International Journal of Nursing Sciences 7 (2020) 29–34

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Contents lists available at ScienceDirect

International Journal of Nursing Sciences

journal homepage: http://www.elsevier.com/journals/international-journal-of-nursing-sciences/2352-0132

Original Article

Effects of Ving Tsun sticking-hand training on upper-limb sensorimotor performance in community-dwelling middle-aged and older adults: A randomized controlled trial

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ARTICLE INFO

Article history:
Received 12 July 2019
Received in revised form
7 November 2019
Accepted 7 November 2019
Available online 9 November 2019

Keywords:
Aged
Exercise movement techniques
Joint position sense
Middle aged
Muscle strength
Upper extremities

ABSTRACT

Objective: To evaluate the effects of Ving Tsun (VT) sticking-hand training on upper-limb joint position sense and muscular performance in community-dwelling middle-aged and older adults.
Methods: Thirty-three adults were randomly allocated to either a VT group or a control group. The VT group received VT sticking-hand training twice per week for 3 months. Measurements were taken before and after the intervention period. The primary outcome was elbow-joint repositioning error, which was measured by an elbow-joint passive positioning and active repositioning test using a universal goniometer. Secondary outcomes were upper-limb muscles' peak force and time taken to reach peak force as measured by a hand-held dynamometer.
Results: No significant time, group or time-by-group interaction effects were found for elbow-joint repositioning error or upper-limb muscle peak force outcomes. Shoulder flexor time to peak force decreased by 33.8% from pre-test to post-test in the VT group ($P = 0.007$). Shoulder abductor, internal and external rotator, and elbow extensor times to peak force decreased by 30.0%–35.9% in the VT group ($P < 0.05$) and by 30.4%–37.1% in the control group ($P < 0.05$).
Conclusions: VT sticking-hand training does not improve elbow-joint position sense or the maximum strength of upper-limb muscles in middle-aged and older adults. However, VT can improve shoulder flexor muscles' time to reach peak force in these populations. VT had no obvious effect on the time required to reach peak force in other shoulder muscles and elbow extensors.

What is known?

- Aging is associated with changes in sensorimotor performances.
- Exercise interventions are known to improve joint proprioception and muscular performance.
- Ving Tsun training might improve upper-limb joint proprioception and muscle strength.

What is new?

- Ving Tsun training cannot improve elbow-joint position sense or the maximum strength of upper-limb muscles in middle-aged and older adults.
- It can improve shoulder flexor muscles' time to reach peak force in these populations.

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Peer review under responsibility of Chinese Nursing Association.

https://doi.org/10.1016/j.ijnss.2019.11.001

- It cannot shorten the time required to reach peak force in other shoulder muscles and elbow extensors.

1. Introduction

Aging is associated with changes in sensorimotor performance due to the morphological and physiological decline of sensory structures (e.g., the preferential loss of distal large myelinated sensory fibers and receptors and degeneration of both white and gray matter in the cerebellum) [1–3] and sarcopenia (i.e., loss of muscle mass) [4,5]. Such natural physiological deteriorations in both the sensory and motor systems can affect older people's upper-limb joint proprioception, which is the sensing of the position and movement of the upper-limb joints in space. Maintaining good upper-limb joint proprioception enables older individuals to reach, manipulate objects, control skilled movements and maintain functional independence [6]. Researchers have reported that healthy older individuals find it more difficult to detect the position of the elbow [6] and finger joints [7] than their younger counterparts. However, to the best of our knowledge, few studies have investigated interventions to improve upper-limb joint proprioception in the aging population [8,9]. Casadio et al. [9] has reported that active assisted arm exercises with and without vision could improve upper limb joint proprioception and motor control in middle-aged and older stroke survivors. Moreover, it is widely acknowledged that upper-limb muscle strength declines with advancing age (primarily due to sarcopenia) [4,5,10], which can affect the functional independence of elderly people [10]; it is essential, therefore, to identify an effective intervention to maintain or improve both upper-limb joint proprioception and the muscle strength of the aging individuals.

