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Stability Limits of Standing Postural Control in Young Male Ving Tsun Chinese Martial Art Practitioners: A Pilot Study in Hong Kong

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Abstract: This study aimed to compare the stability limits of standing balance control between Ving Tsun (VT) practitioners and non-practitioners. Four male VT practitioners (mean age ± standard deviation = 26.3 ± 5.0 years) and 4 healthy active male adults (mean age ± standard deviation = 21.5 ± 2.4 years) as controls participated in the study. Balance ability, specifically limits of stability (LOS) in standing, was assessed using the LOS test. Outcome measures included reaction time, movement velocity, maximum excursion, end-point excursion and directional control in the forward, backward, right and left directions. Results revealed that VT practitioners had lower LOS maximum excursion scores in the backward direction (17.6% lower, $p = 0.020$), and lower directional control scores in both the backward direction (8.6% lower, $p = 0.042$) and to the right side (7.7% lower, $p = 0.043$) compared to the controls. No significant between-group differences in other outcome variables were found ($p > 0.05$). VT practitioners showed inferior LOS balance performance in standing compared to non-practitioners in general, except that they seemed to have better maximum excursion in the forward direction (effect size = 0.951). Further randomized controlled trials are needed to confirm these results.

Keywords: Martial Exercise, Balance, Limits of Stability

1. Introduction

Ving Tsun (VT) or Wing Chun is a traditional Chinese martial art characterized by rapid and powerful punching techniques and dynamic footwork. Its popularity has been increasing across the world in recent years as it is famous for being simple and functional as a means of self-defense [1, 2]. However, its health aspects are largely ignored. Our research team was the first to investigate the potential beneficial effects of VT training on musculoskeletal health, eye-hand coordination, balance control and balance self-efficacy in older and middle-aged adults [3-7]. To summarize our previous research work, we found that VT practitioners had higher ultrasonic radial bone strength [3, 4] and bone mineral density [6], greater leg [4, 6] and arm muscle strength [3, 5] and leg lean (muscle) mass [6], shorter time to reach maximum muscle strength in the elbow extensors [5], better sensory organization of balance control [3], functional balance performance [4] and balance confidence [4], and better eye-hand coordination [5] than non-practitioners. Among all of the measurement outcomes, we are particularly interested in studying the postural control (balance) performance of VT practitioners, as body balance is the most common therapeutic target to reduce the risk of falls among older adults and thus reduce the associated morbidity, mortality and health care costs [8, 9].

It is well known that postural control requires the ability to control the center of gravity (COG) within the base of support (BOS) in any given posture. The boundary (perimeter) of the BOS is known as the limits of stability (LOS). During upright standing, the LOS defines the spatial area through which a person can lean his/her body without changing the BOS. If the body (COG) sways beyond the LOS, a corrective step will be elicited to re-establish a new BOS under the COG or else a fall will occur [10, 11].

Therefore, LOS is an important postural control measure, yet no study has investigated this outcome in VT practitioners thus far. This study aimed to compare the stability limits of standing balance control between VT practitioners and non-practitioners. We hypothesized that individuals who are trained in VT would display an overall LOS balance performance superior to that of active controls. The findings may shed light on the use of VT martial art training for improving LOS of postural control in adult populations.

2. Methods

2.1. Participants

This was an exploratory study comprising a convenience sample of VT practitioners recruited from the Hong Kong Polytechnic University Wing Chun Martial Art Club by personal invitation. Age- and sex-matched healthy active participants acting as controls were recruited from the Bachelor of Science (Physiotherapy) student group of the same university. The inclusion criteria were (1) age between 18 and 40 years, (2) male, and (3) trained in VT for a minimum of 0.5 years. Exclusion criteria were (1) significant musculoskeletal, neurological, visual, vestibular or cardiopulmonary disorders, (2) prolonged use of medications that may affect test performances, or (3) practiced other kinds of martial arts apart from VT. Participants in the control group were selected according to the same inclusion and exclusion criteria mentioned above, except that they did not have any VT experience.

Ethical approval was obtained from the Ethical Review Committee of the Hong Kong Polytechnic University, and all experimental procedures were conducted in accordance with the Declaration of Helsinki. Each participant gave written informed consent before data collection. Data collection was performed by two physiotherapy students under the supervision of a physiotherapist.

2.2. Outcome Measurements

The participants' personal information, VT training experience and medical history were obtained by interviewing them. Their body height and weight were measured using a mechanical scale equipped with a height rod. Body mass index (in kg/m^2) was calculated before the balance assessment. All of the participants were advised not to intake any caffeine or alcohol 48 hours before the test day.

