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Traditional Martial Arts Training Enhances Balance and Neuromuscular Control in Female Modern Martial Artists

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Abstract

To investigate the effects of Traditional Martial Arts training on markers of balance and neuromuscular control in modern martial artists, twenty-three female modern martial arts practitioners (mean age 37.17 ± 11.5), were divided into two matched groups: Intervention (n = 11) and Control (n = 12). The Intervention group participated in a 30 min Traditional Martial Arts training session, twice a week for four weeks. Reach measurements from the Star Excursion Balance Test (SEBT) were analysed to determine whether improvements had occurred. Pair-wise comparisons revealed significant (p = 0.00) improvements in SEBT reach for the intervention group with mean scores improving for both dominant and non-dominant legs (517 ± 18 to 592 ± 21 and 487 ± 18 to 565 ± 20). No significant differences were noted in the control group. The results from the SEBT tests in this study suggest that the modern martial artist can show improvements in balance performance after an intervention of four weeks traditional martial arts training. This presents the possibility that traditional martial art training methods could be incorporated into sport specific injury prevention training programmes for Modern Martial Arts.

Keywords: Balance; Proprioception; Neuromuscular control; Martial arts; Injury prevention

Introduction

Effective joint stability during dynamic sport specific movements is underpinned by both afferent, and proprioceptive, information from the ligament and joint mechanoreceptors and the coordinated efferent response, or neuromuscular control that maintains joint stabilisation through the activation of supporting muscles [1-3]. Without adequate proprioception and neuromuscular control, joint stabilisation relies purely on the passive restraint provided by the ligament and joint structures, leading to functional instability [4]. This results in excessive and repetitive loading of these passive structures that can lead to microtrauma of the involved tissues that, over time, can result in chronic inflammation, weakening of the structures, and eventual rupture [5,6]. Optimising proprioception and neuromuscular control around a joint, therefore, is essential to ensure correct movement biomechanics and improve markers of performance [7,8].

This is particularly so in female athletes, who are more prone to injuries of the knee and ankle than their male counterparts, primarily due to a number of predisposing anatomical and biomechanical factors [9-12]. Of these, several neuromuscular and biomechanical risk factors, such as the tendency to land from jumps in hip extension, dynamic knee valgus, foot pronation, and a time lag in hamstring activation compared to males, can be corrected by appropriate training [9-16].

In order to build robust athletes that can withstand the rigours of training and competition, injury prevention training programmes adopt a multifactorial approach using varying combinations of strength, balance, proprioception, stretching, jump landing, core training, and education [16-19]. In a multifactorial programme, the effectiveness of each element is difficult to quantify however, when interventions are evaluated by testing each one separately, functionally based proprioceptive and technical training interventions appear most effective at reducing both injury recurrence and predictors of injury [19-23].

It can be argued that Traditional Martial Arts (TMA) training, such as the forms practiced in Tai Chi, embeds similar proprioception and neuromuscular control challenges into their conditioning programmes in the shape of forms or katas, with this training showing improvements to proprioception and neuromuscular control in the elderly [24-26]. This raises the possibility that TMA training has the potential to improve markers of injury risk in a functional manner.

TMA forms consist of a combination of changing postures that are performed uninterrupted and smoothly, in a half squat posture, with constant weight transference through bilateral and unilateral stances [24-26] (Figure 1). In line with other proprioception and neuromuscular control training programmes, EMG analysis of TMA movements reveal continuous co-contractions of prime mover and stabilising muscles requiring high levels of strength and endurance [27,28]. Further to this, the deep stances and increased range of motion required during TMA forms training, activates the type three mechanoreceptors, specifically abundant within the ankle ligaments, which are activated only at the extremes of motion [2].

Dynamic neuromuscular training, involving in-depth analysis of the activity's biomechanics, identification and subsequent correction of faulty movement patterns of the athlete, and constant monitoring and feedback from the instructor, both during and after training, has been identified as an effective injury prevention strategy in high-risk populations [10]. The teaching style and the method of practicing TMA forms, with body awareness and instructor feedback emphasised throughout, adheres to this philosophy [10]. When performing TMA (Tai Chi) forms, each stance should be moved through in a reflective manner, concentrating fully on each of the body's positions, with the instructor meticulous in their corrections, providing continuous

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Figure 1: Wu Bu Quan form including start position, horse stance, bow and arrow stance, kick and punch, horse stance and punch, twisted stance, transition stance, single leg stance, crane step, cat stance.

feedback on the biomechanics of the student [24]. Any improvement gained during proprioception exercise is likely due in part to the attention required during such exercise, with repetitive training leading to the unconscious control [21].

