CONTROL OF CENTER OF PRESSURE DURING TAI CHI MOVEMENT

Ge Wu, Juvena Hitt
Department of Physical Therapy, University of Vermont, Burlington, VT, 05401, email: ge.wu@uvm.edu

INTRODUCTION

Tai Chi Chuan (TCC) is shown to be an effective form of balance exercise for elders [1]. However, its mechanisms in improving balance are not yet clearly understood. The purpose of this study was to examine the control of body center of pressure (COP) during single stance of the TCC movements.

METHODS

A total of ten young subjects (age 27±4 years) participated in this study. All subjects had practiced TCC daily for at least two weeks before testing, and signed an Informed Consent Form approved by the University of Vermont Institutional Review Board.

The kinematics of the trunk and limbs were measured using a marker-based Motion Analysis System (BTS). Surface electromyography (EMG) was recorded from tibialis anterior (TA), soleus (SOL), peronaeus longus (PL), rectus femoris (RF), semitendinosus (ST), and tensor fasciae latae (TFL) muscles. The ground contact characteristics were recorded by two force plates (AMTI) and one pressure plate (Tekscan).

Subjects were asked to perform, five times, with bare feet, one basic Yang-style TCC movement, parting the wild horse mane, over a walkway covered by the force and pressure plates. The distances between these plates were adjusted so that subjects could land with the left foot first on the force plate, followed by the right foot on the pressure plate, and the consecutive left foot on the second force plate. The signals from the force and pressure plates, the Motion Analysis System, and the integrated EMG were collected at 50Hz, 15 seconds each trial.

The single stance time was determined based on the force and pressure plate measurement. Following parameters were computed over the single stance phase: spatial position and angular motion of the ankle, knee, hip and shoulder joints, the RMS value of EMG signals of both stance and swing legs, and the foot COP displacement in the medial-lateral and anterior-posterior directions, normalized by foot width (FW) and foot length (FL), respectively.

The mean and standard deviation of each variable, as well as the temporal features of both SW and TCG were calculated for each subject and compared using two-tailed t-test. They were considered statistically different when the p value was less than 0.05.

RESULTS

The foot COP maintained fairly stationary and centered mainly in the center of the foot (Fig. 1). The maximum range of motion was 14±6%FW and 7±2%FL, as compared to 64±8%FW and 72±7%FL over the complete TCC movement. The stance leg remained fairly stationary, while the swing leg went through a large amount of hip adduction and flexion (Table 1), and the shoulder had a large range of displacement (~25cm) in the transverse plane. All six muscles in the stance leg were activated at or above 20%MVC, and remained active for more than 50% of the single stance time (Table 2).

DISCUSSION AND CONCLUSION

These results suggest that TCC movement involves the precise control of body COP. The fact that the foot COP is centered in the midfoot region with minimal movement during single stance is by no means a coincidence. Earlier studies have shown that during quiet, upright stance, body weight is located more towards the heel region, resulting in more planter pressure in the rearfoot than in the forefoot region [2,3]. Moreover, the large amount of leg and trunk movement during single stance tends to shift the body center of mass. Thus, maintaining foot COP in the midfoot region requires a conscious and precise control of the neuromuscular system. It is perhaps the practice of this precise control of the neuromuscular system that helps improve the stability of upright stance.

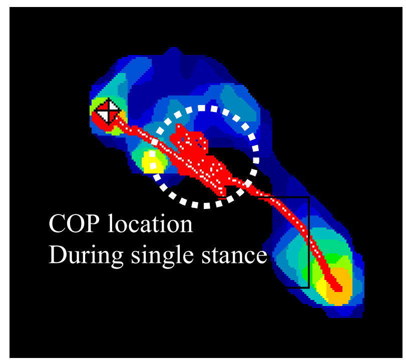

Fig 1. Illustration of foot COP location during single stance.

Table 1. Means and stds of joint ROM (deg)

Joints	Stance leg	Swing leg
Ankle flexion/extension	6±3	14±10
Knee flexion/extension	8±8	74±6
Ankle inversion/eversion	2±5	4±9
Hip flexion/extension	7±3	48±6
Hip abduction/adduction	6±8	20±9

Table 2. Means and stds of stance leg muscle EMG features

Muscles	RMS (%MVC)	On time (% single stance)
TA	38±11	91±19
PL	33±10	80±24
SOL	20±9	57±31
RF	39±15	77±37
TFL	42±16	87±27
ST	21±12	59±38

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