THE EFFECT OF TAI CHI TRAINING ON ANKLE PROPRIOCEPTION IN PARTICIPANTS WITH CHRONIC ANKLE INSTABILITY

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Abstract: Objective: To determine the effect of Tai Chi training on ankle proprioception in participants with Chronic Ankle Instability (CAI). Design: Randomized controlled trial. Method: Forty participants with CAI were randomly divided into a Tai Chi group and a control group, with 20 participants in each group. The Tai Chi group underwent 24-styled simplified Tai Chi rehabilitation training 3 times a week for 8 weeks, while the Control group did not undergo any rehabilitation training. The angular displacement of ankle proprioception (kinesthesia) was collected from both groups before and after rehabilitation training for data analysis. Result: After 8 weeks of training, participants in the Tai Chi group showed significant improvement in ankle proprioception (p<0.05). Conclusion: 8 weeks of Tai Chi training can significantly improve ankle proprioception in patients with CAI, therefore, Tai Chi can be an effective training method for the rehabilitation of CAI patients.

KEYWORDS: Tai Chi, chronic ankle instability, proprioception, rehabilitation

INTRODUCTION: Lateral ankle sprain (LAS) is a common sports injury and the most common joint sprain in the human body (Fong et al., 2007), accounting for about 10% to 30% of all sports injuries (Kobayashi & Gamada, 2014). In the UK, there are more than 5,600 patients with ankle sprains per day (Cooke et al., 2009), or about 1 to 1.5 million cases per year, accounting for 3% to 5% of all emergency cases (Pijnenburg et al., 2000).

Due to the lack of effective treatment, about 10%-30% of patients with acute injury will eventually develop chronic ankle instability (CAI) (McCriskin, 2015). CAI refers to the presence of common symptoms such as pain, instability, and weight-bearing in the patient's ankle joint, which will present with a subjective feeling of the ankle "giving way" (Gribble et al., 2016).

CAI is mainly caused by mechanical ankle instability (MAI) and functional ankle instability (FAI). The main cause of MAI is ligamentous laxity, while the main causes of FAI are reduced postural control, neuromuscular deficits, proprioceptive deficits and reduced muscle strength (Hertel, 2002). It is generally accepted that although FAI and MAI may exist as separate entities, CAI usually occurs due to a combination of both (Denegar & Miller, 2002; Hertel, 2002). There is no expert consensus on a rehabilitation programme for individuals with CAI, so the focus is on improving the common symptoms of CAI mentioned above.

Tai Chi is based on continuous body rotations and weight shifts in training, requiring the trainer to move slowly and with a constant shift of weight. Throughout the process, the trainer's body weight needs to always remain stable, thus providing a significant effect on lower limb muscle strength and postural stability. As the ankle joint moves, the body posture changes and the centre of gravity shifts, the proprioception of the ankle joint is also well enhanced. It has been demonstrated that Tai Chi has a good improvement in balance control for CAI patients and can be a potential means of rehabilitation for CAI (Cruz-Díaz et al., 2020). However, the effect of Tai Chi on ankle proprioception in CAI patients has not been studied. Therefore, the study will use Tai Chi as an intervention to observe its effect on ankle proprioception in CAI patients and provide evidence to support its use as an effective means of rehabilitation for CAI patients.

METHODS:

Participants: A total of 40 (Tai Chi group: age: 22.0 ± 1.1 years; height: 172.8 ± 6.7 cm; weight: 69.3 ± 11.9 kg, mean ± SD. Control group: age:21.5 ± 1.4 years; height: 171.4 ± 7.5 cm; weight: 67.7 ± 14.3 kg, mean ± SD) participants with CAI were recruited, all from the Shandong University of Construction, with 20 in each group. The basic conditions of the participants in the two groups were not significantly different ($p > 0.05$). The inclusion criteria were as follows: (1) At least one significant ankle sprain and the initial sprain must occur within one year of this study enrolment; (2) Cumberland Ankle Instability Tool (CAIT): < 24. Injured ankles have "giving way" and/or recurrent sprain and/or "feelings of instability."; (3) Between the ages of 18 and 35. The exclusion criteria were as follows: (1) Previous surgery on musculoskeletal structures (e.g., bones, joint structures, nerves) in any limb of the lower limb; (2) In the past three months, acute injury of the musculoskeletal structure of other joints of lower limbs affected the integrity and function of joints (i.e. sprain and fracture), resulting in the interruption of expected physical activity for at least one day; (3) Bilateral ankle instability; (4) Under 18 and over 35 years of age.

Intervention: For the Tai Chi group, each subject was trained three times a week for 8 weeks using simplified 24-style Tai Chi, all under supervision. The training is guided by a professional Tai Chi coach. For the control group, no training was performed.

Testing Procedures: A laboratory test was performed before and after the interventions to evaluate each participant's ankle proprioception using a proprioception test device, which showed good test-retest reliability (ICC = 0.74 – 0.94) (Sun et al., 2015). The participant was seated on an adjustable height chair with one foot placed on the platform of the ankle proprioception measurement device and the tested ankle in a neutral position. The knee and hip joints were flexed at 90°, and the angle between the shank and the surface of the platform was 100° when the platform was in a start position (10° of plantar flexion). The participants wore eye masks to eliminate visual and auditory input. The platform moved at an angular velocity of 0.4°/s. The participants were asked to concentrate on their foot and press the hand switch to stop the movement of the platform as soon as they could sense the motion of the foot. The angular displacement from the start position to the stop position of the platform was recorded. The device is programmed to rotate the ankle in the direction of dorsiflexion, plantar flexion, inversion and eversion in a random order a total of 10° of angular displacement in each direction. The time interval between two different rotations randomly ranges from 2 to10 seconds after an indication to start a trial. Each participant had 2 practice trials to become familiar with the test. Each participant had at least 5 trials on the involved ankle for each direction in order to reduce random measurement error. The minimal three angular displacements for dorsiflexion, plantarflexion, inversion and eversion were recorded for the involved ankle for data analysis.

