks, with the course lasting for 90 minutes each time. From the fourth to twelfth week, the participants were dedicated to repeated practice of the movements. In accordance with the requirements of college physical education, the participants in the control group only undertook the regular physical education courses offered by the school, with no fixed training time, duration or choice of sports. Physical activities were not requested specifically.

Before the experiment, 136 copies of the EPQ and SCL-90 questionnaires were distributed to the experimental group and collected on site. At the same time, 113 copies of the SCL-90 questionnaire were distributed to the control group and collected on site. After the experiment, 230 copies of the SCL-90 questionnaire were distributed to the experimental group and the control group, and 230 copies were collected on site. After eliminating invalid questionnaires that had only one answer, omissions, or incomplete basic information, 220 valid questionnaires were selected. A real-name code was adopted for the test.

2.4 Statistical analysis

After the real-name encoding of the questionnaire, a one-to-one correspondence was established to identify the responses of specific students before and after the experiment. Microsoft Excel 2010 was used to build the database. The results of the EPQ and SCL-90 questionnaires were calculated according to the norm, and the T-score was analyzed by SPSS21. The mean/standard deviation method is used for measuring data.

![Cross plot of introversion & extroversion and neuroticism.](https://example.com/cross_plot.png)

**Table 1** The distribution of T-scores on the four scales of EPQ in the experimental group (n=110).

<table>
<thead>
<tr>
<th>Norm value</th>
<th>Norm %</th>
<th>Description</th>
<th>General scale n-%</th>
<th>E scale n-%</th>
<th>N scale n-%</th>
<th>P scale n-%</th>
<th>L scale n-%</th>
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<td>&lt;38.5</td>
<td>12.5</td>
<td>Typical</td>
<td>5-13.64</td>
<td>14-12.73</td>
<td>11-10.00</td>
<td>21-19.09</td>
<td>15-13.64</td>
</tr>
<tr>
<td>38.5-43.3</td>
<td>12.5</td>
<td>Tendency</td>
<td>11-10.00</td>
<td>11-10.00</td>
<td>17-15.45</td>
<td>16-14.55</td>
<td>22-20.00</td>
</tr>
<tr>
<td>43.3-56.7</td>
<td>50.0</td>
<td>Middle</td>
<td>57-51.81</td>
<td>53-48.18</td>
<td>51-46.37</td>
<td>56-43.56</td>
<td>39-35.45</td>
</tr>
<tr>
<td>56.7-61.5</td>
<td>12.5</td>
<td>Tendency</td>
<td>11-10.00</td>
<td>18-16.36</td>
<td>12-10.91</td>
<td>8-7.87</td>
<td>25-22.73</td>
</tr>
<tr>
<td>&gt;61.5</td>
<td>12.5</td>
<td>Typical</td>
<td>16-14.55</td>
<td>14-12.73</td>
<td>19-17.27</td>
<td>14-12.73</td>
<td>9-8.18</td>
</tr>
</tbody>
</table>

DOI: 10.57612/2022.JTS.01.07
3. Results

3.1 Measurement of the EPQ of the participants in the experimental group

The results (Table 1) demonstrated the T-scores of the experimental group on the four scales conformed to the normal distribution of the EPQ 85-question version using the standard T-scores. 

3.2 Personality types of the participants in the experimental group

The EPQ was used to assess the personality tendency and characteristics of the participants according to the T-score in each dimension. By combining the introversion and extroversion with the neuroticism, the scale detected four personality traits: stable extrovert, unstable extrovert, stable introvert, and unstable introvert, with transitional types between them (Figure 1).

It turned out that the personality types of the college students in this study were composed of 42.73% stable extroverts, 36.66% unstable extroverts, 11.82% stable introverts, and 9.09% unstable introverts (Table 2).

3.3 Results of the SCL-90 in both groups before and after the experiment

The SCL-90 questionnaire was distributed to both the experimental group and the control group before and after the experiment. The experimental group practiced Qigong for 12 weeks, while the control group completed the routine college physical education course, during the same period. Before the experiment, there was no difference between the SCL-90 factors for the experimental group and the control group (P>0.1). After the experiment, the factors of the total symptom index, obsessive-compulsive, interpersonal sensibility, depression, anger-hostility, paranoid-anxiety and psychoticism among the experimental group were significantly different from those of the control group (P<0.01). Somatization, anxiety and phobic-anxiety were significantly different (P<0.05) (Table 3). The correlation analysis of the effect between genders in the experimental group before and after the experiment is shown in Table 4. Before the experiment, no factors were affected by gender (p>0.1). After the experiment, the female students showed improvement with respect to the total symptom index, somatization and depression compared with that of the male students (P<0.01). The paranoid-anxiety and psychoticism were significantly improved (P<0.05), and anger-hostility was very significantly improved (P<0.01).