The LOS test was performed using a computerized dynamic posturography (CDP) machine (Smart Equitest, NeuroCom International Inc., Clackamas, OR, USA) with dual force plates and a video screen (for biofeedback). This test assesses the standing participant's ability to intentionally shift his or her body weight or COG in eight spatial directions within a fixed BOS and to briefly maintain postural stability at these target positions. Test-retest reliability of the LOS test was reported to be moderate to good (ICCs: 0.69−0.88) in young adults [12]. One familiarization trial to each target position was allowed for each participant before the actual testing trial [13, 14].

Before the test, each participant was instructed to stand barefoot on the CDP's force platform with standardized foot placement and arms by the sides of the trunk. A safety harness was applied to ensure safety. During the test, the initial center of pressure (COP) of the participant was displayed on the video screen of the CDP machine together with eight spatial target positions (front, right-front, right, right-back, back, left-back, left and left-front). These target positions represent the boundary of the theoretical LOS (100% LOS), which was determined by the machine according to the sway angle of the COG of the participant. The displacements of COP were displayed on screen in real time to provide visual feedback to the participant. On command, the participant moved his or her COP trace to hit one of the eight randomly selected spatial targets located on the LOS perimeter as quickly, accurately and smoothly as possible and briefly maintained this position (i.e., kept the COP as close to the target as possible). To do this, the participant leaned his or her body as far as possible in a given direction without losing balance, stepping or reaching for assistance. The displacements of COP were recorded automatically [13-16].

The LOS test measured the following five parameters for each movement direction, and these outcomes were used for analysis.

(1) Reaction time (in seconds) refers to the time between the command (i.e., presentation of a visual and/or auditory cue) and onset of voluntary shifting of the COP of the participant toward the designated spatial target.

(2) Movement velocity (in degrees/second) quantifies the average velocity of COP movement of the participant quantified for 5 to 95% of the distance from the starting position to the spatial target.

(3) Maximum excursion (in % LOS) describes the maximum distance travelled by COP of the participant during a trial, including movements that pass beyond the designated spatial target.

(4) End-point excursion (in % LOS) measures the distance of COP movement of the participant on the first attempt toward the designated spatial target. It provides an estimate of how far the participant is willing to lean toward the target on the first attempt and reflects the participant's perception of his or her own safety limits.

(5) Directional control (in % accuracy) measures the smoothness of the displacement of the COP of the participant toward the designated spatial target. It is computed using the formula: [(Amount of on-target movement – amount of off-target movement) / Amount of on-target movement] × 100%. Thus, a score of 100% indicates a straight-line path from the starting position toward the designated spatial target without any off-target movement [13-16].

2.3. Statistical Analyses

Statistical analyses were performed using SPSS 20.0 (IBM, Armonk, NY). The two-tailed alpha was set at 0.05. Descriptive statistics were used to describe the demographic data and variables of interest. The Mann-Whitney U test was used to compare the demographic and outcome variables between the VT and control groups. Given the small sample size (n = 8), the effect size (Cohen's d) was also calculated using G*Power 3.1.0 (Franz Faul, University of Kiel, Germany) to supplement the statistical test results. By convention, values of 0.2, 0.5 and 0.8 indicate small, medium and large effect sizes, respectively [17]. In addition, post hoc power analyses were performed to examine the statistical power of the comparisons of the outcome variables between the two groups.

3. Results

Four male VT practitioners with 0.5 to 4 years of VT experience and four active male undergraduate students with no VT experience were eligible to participate in the study. There were no significant differences in any of the demographic variables between the VT and active control group ($p > 0.05$) (Table 1).

Table 1. *Demographic characteristics of the participants.*

	VT group (n = 4)	Control group (n = 4)
Age (years)	26.3 ± 5.0	21.5 ± 2.4
Male:female ratio (n)	4:0	4:0
Height (m)	1.7 ± 0.1	1.7 ± 0.1
Weight (kg)	59.7 ± 9.8	60.7 ± 4.5
Body mass index (kg/m^2)	20.7	21.0
VT experience (years)	1.9 ± 1.5	0

Values are mean ± standard deviations unless otherwise specified.

Mann-Whitney U test results revealed that the VT practitioners had lower maximum excursion scores in the backward direction (17.6% lower, $p = 0.020$) and lower directional control scores in both the backward direction (8.6% lower, $p = 0.042$) and to the right side (7.7% lower, $p = 0.043$) compared to the controls. No significant between-group differences in other outcome variables were found ($p > 0.05$). However, the between-group differences in the movement velocity (backward and right side), maximum excursion (forward and right side) and end-point excursion (forward) were large, with effect sizes ranging from 0.8 to 1.5 (Table 2). VT practitioners showed inferior LOS balance outcomes in general, except that their maximum excursion in the forward direction appeared to be better than that of the controls by 2.4% (effect size = 0.951) (Table 2).