Exercise interventions are known to improve lower-limb joint proprioception because they improve selective attention to sensory cues and neural plastic changes occur in the primary sensory cortex through the repeated practice of motor skills [11,12]. Ving Tsun (VT), also known as Wing Chun, is a Chinese martial art exercise that is characterized by rapid and forceful hand striking techniques and sticking-hand practice [13,14]. VT participants have many opportunities to position their arms in space to block and react to various upper-body attacks [15]. Therefore, VT training might improve upper-limb joint proprioception and muscle strength. Our previous study showed that just 4 weeks of VT training could improve the elbow extensors' isometric peak force and time to peak force of older adults [13]. Long-term practitioners of VT also demonstrated greater hand-grip strength [16], leg muscle strength and lean mass than controls [17,18]. However, the effect of VT training on upper-limb joint proprioception remains unknown. This study aimed to explore the effects of VT training on upper-limb joint proprioception and muscular performance in community-dwelling middle-aged and older adults. We hypothesized that VT (sticking-hand) training would improve both sensory and motor performances in the upper limbs of these individuals.

2. Methods

2.1. Study design

This was a single-blinded, randomized controlled trial with the ClinicalTrials.gov identifier NCT03318289, registered in October 2017. The University of Hong Kong Human Research Ethics Committee approved the study and all participants provided written informed consent before data collection. All procedures were conducted in accordance with the Declaration of Helsinki.

2.2. Participants

Thirty-three apparently healthy middle-aged and older adults were recruited from the Un Chau Neighborhood Elderly Center of the Hong Kong Christian Service through notices placed in the center. The inclusion criteria were (1) aged 55 or above, (2) able to ambulate independently and safely, and (3) able to follow instructions and communicate with others. The exclusion criteria were (1) unstable medical condition (e.g., uncontrolled diabetes), (2) recent injury, (3) a history of fragility fracture, (4) significant musculoskeletal disorder (e.g., osteoarthritis of the knee), (5) sensorimotor or neurological disorder (e.g., stroke), (6) cardiopulmonary disease (e.g., chronic obstructive airway disease), (7) mild cognitive impairment or other cognitive disorder, (8) regular participation in sports training, and (9) fragility that would hinder VT training.

2.3. Randomization, allocation concealment and assessor blinding

Screening and assessments were performed by three blinded physiotherapists and one blinded research assistant. The randomization procedures involved the use of sealed opaque envelopes, which were prepared by an independent person, to ensure concealed allocation. The corresponding author performed the random allocation, including opening the envelopes. A staff member from the Un Chau Neighborhood Elderly Center organized the VT training course but did not participate in the study. The intervention and assessments took place at different sites.

2.4. Intervention

2.4.1. VT group

The VT sticking-hand training protocol was developed by the corresponding author who is a physiotherapist and experienced VT coach. The training regimen was designed based on the principles of motor learning [19] to improve the sensorimotor performance and body balance of the participants. It comprised warm-up exercises, nine VT dynamic sticking-hand drills that were practiced with a partner, and cool-down exercises. The participants were required to position their arms in space accurately and in time during the sticking-hand drills. The detailed training protocol is described in our previous publication [20] and can be viewed at https://youtu.be/ssaYXNGm7hM. Each participant attended a 1-hour supervised VT training session at a sports center twice weekly for 3 months. The training sessions were delivered by a qualified VT coach and an assistant VT coach. To ensure safety, all sticking-hand drills were practiced with a partner in a sequence from expected to unexpected movements and from slow to fast movements under supervision. Appropriate feedback was given to each participant to help him/her to progress through the cognitive, association, and autonomous stages of motor learning [19].

2.4.2. Control group

The participants in this group received no intervention but continued their usual daily activities and medical care, as necessary. They were advised not to engage in any martial art training during the study period.