In contrast to TMA, Modern Martial Arts (MMA) training methods tend to focus upon fitness and fighting techniques and often omit TMA forms practice from their training, finding them too rigid, uniform and time consuming to be of relevance to competitive practice [28,29]. It is therefore possible that these athletes are missing some of the benefits, in terms of proprioception and neuromuscular control, arising from TMA training.

Whilst previous studies have linked improved proprioception with TMA forms training in elderly individuals there are no comparable studies relating to younger, active individuals [24-26]. Our purpose was to explore the effect of TMA training methods, particularly the use of traditional forms training, on proprioception and neuromuscular control in female modern martial artists.

Method

Participants

Twenty-five female modern martial artists, with no previous history of TMA training, no previous head injury or concussion in the last six months, and no acute lower limb injuries, were recruited for this study. Age ranged from 26-49 (Mean 37.2 ± 11.5), experience from one month to 21 years, and levels of achievement from novice to 4th degree black belt. Two subjects were beginners with no grade, three were low grade (white to yellow belts), four were mid-grade (blue to purple belts), and fourteen were black belts between 1st to 4th degree. Permission to approach subjects was sought via letter to the Chief Instructor of North West Chinese Kickboxing.

Experimental design

A repeated measures experimental design was employed. The independent variables were the group conditions of intervention and control. The dependent variable was the measured reach in the Star Excursion Balance Test (SEBT). Significance levels were set apriori at $P < 0.05$. To avoid issues of inter-tester reliability, a single tester conducted all tests. The data collection and intervention took place at North West Chinese Kickboxing (N.W.C.K.B.) Headquarters.

From the 25 participants who volunteered, 23 completed the whole study. Participants were divided into two matched groups based on length of time training and level of achievement.

These were an intervention group (n = 11) that undertook a four-week TMA forms training intervention that replaced some (but not all) of their normal MMA training; and a control group (n = 12) that continued with their usual MMA training. Dominant and non-dominant legs were recorded with dominant leg defined as the preferred stance (balancing) leg when executing a kick.

Instrumentation and procedures

The Star Excursion Balance Test (SEBT) analyses postural control, placing demands on an athlete's proprioception, neuromuscular control, strength, and range of motion [30]. Its use in detecting both knee and ankle instabilities in reference to injury prevention has been well documented, with a recent review concluding that the SEBT should be considered a highly representative, non-instrumented dynamic balance test for physically active individuals that is reliable and valid in both

healthy people and people with injuries to the lower extremity [31-34]. The simplicity and low-tech nature of the SEBT makes it an ideal test to perform on-site and consequently lends itself to participant complicity.

The SEBT was constructed on solid plastic matting using eight tape measures that extended from a central standing point, at a 45-degree angle from each other, creating an eight-direction star. A marker in the centre of the star dictated the position of the base of the first metatarsal.

Each participant was required to stand on one foot in the centre of the star and reach along each direction with the other leg, lightly touching with the big toe at their end of range, then return to a bilateral stance. The distance of each reach was measured and recorded by the tester. Participants were instructed not to put weight through the reaching leg and no movement or heel lifting of the supporting foot was allowed. After each reach, the subject was asked to return to a bilateral stance and wait 5 seconds before the next reach. If any of these conditions were not met, the reach was repeated. Each subject was allowed to practice each reach 6 times prior to testing to reduce any learning effects; the test was then conducted 5 minutes later to reduce any effects of fatigue [5].

To determine the mean average score, participants reached three times in each direction in order. This was then divided by the subject's leg length and divided by one hundred in order to attain normalised data [30].

Intervention

The intervention consisted of a thirty-minute TMA forms training session, performed twice a week for four weeks. The TMA form that was chosen was the Wu Bu Quan (Five Stance Fist) form (Figure 2) as it is a simple beginner-level sequence that teaches the fundamental use of the lower body in Chinese Shaolin Kung Fu. This Form is also somewhat generic, being used as a standardised form in several different TMA styles. The Wu Bu Quan form teaches the five basic stances and the correct transition between them in order to instil balance, stability and correct body mechanics in the beginner. Participants received comprehensive and specific coaching points throughout each session. Participants were barefoot and wore shorts during each session to enable the coach to clearly identify any faulty movement patterns. The training session was performed twice a week at the North West Chinese Kickboxing Headquarters and was timed so that it could replace a portion of the fighters' normal MMA training (usually the warm-up). A register was taken to ensure all participants completed 8 sessions.