Table 2. *Limits of stability test results.*

	VT group (n = 4)	Control group (n = 4)	Effect size	p Value
Reaction time (seconds)				
Forward	0.62 ± 0.31	0.49 ± 0.10	0.564	0.248
Backward	0.57 ± 0.09	0.52 ± 0.23	0.286	0.386
Left	0.54 ± 0.17	0.53 ± 0.07	0.077	0.885
Right	0.84 ± 0.38	0.65 ± 0.09	0.688	0.773
Movement velocity (degrees/second)				
Forward	5.30 ± 2.07	6.45 ± 2.64	0.485	0.386
Backward	2.48 ± 0.91	3.58 ± 0.54	1.470	0.149
Left	5.48 ± 2.17	4.88 ± 2.51	0.256	0.561
Right	5.33 ± 0.69	6.90 ± 1.36	1.456	0.083
Maximum excursion (%)				
Forward	107.25 ± 3.30	104.75 ± 1.71	0.951	0.243
Backward	81.00 ± 5.72	98.25 ± 5.91	2.966	0.020*
Left	98.50 ± 6.45	100.50 ± 3.42	0.387	0.770
Right	97.50 ± 6.03	101.75 ± 1.71	0.959	0.191
End-point excursion (%)				
Forward	90.50 ± 5.97	97.50 ± 11.00	0.791	0.309
Backward	64.00 ± 13.22	72.00 ± 17.34	0.519	0.237
Left	88.75 ± 9.57	92.50 ± 7.94	0.426	0.468
Right	83.50 ± 8.58	85.25 ± 12.97	0.159	0.772
Directional control (%)				
Forward	90.00 ± 2.94	90.50 ± 5.00	0.122	0.885
Backward	80.00 ± 3.83	87.50 ± 4.51	1.793	0.042*
Left	86.25 ± 5.38	87.75 ± 7.59	0.228	0.663
Right	84.00 ± 4.83	91.00 ± 4.83	1.449	0.043*

Values are mean ± standard deviations unless otherwise specified.
* $p < 0.05$

Post hoc power analyses showed that the statistical powers for the between-group comparisons of all LOS outcomes were low, ranging from 0.051 to 0.565, except for the maximum excursion in the backward direction outcome (statistical power = 0.934).

4. Discussion

In some contrast to our hypothesis that VT practitioners would have better stability limits of standing postural control than non-practitioners, our results revealed that non-VT participants outperformed the VT practitioners on most of the LOS balance outcomes, including movement velocity (backward and to the right side), maximum excursion (backward, to the left and right sides), end-point excursion (forward) and directional control (backward and to the right side) (Table 2). These unexpected findings could be explained by the fact that VT training is dynamic in nature. Training in VT requires the practitioners to react to postural threats (e.g., an incoming attack) by redirecting the external perturbation forces via dynamic footwork. Leaning the body toward one's stability limit with a stationary BOS is the worst balance strategy from the martial artist's point of view, and it is not advocated by VT instructors [1,2]. Therefore, the LOS test used in this study may not be the best assessment method to measure the sport-specific balance ability of VT practitioners [18].

Despite this, our VT practitioners showed better maximum excursion exclusively in the forward direction compared with the controls (Table 2). This finding was not surprising given that VT practitioners are trained to lean forward to attack their opponent (e.g., to execute a punch at a very fast speed) during VT free sparring (chi sao) exercise [2]. So, their maximum excursion exceeded 100% of their theoretical LOS.

We also found no significant differences in reaction time (in all movement directions) between the VT and control groups (Table 2). Because reaction time in this study refers to the duration between the presentation of a visual/auditory cue and the onset of voluntary shifting of the COP as registered by the CPD's force platform, we measured the simple reaction time of the participants. Previous studies have reported that martial arts training can only improve the choice reaction time (i.e., the participant must choose the appropriate reaction from several choices as soon as possible), but not the simple reaction time, of the athletes [19,20]. Thus, our finding is in exact agreement with previous studies [19,20] concluding that the simple reaction time was similar between the martial art (VT)-trained participants and control participants. In a future study, the choice reaction time for balance control may be measured instead to reflect the actual training effect of VT.

The major limitation of this study is that it was underpowered to detect any significant differences in LOS outcomes between the VT and control groups. Future studies must increase the sample size and include both male and female participants with more VT training experience (e.g., practiced in VT for more than three years) to enhance the generalizability and applicability of the results. Another limitation is the cross-sectional study design (i.e., a single point of data collection for each participant is employed). We are not sure whether the between-group differences in LOS performance were due to VT training itself or to other factors, such as genetic factors. Finally, since our participants were young and healthy individuals, the study results cannot be generalized to older individuals who have balance difficulties. Further randomized controlled trials are certainly needed to confirm the results before VT training is incorporated into balance enhancement/fall prevention programs for elderly people in clinical or community settings.

5. Conclusion

VT practitioners had inferior stability limits of standing postural control to those of non-practitioners in general, except that they showed better maximum excursion in the forward direction. Further randomized controlled trials are needed to confirm these results.

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