



Original Article

## Correlation between center of pressure and functional balance in non-faller elderly practitioners of Tai Chi Chuan

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**Abstract.** [Purpose] This study aimed to determine the correlation between center of pressure and functional balance in non-faller elderly practitioners of Tai Chi. [Subjects and Methods] For the study, nine non-faller elderly practitioners of Tai Chi who were able to maintain a standing posture and walk independently were recruited. Timed one-leg standing and timed up-and-go tests were used as functional balance tests and force platform to measure the center of pressure. The Pearson correlation coefficient was calculated for the timed up-and-go/timed one-leg standing test scores and center of pressure parameter values. [Results] None of the correlations was statistically significant, but moderate correlations were observed between the pairs timed one-leg standing/sway area of center of pressure, timed one-leg standing/standard deviation of center of pressure in the mediolateral direction, timed one-leg standing/mean velocity of center of pressure in the anteroposterior direction, and timed up-and-go test sway area of center of pressure. [Conclusion] Timed one-leg standing is more appropriate than timed up-and-go test for the measurement of functional balance in non-faller elderly practitioners of Tai Chi.

**Key words:** Functional assessment, Older adults, Center of pressure

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### INTRODUCTION

Postural instability is a major risk factor of falling in the elderly. In this context, balance disorders observed during aging have a significant impact on the functional independence and quality of life of aged adults<sup>1, 2</sup>. For physical therapists, it is relevant to maintain or improve motor function as long as possible. Several interventions have been proposed to achieve this aim, one of them being Tai Chi, which has shown a positive impact on the balance of the elderly population<sup>3</sup>, although a greater proportion of practitioners do it for recreational purposes.

Motor function may be assessed by using different strategies, including clinical and instrumental assessments. Among the clinical functional tests are the timed one-leg standing (TOLS)<sup>4</sup> and timed up-and-go (TUG) tests<sup>5</sup>. The TOLS test is a functional test that evaluates static stability<sup>4</sup>. It is considered potentially useful for predicting functional decline and is shown to be sensitive to clinical intervention changes. The TUG test assesses gait-related activities that involve dynamic stability<sup>5</sup>. It involves rising from a chair, walking 3 m, turning, walking back, and sitting down again. The task thus corresponds to activities regularly encountered in daily life. Both tests involve time as a measurement parameter; however, the time taken may not be a relevant criterion for the accurate assessment of static or dynamic stability<sup>6</sup>. Furthermore, as balance control declines gradually with aging<sup>7</sup>, current clinical tools are not sensitive enough to detect early stage impairments in the elderly<sup>8</sup>.

Other instrumented measurements are costlier and difficult to acquire by clinical centers; however, they provide greater accuracy of measurements of postural parameters that may affect dynamic or static stability. Postural control is usually

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assessed by the interpretation of parameters derived from the center of pressure (COP), such as velocity and area of COP displacement ( $COP_{Sway}$ )<sup>9</sup>). The velocity of the COP describes the neuromuscular response to shifts in the body's center of mass and serves as an indicator of stability. The mean velocity of the COP has high reliability (intraclass correlation coefficient >0.8) as a measurement parameter during standing balance and is sensitive to changes in age-related postural impairment<sup>10</sup>. However, significant increases in other COP parameter values in the elderly are recognized as signs of postural impairment. In this sense, the mediolateral and anteroposterior components also show changes related to the impairment of postural control in the elderly<sup>7</sup>.

Both tests are interesting in their predictive capacity for the general function and stability of the elderly, and are widely used by clinicians to detect a possible risk of falls in this age group<sup>4-6,8</sup>). However, knowledge is lacking about the correlation between these clinical tests and instrumented measurements (COP parameters) in elderly practitioners of Tai Chi, which could change how the functional balance of this group is assessed. Thus, the aim of this study was to determine the correlation between COP and functional balance in non-faller elderly practitioners of Tai Chi Chuan (NFEPTC).

## SUBJECTS AND METHODS

Nine NFEPTC who could maintain a standing posture and walk independently were recruited for this study. The study sample was obtained from the Tai Chi Chuan Centre for Older Adults. Elderly practitioners with a Mini Mental State Examination score of <17 points were excluded. This research was approved by the ethical committee of the Universidad de Talca, Chile (2014-VG), in accordance with the ethical standards of the Declaration of Helsinki. All participants were informed of the experimental procedures and signed an informed consent form prior to the experiment.

All the participants practiced Tai Chi Chuan for >4 years at a frequency of 3 times per week for at least 60 minutes each time. The sessions were provided by a trainer certified to conduct trainings in Tai Chi Chuan. The characteristics of all the participants were recorded, including age, gender, weight, height, and body mass index.

The TOLS and TUG<sup>4,5</sup> tests were conducted the clinical tests, and the standing balance test on a force plate was conducted as the laboratory test. In the TOLS test, the time (in seconds) for which the patient was able to maintain a standing position on the dominant foot was considered in order to assess the static balance of the subject<sup>4</sup>). The TUG test measured the time (in seconds) it takes for a person to make a route (3 m) that goes from the sitting position to standing and sitting again<sup>5</sup>).