Table 3 Results of the SCL-90 in the experimental group and the control group (n=220).

<table>
<thead>
<tr>
<th>Influence</th>
<th>Before experiment</th>
<th>After experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor(t)</td>
<td>Experimental</td>
<td>Control</td>
</tr>
<tr>
<td>Total symptom index</td>
<td>1.63±0.47</td>
<td>1.69±0.47</td>
</tr>
<tr>
<td>Somatization</td>
<td>1.45±0.51</td>
<td>1.50±0.52</td>
</tr>
<tr>
<td>Obsessive-compulsive</td>
<td>2.03±0.63</td>
<td>2.06±0.63</td>
</tr>
<tr>
<td>Interpersonal sensibility</td>
<td>1.82±0.62</td>
<td>1.87±0.63</td>
</tr>
<tr>
<td>Depression</td>
<td>1.59±0.54</td>
<td>1.69±0.54</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1.57±0.53</td>
<td>1.66±0.62</td>
</tr>
<tr>
<td>Anger-hostility</td>
<td>1.59±0.57</td>
<td>1.64±0.57</td>
</tr>
<tr>
<td>Phobic-anxiety</td>
<td>1.52±0.49</td>
<td>1.56±0.51</td>
</tr>
<tr>
<td>Paranoid-anxiety</td>
<td>1.59±0.54</td>
<td>1.65±0.54</td>
</tr>
<tr>
<td>Psychoticism</td>
<td>1.53±0.53</td>
<td>1.58±0.54</td>
</tr>
<tr>
<td>Sleep and dietary</td>
<td>1.58±0.45</td>
<td>1.61±0.48</td>
</tr>
</tbody>
</table>

Table 2 Personality types of the college students in the experimental group (n=110).

<table>
<thead>
<tr>
<th>Personality type</th>
<th>Sample size</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable extrovert</td>
<td>47</td>
<td>42.73</td>
</tr>
<tr>
<td>Unstable extrovert</td>
<td>40</td>
<td>36.36</td>
</tr>
<tr>
<td>Stable introvert</td>
<td>13</td>
<td>11.82</td>
</tr>
<tr>
<td>Unstable introvert</td>
<td>10</td>
<td>9.09</td>
</tr>
<tr>
<td>Total sample size</td>
<td>110</td>
<td>100</td>
</tr>
</tbody>
</table>

DOI: 10.57612/2022.JTS.01.07
Table 4: Results of the SCL-90 between genders in the experimental group (n=110).

