A Tai Chi Chuan Training Model to Improve Balance Control in Older Adults

Strawberry Gatts*

Clinical Biomechanics and Rehabilitation Lab, Department of Kinesiology, College of Applied Health Science, University of Illinois at Chicago, USA

Abstract: The first goal of this article is to present nine Tai Chi Chuan training principles and incorporate them into a current model of motor control and motor learning theory. The second goal is to present a Tai Chi Chuan training model. The third goal is to construct a theory as to how Tai Chi Chuan principles may improve balance and motor skills in an aging population. Evidence from the areas of motor control, biomechanics, and human physiology are drawn upon to build a theory of motor skill learning and construct a Tai Chi Chuan training model.

Keywords: Posture control, rehabilitation, intervention, Taiji, aging, motor learning, dual task.

INTRODUCTION

Tai Chi Chuan’s definitive origin is presently unknown and is surrounded by myth and speculation. However, Huang [1], a sociologist and anthropologist, and transmissions from the Yang family [2] present information that Tai Chi Chuan’s forms and oral transmissions were already developed by the T’ang dynasty. According to Huang, Taoist Hsu Hsuan Ping transmitted 37 Tai Chi postures and 5 classic treatises concerning the development of the body-mind-energy and functional applications to his students [1]. Interestingly, documents from the Yang family trace their Tai Chi Chuan lineage through multiple generations back to Hsu Hsuan Ping [2].

The ideograms for Tai Chi Chuan may help give further insight into this ancient art. Literally translated, Tai Chi Chuan refers to supreme/ultimate (Tai) unifying of polarities (Chi) expressed with a closed/curled hand (Chuan). Tai Chi Chuan is called Tai Chi Chuan because the closed/curled hand follows the principles of Tai Chi movement. Tai Chi Chuan is based upon the premise that physical movement is fundamental to human physical and mental health and survival. Tai Chi theory supplies the concept that the body, mind, intent and vital energy are inseparable and must be understood as a single phenomenon. Thus, these parts are ideally trained as an interactive unity [1, 2, 3], whether the focus is martial, meditational, medical, exercise, or spiritual.

Unfortunately, with the rising popularity and spreading of Tai Chi Chuan, traditional time-tested forms and training principles are being lost amid a growing number of personalized interpretations. Master Fuzhong Wen and Swaim express regret at the dilution of traditional forms that are being increasingly hybridized and packaged to meet commercial and sports exhibition interests [3]. Many people do not understand that fragmented or distorted Tai Chi Chuan forms that lack fundamental principles impede progress, produce fewer benefits, make the benefits take longer to appear, if appearing at all, and can eventually result in injury from improper alignment and erroneous muscle force, even though a form may have been created with the best of intentions to make the form easier to learn. The forms without the principles are said to be “empty” or “devoid” of real substance.

What are some of the principles that generate benefits to balance? In training over 6000 individuals, many of whom had impairments such as spine, hip, and knee surgery, joint replacements, arthritis, stroke, frozen joints, diabetes, Parkinson’s Disease, multiple sclerosis, fibromyalgia, joint or back pain, and other impairments due to aging or accidents, the author found that the following principles are important to include. They form the basis of the Tai Chi Chuan Balance Training model and exercise protocol.

NINE TAI CHI CHUAN PRINCIPLES IN THE TRAINING MODEL

Principle 1: Head and trunk are kept vertically upright. They do not rotate “en-bloc.”

Principle 2: A channel is used to guide foot position and placement. A channel is created by vertically aligning the ankle joint centers with the hip joint centers during stance. The distance between the feet is called the channel.

Principle 3: Postures and transitions are positioned accurately and move through 8 directions of space.

Principle 4: Movements rotate around the spine and waist.

Principle 5: Strive to keep limb velocity smooth and even.

Principle 6: Muscle activity is relaxed and without strain. Joints are flexed.

Principle 7: The whole body center of mass (COM) is always supported.

Principle 8: Movements rotate around the spine and waist.