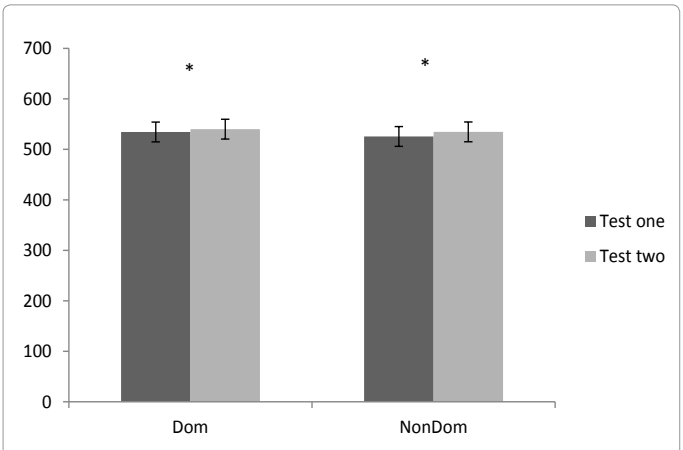

Figure 2: SEBT results: Control group - Differences in reach measurements for the control group between test one and test two for the dominant leg (Dom), and for the non-dominant leg (NonDom).

All sessions were conducted by a forth degree Kickboxing black belt and Bagua Zang student, and a third degree Kung Fu Black sash and Traditional Bagua Zang teacher.

Pilot tests

Pilot tests were conducted for the SEBT, with the raw data analysed for the control group (dominant leg), before normalisation, and before summing. In order to assess the consistency between test measurements and therefore establish test-retest reliability, multiple intra-class coefficient correlation tests (ICC's) were performed for the SEBT in each of the eight directions. Strong correlations were observed in all directions, (ICC's of r = 9.91 - 9.96; p = 0.00).

Statistical Analysis

All data was imported into SPSS statistical analysis software version 17 and significance levels were set at $P < 0.05$. For the SEBT, the normalised data of eight reaches for both the dominant and non-dominant leg were summed [33]. To measure whether there was a difference in reach between the groups after the intervention, a two-way, analysis of variance (ANOVA) was performed for both the dominant and non-dominant legs of both groups. Pair-wise comparisons were used to identify where any differences occurred. Results are expressed as mean ± SEM.

Results

Pair-wise comparisons revealed that for the intervention group there was a significant (p = 0.00) improvement in the mean SEBT scores for dominant leg from 517 ± 18 to 592 ± 21 and also a significant improvement (p = 0.00) in the non-dominant leg from 487 ± 18 to 565 ± 20 following the intervention (Figure 3).

For the control group there were no significant differences in scores between tests (534 ± 17 to 540 ± 20 dominant; 525 ± 17 to 534 ± 19 non-dominant) (Figure 1).

Discussion

The increase in reach measurement in the SEBT, post intervention, suggests that four weeks of Traditional Martial Arts training can improve balance performance in females who practice Modern Martial Arts. The execution of the Wu Bu Chuan Form used in the current study requires students to move through extreme angles of ankle, knee,

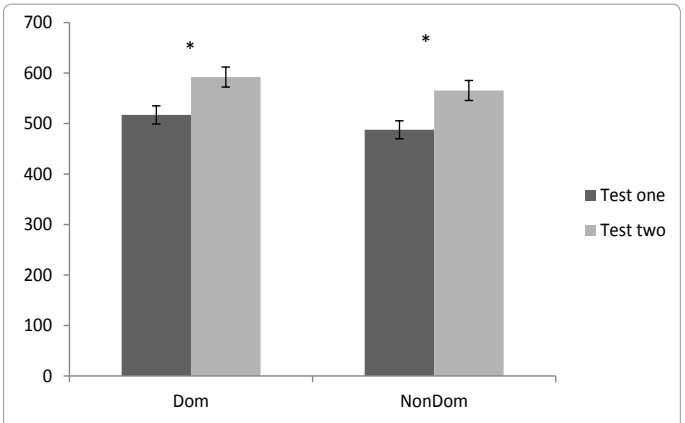

Figure 3: SEBT Results: Intervention Group - Differences in reach measurements for the intervention group between test one and test two for the dominant leg (Dom), and for the non-dominant leg (NonDom). Note that the differences observed between Test one and Test two for both dominant and non-dominant legs were significant (p = 0.00).