<table>
<thead>
<tr>
<th>Influence</th>
<th>Before experiment</th>
<th>After experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental group</td>
<td>Control group</td>
</tr>
<tr>
<td>Factor(f)</td>
<td>Experimental group</td>
<td>Control group</td>
</tr>
<tr>
<td>Total symptom index</td>
<td>1.63±0.47</td>
<td>1.69±0.47</td>
</tr>
<tr>
<td></td>
<td>0.37</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>1.51±0.44</td>
<td>1.70±0.47</td>
</tr>
<tr>
<td></td>
<td>0.00***</td>
<td></td>
</tr>
<tr>
<td>Somatization</td>
<td>1.45±0.51</td>
<td>1.50±0.52</td>
</tr>
<tr>
<td></td>
<td>0.52</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>1.38±0.50</td>
<td>1.53±0.50</td>
</tr>
<tr>
<td></td>
<td>0.02**</td>
<td></td>
</tr>
<tr>
<td>Obsessive-compulsive</td>
<td>2.03±0.63</td>
<td>2.06±0.63</td>
</tr>
<tr>
<td></td>
<td>0.77</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>1.79±0.55</td>
<td>2.06±0.63</td>
</tr>
<tr>
<td></td>
<td>0.00***</td>
<td></td>
</tr>
<tr>
<td>Interpersonal sensibility</td>
<td>1.82±0.62</td>
<td>1.87±0.63</td>
</tr>
<tr>
<td></td>
<td>0.61</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>1.65±0.50</td>
<td>1.88±0.63</td>
</tr>
<tr>
<td></td>
<td>0.00***</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>1.59±0.54</td>
<td>1.69±0.54</td>
</tr>
<tr>
<td></td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>1.48±0.47</td>
<td>1.72±0.53</td>
</tr>
<tr>
<td></td>
<td>0.00***</td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td>1.57±0.53</td>
<td>1.66±0.62</td>
</tr>
<tr>
<td></td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>1.51±0.51</td>
<td>1.69±0.62</td>
</tr>
<tr>
<td></td>
<td>0.02**</td>
<td></td>
</tr>
<tr>
<td>Anger-hostility</td>
<td>1.59±0.57</td>
<td>1.64±0.57</td>
</tr>
<tr>
<td></td>
<td>0.54</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>1.47±0.52</td>
<td>1.65±0.56</td>
</tr>
<tr>
<td></td>
<td>0.01***</td>
<td></td>
</tr>
<tr>
<td>Phobic-anxiety</td>
<td>1.52±0.49</td>
<td>1.56±0.51</td>
</tr>
<tr>
<td></td>
<td>0.54</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>1.48±0.49</td>
<td>1.59±0.50</td>
</tr>
<tr>
<td></td>
<td>0.07**</td>
<td></td>
</tr>
<tr>
<td>Paranoiac-anxiety</td>
<td>1.59±0.54</td>
<td>1.65±0.54</td>
</tr>
<tr>
<td></td>
<td>0.39</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>1.42±0.47</td>
<td>1.69±0.53</td>
</tr>
<tr>
<td></td>
<td>0.00***</td>
<td></td>
</tr>
<tr>
<td>Psychoticism</td>
<td>1.53±0.53</td>
<td>1.58±0.54</td>
</tr>
<tr>
<td></td>
<td>0.52</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>1.42±0.46</td>
<td>1.61±0.53</td>
</tr>
<tr>
<td></td>
<td>0.01***</td>
<td></td>
</tr>
<tr>
<td>Sleep and dietary</td>
<td>1.58±0.45</td>
<td>1.61±0.48</td>
</tr>
<tr>
<td></td>
<td>0.55</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>1.54±0.54</td>
<td>1.64±0.47</td>
</tr>
<tr>
<td></td>
<td>0.17</td>
<td></td>
</tr>
</tbody>
</table>

Male n=28, Female n=82, ***P≤0.01, **P≤0.05, *P≤0.1.

Table 5: Results of the SCL-90 in the extroverts of the experimental group (n=87).

<table>
<thead>
<tr>
<th>Influence</th>
<th>Before exercise</th>
<th>After exercise</th>
<th>sig</th>
<th>Before exercise</th>
<th>After exercise</th>
<th>sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor(f)</td>
<td>Experimental</td>
<td>Control</td>
<td></td>
<td>Experimental</td>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>Total symptom index</td>
<td>1.88±0.52</td>
<td>1.66±0.47</td>
<td>0.04**</td>
<td>1.40±0.29</td>
<td>1.37±0.35</td>
<td>0.62</td>
</tr>
<tr>
<td>Somatization</td>
<td>1.69±0.62</td>
<td>1.53±0.56</td>
<td>0.07*</td>
<td>1.26±0.32</td>
<td>1.24±0.36</td>
<td>0.64</td>
</tr>
<tr>
<td>Obsessive-compulsive</td>
<td>2.31±0.70</td>
<td>1.96±0.53</td>
<td>0.00***</td>
<td>1.80±0.46</td>
<td>1.64±0.45</td>
<td>0.03*</td>
</tr>
<tr>
<td>Interpersonal sensibility</td>
<td>2.13±0.66</td>
<td>1.79±0.52</td>
<td>0.00***</td>
<td>1.51±0.41</td>
<td>1.50±0.45</td>
<td>0.97</td>
</tr>
<tr>
<td>Depression</td>
<td>1.85±0.58</td>
<td>1.59±0.49</td>
<td>0.00***</td>
<td>1.34±0.38</td>
<td>1.36±0.44</td>
<td>0.85</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1.83±0.62</td>
<td>1.67±0.56</td>
<td>0.11</td>
<td>1.32±0.32</td>
<td>1.34±0.38</td>
<td>0.76</td>
</tr>
<tr>
<td>Anger-hostility</td>
<td>1.87±0.59</td>
<td>1.64±0.59</td>
<td>0.01***</td>
<td>1.33±0.33</td>
<td>1.32±0.43</td>
<td>0.91</td>
</tr>
<tr>
<td>Phobic-anxiety</td>
<td>1.66±0.49</td>
<td>1.58±0.46</td>
<td>0.35</td>
<td>1.36±0.41</td>
<td>1.36±0.46</td>
<td>0.94</td>
</tr>
<tr>
<td>Paranoiac-anxiety</td>
<td>1.86±0.61</td>
<td>1.55±0.52</td>
<td>0.00***</td>
<td>1.38±0.36</td>
<td>1.32±0.39</td>
<td>0.36</td>
</tr>
<tr>
<td>Psychoticism</td>
<td>1.81±0.61</td>
<td>1.58±0.50</td>
<td>0.01***</td>
<td>1.26±0.26</td>
<td>1.27±0.31</td>
<td>0.85</td>
</tr>
<tr>
<td>Sleep and dietary</td>
<td>1.79±0.51</td>
<td>1.71±0.63</td>
<td>0.38</td>
<td>1.40±0.31</td>
<td>1.38±0.38</td>
<td>0.72</td>
</tr>
</tbody>
</table>