Principle 9: Movements and weight shifts have a sequential flow pattern.

Principle 10: Movements are performed in slow motion. Theoretically, this naturally slows and deepens the breath, improves sensory attention.

*Address correspondence to this author at the Clinical Biomechanics and Rehabilitation Lab, Department of Kinesiology, College of Applied Health Science, University of Illinois at Chicago, c/o 449 Homestead Rd #2, La Grange Park, IL 60526, USA; Tel: 312-413-7762; E-mail: sgatts@uic.edu; sgatts@uoneuro.uoregon.edu
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This may atrophy the habit of medial cross-stepping or stepping laterally, which can result in a twist of the contact foot ankle. A twist of the ankle can throw the base of support to the outside of the foot and has been observed to result in a twisting of the body and can produce a lateral fall [7].

MOTOR DEFICITS COMMONLY FOUND IN AGING POPULATIONS ADDRESSED BY THE 9 PRINCIPLES AND 4 KEY POINTS OF THE TRAINING MODEL

Every movement task requires that appropriate muscles be activated and unnecessary activation of other muscles and joints be eliminated. Research has shown that postural alignment during stance and dynamic stepping movements strongly influence muscle activation relationships. For example, healthy children who mimic the crouched posture of diplegic children show similar muscle responses to the impaired children when they are perturbed [8]. Since it is common for older adults to walk with a forward flexion of the trunk coupled with reduced step length, rehabilitation and training models should include exercises to optimize vertical postural alignment coupled with stepping practice.

Excessive co-activation of agonist and antagonist muscles is commonly observed during early stages of learning new motor skills. Muscle sequencing is considered a co-activation problem. Since infants employ co-activation during early acquisition of balance skills, coactivation is thought to be a simplified, primitive level of coordination [9]. Co-activation is commonly used as an ongoing strategy by those who have lost or are unable to utilize dynamic limb control. When co-activation is employed as a balance strategy, it constrains the degrees of freedom by fixing angles of the limb into a rigid segment. This results in loss of flexibility and functionality, which can be devastating when trying to recover from a balance challenge.

Proactive control of trunk verticality in sagittal and frontal planes is important because it stabilizes the head, which contains visual and vestibular sensory references. Interestingly, the regulating “center point” of the vestibular system activity is based upon a vertically upright body posture [10]. Llinases [10] describes “center point” as the level at which the most neuronal receptors for a given sensory mode operate. The center point is the most common firing rate or pattern for these receptors. Firing rates above or below this central point trigger events that bring the system toward its natural center point. Vestibular neurons fire most frequently during the least amount of body movement away from verticality. This underscores the importance of vertical head and trunk alignment as a center point, and is evidence supporting the meaning of the Tai Chi Chuan alignment principle “head suspended from above, trunk maintained vertically upright” [1, 2, 3]. This regulating function of the center point perfectly describes the Chinese characters “Tai” (supreme, ultimate) “Chi” (the unity or “center” that bonds the two extremes).

Maintenance of a vertical trunk also reduces forces required to support the whole body COM, and facilitates upper and lower segmental coordination. Research has reported that higher impact forces and a 22% higher rate of loading

and motor control, and permits online error correction of posture, trajectory, and muscle force.

TAI CHI CHUAN MOTOR SKILL LEARNING THEORY

Although the Tai Chi Chuan principles are important to incorporate in the physical practice, research into motor skill learning has shown the structure of practice impacts how well people retain what they learn. Traditional Tai Chi Chuan training methods emphasize the importance of “blocked” practice. Simon and Bjork [4] have shown that blocked practice leads to improved current performance, but that enhanced skill retention is shown when random practice patterns are interwoven with blocked practice. The Tai Chi Chuan training model initially uses repetitive “blocked” practice. The model incorporates both blocked and randomized practice structures because the complex whole body motor skills being developed must be sufficiently acquired before they can be retained.