2.5. Outcome measurements

All participants, except those who dropped out, were assessed at baseline (pre-test) and within one week after the end of the intervention period (post-test) at the Un Chau Neighborhood Elderly Center. Fig. 1 shows the flowchart of the study. All participants underwent the following tests in a random order.

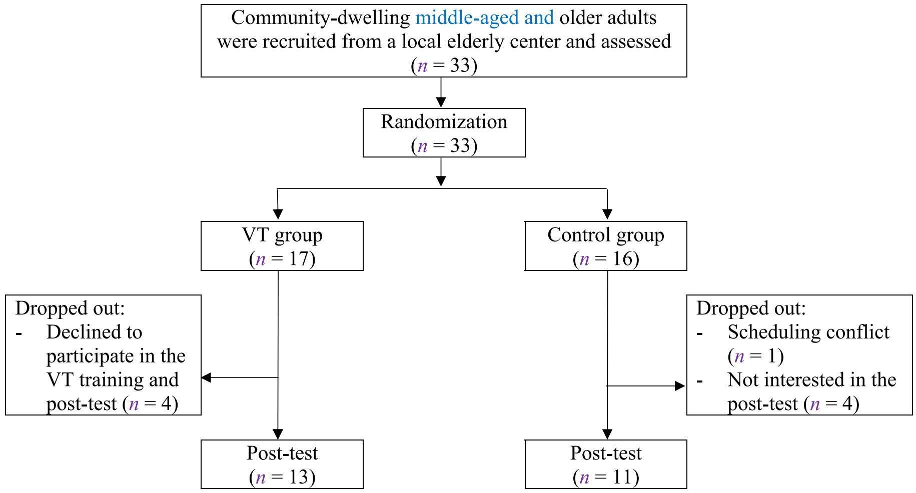

Fig. 1. Flowchart of the study. VT = Ving Tsun.

2.5.1. Primary outcome measure

Elbow-joint position sense was measured with the participant sitting with back supported and feet flat on the floor. The testing forearm was in a neutral position (semi-pronated) and the elbow was supported on a table so that the shoulder was also in a neutral position. Only the dominant side was tested because a previous study showed that elbow-joint position sense is similar between the right and left sides [21]. The starting position of the elbow was taken at 0° (full extension). The elbow was then moved by the assessor to a new position within the range of 45 to 75° of elbow flexion and remained in that position for 3 s. Another assessor measured the designated elbow-joint angle using a universal goniometer following standardized procedures [22]. Then, the testing elbow was positioned back to full extension (starting position). Five seconds later, the participant was asked to actively position the elbow joint to the previous joint angle. The elbow-joint angle that the participant produced was measured using the universal goniometer. The discrepancy between the two elbow joint positions (absolute error) was calculated. Two trials were conducted with a 30-s rest in between. The mean absolute joint angle repositioning error (in degrees) of the two trials was calculated. The test-retest reliability of this test was found to be satisfactory ($ICC_{2,1} = 0.59$) [23].

2.5.2. Secondary outcome measures

The maximum isometric muscle strength (peak force) and time to peak force of the participants' dominant shoulder flexors, shoulder abductors, shoulder internal and external rotators, and elbow extensors were measured using the Lafayette Manual Muscle Test System (Lafayette Instrument Company, Lafayette, LA) following standardized manual muscle testing procedures [22] and dynamometer placements [24]. The reliability of this measurement method in community-dwelling elderly adults has been found to be perfect ($ICC_{2,2} = 0.97–1.00$) [25]. During the test, each participant was instructed to contract the respective muscle group as hard and as fast as possible. The peak force was generated for 2 s for each muscle group and two testing trials were performed. The average peak force (in kg) and average time to peak force (in seconds) of the two trials were calculated and used for analysis.