Unstable Extroverts n=40, Stable Extroverts n=47, ***P≤0.01, **P≤0.05, *P≤0.1
Table 6 Results of the SCL-90 in the introverts of the experimental group (n=23).

<table>
<thead>
<tr>
<th>Factor</th>
<th>Unstable introvert</th>
<th>Stable introvert</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before exercise (x̄±s)</td>
<td>After exercise (x̄±s)</td>
</tr>
<tr>
<td>Total symptom index</td>
<td>1.95±0.35</td>
<td>1.92±0.65</td>
</tr>
<tr>
<td>Somatization</td>
<td>1.69±0.65</td>
<td>1.72±0.97</td>
</tr>
<tr>
<td>Obsessive-compulsive</td>
<td>2.68±0.56</td>
<td>2.27±0.35</td>
</tr>
<tr>
<td>Interpersonal sensitivity</td>
<td>2.33±0.65</td>
<td>2.19±0.51</td>
</tr>
<tr>
<td>Depression</td>
<td>1.96±0.34</td>
<td>1.95±0.46</td>
</tr>
<tr>
<td>Anxiety</td>
<td>1.63±0.43</td>
<td>1.82±0.67</td>
</tr>
<tr>
<td>Anger-hostility</td>
<td>1.94±0.52</td>
<td>1.89±0.62</td>
</tr>
<tr>
<td>Phobic-anxiety</td>
<td>1.86±0.64</td>
<td>1.93±0.81</td>
</tr>
<tr>
<td>Paranoid-anxiety</td>
<td>1.89±0.34</td>
<td>1.69±0.82</td>
</tr>
<tr>
<td>Psychoticism</td>
<td>1.77±0.40</td>
<td>1.83±0.97</td>
</tr>
<tr>
<td>Sleep and dietary</td>
<td>1.67±0.38</td>
<td>1.83±0.82</td>
</tr>
</tbody>
</table>

Unstable Introvert n=10, Stable Introvert n=13, ***P<0.01, **P<0.05, *P<0.1

4.4 Discussion

4.1 Personality types and emotion manifestation of participants

Eysenck distinguished the personality types by two dimensions, introversion/extroversion and neuroticism and divided into normal personality and psychopathic personality. People who are neurotically unstable tend to be moody and easily excited while people who are neurotically stable react slowly and moderately and recover easily. The more unstable the people are, the more mental problems tend to appear. The more introverted the personality is, the more noticeable the mental problems are.34-36

In this experiment, the extroversion, which is expressed as being sociable, lively and cheerful, accounted for 79.09%. The unstable, which is manifested as a lack of trust, suspicion, anxiety, nervousness, anger, and a tendency to have prominent psychological problems, accounted for 45.45%. People who are stable extroverts are likely to be calm, cheerful and positive, and can adjust their negative emotions to the baseline quickly, while people who are unstable extroverts show the characteristics of desire for stimulation and adventure, impulsiveness, and have a strong emotional reaction. People with stable introversion are silent, steady, and gentle. However, people with unstable introversion seldom attack others, and they are always worried as well as moody.