Data Reduction: For each participant, the average value of angular displacement of the 3 successful trials of dorsiflexion, plantar flexion, inversion and eversion were calculated. The average values of angular displacement for the involved ankle were calculated and used for data analysis.

Statistical Analysis: The experimental data were processed using Excel and SPSS 27.0 statistical software. The results were expressed as Mean ± SD. The data were not tested for normal distribution before processing, and therefore a Mann-Whitney U test was utilised to compare between groups according to the significant difference. Comparisons within groups before and after training were made employing Wilcoxon signed-rank test. $P<0.05$ for significant differences and $P<0.01$ for highly significant differences.

RESULTS: There was no significant difference in proprioception between the two groups of subjects in the same period of group comparison ($P > 0.05$). After the training intervention, the

means of four indicators of ankle proprioception, namely inversion, eversion, plantarflexion and dorsiflexion, were smaller in the Tai Chi group than before the training, and the differences were highly significant ($P < 0.01$, Table 1), whereas there was no significant difference in the control group before and after the training ($P > 0.05$, Table 1).

Table 1: Comparison of Ankle Proprioception of participants before and after Intervention (TC = Tai Chi group; CON = Control group)

	Group	Timeline		*P* Value (95% confidence interval)
		Baseline (°) (Mean ± SD)	**Post-Intervention (°)** (Mean ± SD)	
Inversion	Tai	4.66 ± 2.60	2.72 ± 2.01	＜0.001
	CON	4.56 ± 2.42	4.58 ± 2.39	0.407
Eversion	TC	4.97 ± 3.32	2.79 ± 1.76	＜0.001
	CON	2.32 ± 4.58	2.28 ± 3.46	0.531
plantarflexion	TC	2.07 ± 2.58	1.33 ± 1.22	＜0.001
	CON	0.85 ± 1.79	0.82 ± 1.49	0.729
dorsiflexion	TC	2.48 ± 2.24	1.93 ± 2.72	0.002
	CON	1.79 ± 2.30	1.78 ± 2.04	0.887

DISCUSSION: Proprioception is a special form of sensation that differs from superficial and deep sensations. Depending on the type of proprioceptor, proprioception in joints can be subdivided into joint position sensation and joint kinesthesia. Proprioception plays a very important role in precise motor procedures. After the formation of proprioceptive afferent information, the central nervous system is involved in controlling the formation of muscle reflexes that provide kinetic support for maintaining joint stability and are particularly important in the functional recovery of the ankle joint and in the prognosis of injury (Jinghua Qian, 2011). Functional instability of the joint due to reduced proprioceptive feedback can further lead to re-injury of the delicate tissues within the joint, creating a vicious cycle of repeated injury, and therefore measurement and evaluation of proprioception are particularly important in chronic ankle instability.

As shown in Table 1, 8 weeks of Tai Chi training was able to improve ankle proprioception in patients with CAI. The reason for this may be that regular tai chi exercise strengthens the subject's lower limb muscle strength, coordination, muscle control and corresponding proprioception. On the other hand, during the practice of tai chi, the participants had to shift their centre of gravity (one foot - both feet) and during this form of weight-bearing, the proprioceptors in the tissues around the ankle joint were constantly stimulated and the stimulation was transmitted to the higher centres through the receptors, which could be another reason for the improvement of proprioception during tai chi practice. A study by JiajiaYe et al. (Jiajia Ye & Lisong Wang, 2017) where 25 elderly patients with knee osteoarthritis were given 12 weeks of regular tai chi exercise, concluded that regular tai chi practise improved proprioception and balance in the lower limbs of elderly patients with knee osteoarthritis which is consistent with the results of this study. It was also found that those who performed regular tai chi exercises for more than one and a half hours per day had significantly better proprioception in the knee and ankle joints than those who performed different sports and the same exercise intensity such as running and swimming (Qu Bing & Jiejiao Zheng, 2017). Tai Chi exercises show many proprioceptive training techniques, such as weight-bearing, position-holding, joint compression and tension. During exercise, the various proprioceptors in the ankle joint are constantly stimulated and the synapses of the spinal ganglion cells located therein can rapidly transmit information such as joint position and movement to the higher central nervous system, improving the responsiveness of the neuromuscular system. Frequent stimulation of joint proprioceptors during long-term tai chi training can facilitate and consolidate the process of proprioceptive transmission, creating a follow-up effect, which is one of the reasons why tai chi training improves the proprioception of the ankle joint.

There were some limitations in this study. Firstly, no single form of Tai Chi was proved to be effective for ankle function. Therefore, simplifying Tai Chi movements according to the characteristics of CAI for future interventions could be further investigated. Secondly, there were no other rehabilitation training groups in this study, so the comparative rehabilitation effect of Tai Chi and other rehabilitation methods on the proprioception of CAI patients is unknown.

CONCLUSION: 8 weeks of Tai Chi training can significantly improve ankle proprioception in patients with CAI, therefore, Tai Chi can be an effective training method for the rehabilitation of CAI patients.

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