and hip flexion continuously until completion of the sequence. This is similar to the extreme angles observed at the ankle, knee, and hip joints during performance of the SEBT [30]. It is therefore likely that the observed increase in reach measurements, post intervention, was due to an improvement in proprioception and neuromuscular control brought about by the performance of TMA forms.

Previous studies reporting links between TMA forms training, and proprioception and neuromuscular improvement, have focused upon the elderly [24-26]. Our results suggest that similar benefits can be attained by a younger, more active, female population and also raises the possibility that TMA forms training can be utilised by the MMA community as part of an injury prevention training protocol.

Forms as injury prevention training

In order to improve proprioception and neuromuscular control, previous studies on injury prevention training have employed movements and techniques that are specific to the sport involved [10,16,25]. Although the movements and techniques in martial arts differ somewhat to those above, comparisons can still be made with the TMA forms training used in the current study. When developing neuromuscular training protocols for ACL injury prevention in female athletes, the importance of including exercises that repetitively produce knee flexion angles that are greater than 45 degrees, must be stressed, thereby reducing quadriceps dominance and encouraging hamstring strength and co-activation, thereby decreasing the load on the ACL [10]. Whilst the exercises used previously to produce this knee flexion angle were broad jumps and squat jumps, the current study achieved this knee angle in a closed chain manner whilst moving between bilateral and unilateral stances (e.g. horse stance, single leg stance, and crane step) throughout the form [10].

Single leg balance and hop and hold exercises have previously been incorporated into programmes to encourage proprioception and provide stability in single leg stances [10]. These positions mirror the single leg stance, crane step, and kick stances utilised in the current study. This is in accord with, which attributes the effectiveness of TMA forms training in developing proprioception and neuromuscular control to the strength and coordination required to move the centre of gravity through moving postures in a deep squat position [28].

Another key similarity with previous studies is the emphasis placed upon the continuous visual and verbal feedback of the athletes' technique, which appears to facilitate cognitive processing by the athlete, and result in improved movement patterns [8-10]. Because TMA have these coaching methods deeply embedded within their systems, participants in the intervention group in the current study received extensive and thorough technical feedback throughout. It is therefore possible that this could also have contributed to the improvement in SEBT measures.

Limitations

Whilst the results of this study demonstrate that 4 weeks is long enough to produce significant improvements in SEBT scores within this population, because we only used pre- and post- intervention testing, we were unable to determine exactly how soon SEBT scores improved. When investigating the effects of a four-week balance training intervention, using the SEBT procedure, retesting the participants at two-weeks and again at four-weeks, revealed that improvements had already occurred at two-weeks [35,36]. This raises the possibility that a shorter targeted period of TMA training could also produce benefits for the modern martial artist. We also did not monitor the length of time that the improvements shown in this study remained. This information would be useful deciding how to implement TMA or other proprioception and neuromuscular control training. For example, whether to incorporate TMA into the weekly training sessions, or add TMA forms to early pre-fight preparation training.

We recognise that the Wu Bu Chuan form utilised in the current study is designed to develop stability in the basic stances for beginners. Progressively harder and more involved TMA forms often include movements that require higher levels of force acceptance, explosiveness and greater dynamic control, and appear to reflect similar studies in this area, where plyometrics are emphasised in Injury Prevention Training Programmes [8,16].

Practical Applications

The results from the SEBT in this study, suggest that the modern martial artist can show improvements in proprioception and neuromuscular control after an intervention of four weeks of TMA forms training, when compared to modern martial artists in the control group. Previous Studies, involving Sports Specific Injury Training Programmes and TMA traditional forms (Tai Chi) training [8,16,19,24-26] have also concluded that there is a direct relationship between the training utilised in their studies and improvements in proprioception and neuromuscular control. This presents the possibility that the practice of TMA forms, as highlighted in this study, could be used as a Sport Specific Injury Prevention Training Programme for the MMA community.

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