According to Eysenck’s study, neuroticism is associated with the function of the autonomic nervous system, especially the sympathetic nervous system. When anxiety, irritability and tension occur, it can easily cause the disorder of the autonomic nerves, and somatic symptoms such as chest tightness, headache, dizziness, and systemic fatigue caused by muscle tension.37 At the same time, there is no universally recognized and feasible clinical objective index for the diagnosis of autonomic nerve dysfunction. Therefore, the neurotrophic drugs and the neuroleptic drugs are usually applied to treatment, which can easily lead to prolonged drug dependence.38

On the basis of the theory of Traditional Chinese Medicine, such disorders are usually caused by excessive anxiety, overexertion, unfilled desires, depression, anger, and so on. This generally happens more to women than to men. Some scholars believed that the key to the disorders lay in effective early treatment and psychological advice. By balancing qi and blood as well as regulating the functions of the viscera, the pathological and hyperactive state of the sympathetic nervous system will recover to a normal level, and the symptoms of autonomic nerve disorders will be cured from the root.

4.2 Effect of Qigong on the factor changes in the SCL-90

4.2.1 Effect of Qigong on the factor changes in the SCL-90 between groups

The results showed that after the experiment, the factors of the SCL-90 in the experimental group were very significantly improved compared with the control group in terms of total symptom index, obsessive-compulsive, interpersonal sensitivity, depression, anger-hostility, paranoid-anxiety, and psychoticism and were significantly improved in somatization, anxiety, and phobic-anxiety. The Qigong exercise was shown to be more effective than other sports in regulating emotions.

In the practice of Qigong, in addition to the emphasis on the range of movement, change of direction, rhythm of action, and coordination of limbs, people should also integrate the thoughts of five animals into the action, so that the actions and breath can be coordinated. Moreover, people can strengthen the visceral functions and soothe the qi and blood circulation through active-breathing methods such as reverse abdominal breath, abdominal breath and holding one’s breath so as to achieve the effects of benefiting the internal organs as well as the external body. The autonomic nervous system would also be affected by the concentration of thoughts, meditation, getting quiet and so on. Thereby the visceral activities can be regulated and the emotion can be adjusted.

Some studies have examined the harmfulness of the psychological trauma given by negative emotions. The Canadian physiologist Han Selye believed that when...
the men’s adaptation ability to stress reaches the stage of exhaustion under the strain, men would lose the ability to respond to changes and suffer from anxiety, headaches, elevated blood pressure, and other symptoms, leading to physical and mental diseases. Strong emotional changes (fear, anger, etc.) can cause animals to have a “fight or flight” response. Modern cognitive neuroscience has shown that internal organs of the monkey would fester to death because of the chronic stress, anxiety and fear. Meanwhile, clinical cases have shown that working overtime without rests and being urged, scolded, and threatened would lead to the breakdown of one’s physical system as well as the mental diseases such as anxiety, fear and depression.40

Quite a number of patients with autonomic nerve dysfunction have higher excitability in nerve system and poorer stability in nerve function than that of the ordinary people, which is manifested by high intensity and fast speed of reaction and being more emotional.41 People with paranoid-anxiety, anger-hostility, obsessive-compulsive, interpersonal sensitivity and psychosomaticism may be emotionally sentimental, lacking in trust, and it is difficult for them to be persistent. They are more sensitive to the state of stress and nervousness, which restricts their cultivation of positive qualities and makes it harder for them to be self-discipline.42

However, it is said that Qigong exercise emphasizes the regulation of the spirit in the long term, which can enhance the brain’s ability to regulate the autonomic nerves and the glands, and thus improve the secretion function of the glands, and finally achieve the unity of nerves and the glands, and thus improve the secretion of the glands, and finally achieve the unity of nerves and the glands.43 Qigong exercise can relax the body and mind, and improve the autonomic nerve function and relieve the sympathetic hyperactivity, which is good for the mental health.

4.2.2 Effect of Qigong on the factor changes in the SCL-90 between genders

For teenagers in adolescence, given that the gonads develop and mature constantly, the autonomic nervous system is likely to be unstable which is manifested as abnormal mood swings. Compared with males, females tend to go through huge mood swings caused by the physiological phenomenon, such as menstruation, which could lead to anxiety, depression and anger-hostility.43 It is also clinically visible that autonomic nerve function disorders are 2 to 10 times common in females than in males.44

In this study, the results of the SCL-90 in the female participants improved when compared with the male participants, for example, the anger-hostility was very significantly different, the paranoid-anxiety and psychosomaticism were significantly different, the depression, somatization and total symptom index were different. This also proved that Qigong exercise has a better influence on females than on males in mental health.