A second factor identified with superior learning is knowledge of results (KR). Optimal KR is considered the single most important determinant of learning, with the exception of practice itself [5]. Enhanced motor skill learning and retention has been shown when subjects are required to reconstruct a given motor program or movement pattern on their own [5]. The Tai Chi Chuan training model presented in this article accords with traditional Tai Chi Chuan training. It requires practitioners to periodically reconstruct an exercise or form while applying one or more principles from the above list. For example, performers are invited to physically illustrate and verbally describe what they have found regarding how different positions of the head, trunk, or feet improve or detract from dynamic stability during weight shifts, stepping, or walking. Additionally, the training model incorporates 100% KR coupled with self-directed error estimate by each person during each performance in the initial learning stage. This KR schedule is supported by previous research. Subjects receiving 100% KR who were required to estimate error during skill acquisition performed better than those receiving intermittent KR. Those who received 100% KR without error-estimation performed the worst [6].

THE TAI CHI CHUAN TRAINING MODEL

Four key points of the training model are: 1) attending to accurate spatial relationships of trunk and leg/foot position during weight shifting and stepping movements, 2) eight directions of space form a grid for body orientation and form movement. This is similar to the eight directions shown on a map commonly used to orient and guide movement in space, 3) trunk and head are vertically upright rather than leaning in any direction, 4) a channel is maintained at all times when both feet are on the ground. This means that step width should match hip center width during stance or gait.
are associated with a forward flexion of the trunk compared to trunk vertical gait. Thus, greater downward trunk accelerations at initial contact may be responsible for the higher impact forces and faster loading rates during trunk-flexed gait [11]. Since older populations often have muscle weakness and reduced ability to organize muscle forces, maintaining a vertical trunk would likely improve balance and reduce falls.

Gatts and Woollacott [12, 13] compared the efficacy of the Tai Chi Chuan (TC) balance exercise training model to theoretically similar control exercise training by examining neuromuscular response characteristics underlying dynamic balance recovery in balance-impaired older adults (age 68-92, BERG 44 or less) at high-risk for falling. TC subjects, but not controls, significantly reduced TA response time from 148.92 ± 45.11 ms to 98.67 ± 17.22 ms (p<0.004) and eliminated occurrence of co-contraction of antagonist muscles (p<0.003) of the perturbed leg. The TC training transferred to significant improvement on four clinical measures of functional balance (Timed Up and GO, Functional Reach, One leg Stance, Tandem Stance), while controls improved significantly only on Functional Reach. Overall, TC training transferred to significantly faster and better coordinated neuromuscular responses controlling the ankle joint during perturbed gait in balance-impaired seniors with surgical interventions to their back, hips, knees and arthritis.

The researchers also recorded kinematic, center of pressure (COP) and COM simultaneously with the EMG data and reported results in a separate paper [13]. Only TC training significantly reduced tripping (defined as an unexpected drop of the swing leg) after slipping (p<0.005) and medial cross-step distance (p<0.038), and increased the use of swing leg heel strike (p<0.001). COM anterior-posterior (A/P) path significantly increased after TC (p<0.017) but not after control training, implying TC training improved the ability to tolerate unsteadiness. Results suggest that after TC subjects took a longer step and increased mechanical loading at the hip when stepping onto an unstable surface. This may indicate greater confidence and self-efficacy.

SUMMARY

Although certain Tai Chi Chuan exercises, movements, postures, form transitions and sequences of progression are fundamental training for all populations who are able to stand, the exact training program will vary according to specific needs and baseline capabilities of the population or individuals undergoing training. Additionally, the selected training protocol and methods of delivery can dramatically alter participant’s safety, physiological conditioning, learning time, and the resultant conditioned behavior.

This article is intended to be used as a guide to provide information about Tai Chi Chuan principles and to inform how these principles are the active substance within form and exercise practice that produces the desired changes. A Tai Chi Chuan motor learning model that accords with principles of motor skill learning is presented. How nine Tai Chi Chuan training principles and four key essential points in the training model relate to motor deficits commonly found in aging populations is also covered.

REFERENCES