2.6. Statistical analyses

G*Power version 3.1.9.2 (Franz Faul, Universitat Kiel, Germany) was used to estimate the sample size. On the basis of Fong et al. [17], an effect size of 1.35 was assumed. With α at 5% (two-tailed) and power at 80%, 10 older participants per group were required. Assuming a 25% dropout rate, a minimum of 13 participants per group (26 participants in total) was required.

SPSS version 25.0 (IBM, Armonk, NY) was used for data analysis. The intention-to-treat principle (last observation carried forward) was used to handle any missing data. Descriptive statistics were calculated for all variables. The demographic and baseline outcome variables were compared between the two groups using chi-square tests (for sex) and independent t-tests (for all other variables). Then, each outcome variable was compared between and within groups using a two-way repeated measures analysis of variance (ANOVA) with an adjustment for the baseline value or demographic covariates, as appropriate. The between-subjects factor was group and the within-subject factor was time. If ANOVA revealed a significant time-by-group interaction effect, time effect or group effect, a post hoc analysis was performed using paired t-tests (for within-group comparison) and/or independent t-tests (for between-group comparison). The overall significance level was set at 5% (two-tailed).

3. Results

3.1. Participants

Between November and December 2017, 33 community-dwelling middle-aged and older adults were screened for eligibility and participated in the study. All of them underwent a baseline assessment and were randomized to either the VT group ($n = 17$) or control group ($n = 16$) (Fig. 1). The demographic characteristics (Table 1) and outcome variables at baseline (Table 2) of the two groups were similar. Four participants dropped out of the VT group and five dropped out of the control group. Their reasons for dropping out are shown in Fig. 1. The attendance rate of the VT group was 77% and the total training time was 19 h for each participant. No changes in the participants' medication or exercise habit were noted during the study period. No adverse events were reported.

3.2. Primary outcome

No significant time ($F(1,31) = 0.037$, $P = 0.848$), group

Table 1
Demographic characteristics of the participants.

Characteristics	VT group ($n = 17$)	Control group ($n = 16$)	t/χ^2	P
Age (years)	67.5 ± 6.3	72.1 ± 10.3	$t = -1.561$	0.129
Sex (number of males/number of females)	2/15	3/13	$\chi^2 = 0.313$	0.576
Height (m)	1.5 ± 0.1	1.5 ± 0.1	$t = 0.430$	0.670
Body weight (kg)	55.5 ± 8.9	55.2 ± 7.8	$t = 0.117$	0.908
Body mass index ($kg \cdot m^{-2}$)	23.3 ± 3.5	23.4 ± 3.0	$t = -0.140$	0.889
Resting systolic blood pressure (mmHg)	130.9 ± 15.9	131.4 ± 18.5	$t = -0.083$	0.935
Resting diastolic blood pressure (mmHg)	72.5 ± 10.4	73.3 ± 9.2	$t = -0.246$	0.807
Resting heart rate (bpm)	75.7 ± 10.6	71.9 ± 9.6	$t = 1.081$	0.288
Habitual physical activity level (metabolic equivalent hours per week)	14.4 ± 19.0	14.2 ± 13.0	$t = 0.031$	0.976

Note:Means ± standard deviations are presented unless specified otherwise. VT = Ving Tsun.

Table 2
Comparison of outcome variables between VT and control groups (*Mean* ± *SD*).