4.3 Effect of Qigong on the participants with different personality types

4.3.1 Effect of Qigong on the unstable extroverts

Due to Eysenck personality theory, extroversion, neuroticism and psychosomaticism are the important factors which affect mental health.46 Individuals with high scores of neuroticism tend to show high intensity and fast speed of reaction and being more emotional, and they are more sensitive to the state of stress and nervousness, which restricts their cultivation of positive qualities and makes it harder for them to be self-discipline.42

Qigong has a measurable effect on people with the unstable types, especially in terms of positive impacts on the viscera, joints and nerves. People who practice Qigong can relax their bodies by combining the soft and deep breath with the gentle movements. The meditation of the mind generates direct effects on the autonomic nervous system, and buffers the stimulation of negative emotions on the brain.

In this experiment, after 12-week intervention, the unstable extroverts showed very significant improvement in terms of the obsessive-compulsive, interpersonal sensitivity, depression, paranoid-anxiety, psychosomaticism and anger-hostility. The overall symptom index improved significantly. This also confirmed the results that showed a positive correlation between obsessive-compulsive and the emotionality(N) in the Eysenck questionnaire.46-48

Some scholars have proposed that when choosing emotional regulation strategies, different personality traits should be taken into consideration.49 People who are extroverts can actively use emotional adjustment to improve their mental health, whereas the people with high neuroticism tend to use ineffective emotional adjustment strategies.50 Personality may indirectly put impacts on individuals’ mental health through different ways of reacting.52 Qigong, as a positive way of physical and mental adjustment, has a positive role in the regulation of irritability, anger and impatience among the unstable extroverts.

4.3.2 Effect of Qigong on the stable and unstable introverts

The emotion characteristics of the introverts such as unwillingness to communicate, suspiciousness, phlegmatic indifference to people, anxiety, worry, and depression can easily lead to alexithymia. Studies have found that the alexithymia is not conveyed to the cerebral cortex, which is expressed through language signs, but through the autonomic nerve and forming the so-called “organ expression”.53 Such “organ expressions” would cause physical aggression which is manifested as the palpations, shortness of breath, chest tightness and elevated blood pressure. Therefore, neuroticism is positively correlated with hypertension and coronary heart disease (Jokela, Pulkkki-Rialck, Elovainio, & Kivimäki, 2014; Turiano, Pitzer, Armour, Karlamangla, & Mroczek, 2012),54 and somatic discomforts such as fatigue and nausea.52 People with neurotic personality types are more likely to use “organ expression” to release negative emotions and produce somatic reactions.

In this experiment, somatization among the stable introverts was significantly improved. It was believed that the somatic improvement in “organ language” owed to the regulation of Qigong on the autonomic nerves, which also further demonstrated the overall effects of Qigong on the body and mind. If the frequency and intervention time of the exercise, and the sample size of the experiment are increased, this may also lead to the improvement of the unstable introverts. In this case, further studies are required.

5. Conclusion

After 12-week Qigong exercise, the total symptom index, interpersonal sensitivity, obsessive-compulsive, paranoid-anxiety, depression, psychosomaticism and anger-hostility of the participants were very significantly different when compared with the baseline. There were also significant differences in somatization and anxiety. Meanwhile, the female participants in the experimental group showed a very significant difference in terms of anger-hostility and there were significant differences in terms of paranoid-anxiety and psychosomaticism and differences in terms of somatization, depression and the total symptom index. The improvement in the factors of the SCL-90 among the unstable extroverts in the experimental group were as follows (with the results ranked from the strongest differences to the weakest): obsessive-compulsive, interpersonal sensitivity, depression, anger-hostility, paranoid-anxiety, and psychosomaticism; the total symptom index was significantly different; and the somatization was different. There was also difference in somatization among the stable introverts.

These results suggest that Qigong exercise would be conducive to college students’ physical and mental health. Moreover, it also expands new ways to regulate the mental health of college students.

Qigong plays a positive role in promoting the coordinated development of the college students’ physical and mental health. People can engage in appropriate practices to ameliorate their poor emotions. Qigong can also meet the demands of the college students’ mental health in daily life, where students routinely experienced pressure to study non-stop for many hours and suffer the effects of intense competition.

This argues that modern scientific theories should be integrated into the basis of traditional health culture. Research on the theory of skills and practical applications should be strengthened, in order to provide the theoretical basis and scientific data to support the idea that traditional Chinese sports can improve the mental health of college students. This

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being very important to satisfy the needs to develop a population that is comfortable in the high-paced life of modern society.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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