Variables	VT group ($n = 17$)		Control group ($n = 16$)		Group		Time		Time × Group	
	Pre-test	Post-test	Pre-test	Post-test	F	P	F	P	F	P
Primary outcome										
Elbow-joint repositioning error (degree)	6.24 ± 4.99	5.94 ± 6.42	6.44 ± 5.81	6.19 ± 5.37	0.026	0.872	0.037	0.848	<0.001	0.988
Secondary outcomes										
Muscle peak force (kg)										
Shoulder flexors	7.83 ± 2.14	7.97 ± 2.90	8.12 ± 2.19	8.30 ± 2.37	0.157	0.694	0.250	0.621	0.004	0.951
Shoulder abductors	7.25 ± 2.10	8.22 ± 2.40	7.73 ± 2.29	8.32 ± 2.03	0.194	0.662	3.565	0.068	0.202	0.656
Shoulder internal rotators	7.06 ± 2.82	6.29 ± 2.39	6.36 ± 1.95	6.19 ± 1.56	0.316	0.578	2.255	0.143	0.901	0.350
Shoulder external rotators	6.52 ± 2.12	6.64 ± 2.47	6.12 ± 1.94	6.18 ± 1.73	0.395	0.534	0.100	0.754	0.011	0.918
Elbow extensors	7.74 ± 2.14	8.29 ± 3.54	7.44 ± 2.44	7.39 ± 2.16	0.528	0.473	0.404	0.530	0.555	0.462
Muscle time to peak force (s)										
Shoulder flexors	2.40 ± 0.61	1.59 ± 0.99[a]	2.07 ± 0.71	1.54 ± 0.98	0.678	0.416	13.379	0.001	0.616	0.439
Shoulder abductors	2.02 ± 0.76	1.31 ± 0.94[a]	2.04 ± 0.78	1.42 ± 0.95[a]	0.069	0.794	13.832	0.001	0.060	0.808
Shoulder internal rotators	2.30 ± 0.63	1.61 ± 1.18[a]	2.28 ± 0.89	1.46 ± 1.01[a]	0.082	0.777	19.616	<0.001	0.133	0.718
Shoulder external rotators	1.99 ± 0.78	1.33 ± 0.83[a]	2.13 ± 0.86	1.34 ± 1.13[a]	0.068	0.796	18.281	<0.001	0.131	0.720
Elbow extensors	2.45 ± 0.43	1.57 ± 0.95[a]	2.46 ± 0.75	1.58 ± 0.99[a]	0.001	0.976	30.246	<0.001	<0.001	0.987

Note: SD = standard deviation. VT = Ving Tsun.
[a] Within-group change: $P < 0.05$ compared with the baseline value.

($F(1,31) = 0.026$, $P = 0.872$), or time-by-group interaction effects ($F(1,31) < 0.001$, $P = 0.988$) were found in the elbow-joint repositioning error outcome (Table 2), indicating that VT training did not improve the elbow-joint position sense of the participants.

3.3. *Secondary outcomes*

No significant main or interaction effects were found for the muscle peak force of shoulder flexors, abductors, internal and external rotators, or elbow extensors (all $P > 0.05$) (Table 2). However, the time effect was significant for all time to peak force outcomes (all $P < 0.05$). Post hoc analysis revealed that shoulder flexors' time to peak force decreased by 33.8% in the VT group only ($P = 0.007$). In addition, shoulder abductors, internal rotators and external rotators and elbow extensors' times to peak force decreased by 30.0%–35.9% in the VT group (all $P < 0.05$) and 30.4%–37.1% in the control group (all $P < 0.05$) (Table 2).

4. Discussion

This was the first study to show that a 3-month VT Chinese martial art training program can improve shoulder muscles' time to peak force in community-dwelling middle-aged and older adults but not the maximum strength of their upper-limb muscles or their elbow-joint position sense. These findings, especially the negative finding for elbow-joint position sense, are surprising because theoretically, proprioceptive sensation is crucial to developing motor control when learning new skills such as VT sticking-hand techniques [26]. As a result, an internal model of the dynamic properties of the limb should have been established in the brain after training [27]. However, our results revealed that short-term VT training did not improve the elbow-joint position sense of healthy middle-aged and older adults. Plausible reasons are as follows. First, the elbow joint was not in a weight-bearing position during VT sticking-hand exercises. Previous studies have suggested that only moderately challenging weight-bearing activities (such as Tai Chi) can improve joint proprioception or joint position sense [11,12]. Second, we measured the accuracy of joint position replication in this study but did not measure joint kinesthesia or the ability to detect joint motion. As VT sticking-hand training is dynamic in nature, the elbow joint's threshold to detect passive motion (a joint kinesthesia test) [28] may better reflect the changes in joint proprioception associated with VT training.

Another unexpected finding of this study was that the peak force of upper-limb muscles did not improve with VT training. This finding is somewhat in contrast to our previous study's finding that just 4 weeks of VT training could improve elbow extensor peak force in middle-aged and older adults [13]. The discrepancy in findings can be explained by the different VT training methods adopted in the different studies. In our earlier study, we focused on punching techniques such as striking a focus mitt and the training frequency was 7 days per week (the participants attended VT training sessions twice per week and practiced VT daily at home). The present study emphasized sticking-hand drills and the training frequency was reduced to twice per week (1 hour each time). We postulate that the inadequate training volume and lack of a functional-neuromuscular strength training component in the protocol of the present study was the main contributor to the negative findings in the upper-limb peak muscle force outcomes. Future studies could incorporate functional muscle strengthening exercises into the VT sticking-hand drills and increase the training frequency to 7 days per week.

Although the peak force of upper-limb muscles did not improve with VT training, the time required to reach peak force in shoulder flexors was decreased only in the VT group at the end of the study. In addition, the time required to reach peak force in shoulder abductors, internal and external rotators, and elbow extensors had decreased in both groups post-test. These findings also differ from those of our previous study, which found that short-term VT training could reduce the time required to reach peak force in elbow extensors but not in shoulder flexors [13]. Again, the major reason for the discrepancies in the results was the different VT training protocols adopted in the different studies. According to the principle of specificity in exercise training [29], our results suggest that VT sticking-hand drills can improve the time the shoulder flexors take to reach peak force in middle-aged and older adults. Such improvement may be related to better neuromuscular coordination in the shoulder flexors (the prime mover) associated with repeated VT sticking-hand practice [30]. To test this hypothesis, electromyography could be used to assess the timing of muscle contraction in the upper limbs during VT sticking-hand exercises [31]. The decrease in time required to reach peak force in shoulder abductors, internal and external rotators, and elbow extensors may have been due to a testing effect: the pre-test may have sensitized the participants in unanticipated ways, leading to improved post-test performance [32]. Thus, the internal validity of the study may have been compromised by this effect.

This study had several other limitations in addition to those mentioned above and the findings should be interpreted with caution. First, static isometric muscle strength was measured, which may not reflect the muscle strength gained through dynamic sticking-hand training. A further study should measure upper-limb muscle strength dynamically (for example, by using an isokinetic machine). Second, due to the nature of the intervention, the participants were not blinded to group assignment and this may have introduced some biases. Third, the findings of this experimental study may not be generalizable to daily life, and better shoulder flexor performance does not necessarily mean better upper-limb function in daily activities. Finally, we were too optimistic when estimating sample size (a large effect size of 1.35 was assumed) that resulted in a rather small sample. With such a small sample and the use of intention-to-treat method to handle the missing data due to attrition, it is plausible that the training effects of VT were underestimated. Further study should, therefore, increase the sample size to explore the potential benefits of VT training on upper-limb sensorimotor performance in community-dwelling middle-aged and older adults.

5. Conclusions

Three months of VT Chinese martial art sticking-hand training did not improve elbow-joint position sense or the maximum strength of upper-limb muscles in community-dwelling middle-aged and older adults. However, VT sticking-hand training did improve shoulder flexors' time to peak force. A testing effect may have masked the effect of VT on time required to reach peak force in shoulder abductors, internal and external rotators, and elbow extensors.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgments

The authors thank Master Po Tim Leung and Master Kam Yuen Lee for teaching and demonstrating Ving Tsun Chinese martial art. This work was partially supported by the Hong Kong College of Community Medicine (TY Chau Training and Research Scholarship 2017).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnss.2019.11.001.

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