Laboratory measurements (COP parameters) were obtained with a force plate (AMTI OR67, Advanced Mechanical Technologies Inc., Boston, MA, USA). The COP parameters were as follows:  $COP_{Sway}$ , standard deviation of the COP in the mediolateral ( $SD_{ML}$ ) and anteroposterior ( $SD_{AP}$ ) directions, and mean velocity of the COP in both directions ( $V_{ML}$  and  $V_{AP}$ ). The AMTI NetForce (Advanced Mechanical Technologies Inc., Boston, MA, USA) software was used for the acquisition.

Low-pass and second-order Butterworth filters were used with a cutoff frequency of 40 Hz, and COP displacements were recorded at a sampling rate of 200 Hz during the "open eyes" (OE) condition. In the OE condition, the subject stared at a target on a wall located 1.5 m away. This condition was repeated three times for each participant and averaged for analysis. MATLAB R2012 (MathWorks Inc., Natick, MA, USA) was used for data processing. In all the tests, a physical therapist ensured the patient's safety.

Means and standard deviations were obtained for the demographic and anthropometric characteristics. Pearson correlation coefficients were calculated to estimate the correlation between the clinical test scores (TOLS and TUG) and the COP parameter values. IBM-SPSS 20.00 was used (SPSS Inc., IL, USA), and the level of significance was set at  $p < 0.05$ .

## RESULTS

The characteristics of the nine participants expressed in means and standard deviations were as follows: age,  $70.88 \pm 5.62$  years; weight,  $72.34 \pm 9.71$  kg; height,  $1.55 \pm 0.07$  m; and body mass index,  $30.01 \pm 2.52$  kg/m<sup>2</sup>.

The Pearson correlation coefficients between the clinical test scores (TUG and TOLS) and the COP parameter values are shown in Table 1. None of the correlations was statistically significant ( $p > 0.05$ ), but moderate correlations ( $r < -0.3$ ) were observed between the pairs TOLS/ $COP_{Sway}$ , TOLS/ $SD_{ML}$ , TOLS/ $V_{AP}$ , and TUG/ $COP_{Sway}$ .

## DISCUSSION

The COP parameter values were less correlated with the TUG test scores compared with the TOLS test scores. This could be explained by the relative complexity of the motor sequence involved in the TUG test, during which participants have to understand the correct flow of actions<sup>11</sup>) with respect to the TOLS test. This is an important fact because a recent systematic review revealed that the TUG test is widely used (over the TOLS test) in the assessment of Tai Chi Chuan practitioners' functional balance<sup>12</sup>). Similar to those of other research studies<sup>13</sup>), the present findings suggest that the TUG test is not adequate to measure balance, considering the low correlations with the COP parameter values, except for  $COP_{Sway}$ .

Research has shown that the displacement of the COP in the mediolateral and anteroposterior directions is sensitive to changes in age in the elderly<sup>14,15</sup>). In line with this, the TOLS test scores showed moderate correlations with the  $SD_{ML}$  and  $V_{AP}$  values; therefore, the TOLS test is more suitable than the TUG test for measuring functional balance.

In contrast, previous research has shown greater correlations between TOLS test scores and COP parameter values<sup>16</sup>), but

**Table 1.** Pearson correlation coefficients between the clinical test scores and the COP parameter values

COP parameter	TUG (p value)	TOLS (p value)
COP <sub>Sway</sub>	0.353 (0.218)	-0.530 (0.110)
SD <sub>ML</sub>	0.296 (0.260)	-0.477 (0.140)
SD <sub>AP</sub>	0.080 (0.432)	-0.202 (0.332)
V <sub>AP</sub>	-0.226 (0.313)	-0.146 (0.337)
V <sub>ML</sub>	0.189 (0.342)	-0.415 (0.177)

COP: center of pressure; COP<sub>Sway</sub>: area of COP sway in cm<sup>2</sup>; SD<sub>ML</sub> and SD<sub>AP</sub>: standard deviation of COP in the mediolateral and anteroposterior directions, both in cm; V<sub>ML</sub> and V<sub>AP</sub>: COP velocity in the mediolateral and anteroposterior directions, both in cm/sec

that research included elderly subjects who were nonpractitioners of Tai Chi. This fact suggests that the TOLS test is less adequate in measuring functional balance in NFEPTC than in nonpractitioners of Tai Chi. However, the fact that the TUG and TOLS tests could not be applied specifically for the elderly population should be considered, as the gait speed test (GST)<sup>13</sup>. Therefore, further research is necessary in order to assess balance with tests such as the GST.

The limited sample size in the present study has to be considered. Despite the moderate correlations found in this study, none of these correlations was statistically significant. Certainly, the main reason for this was the small sample size. In fact, the correlations have to be >0.8 in order to achieve statistical significance. Therefore, a key recommendation for future studies is to increase the sample size. Another limitation is the heterogeneity of the sample, especially in terms of age. This could act as an effect modifier variable, considering that correlations would differ between subjects aged 60 and 80 years.

Despite these limitations, the present data offer insights for future clinical assessment of elderly practitioners of Tai Chi Chuan. These findings routed further research, which would be interesting if a control group (i.e., healthy elderly nonpractitioners of Tai Chi) were incorporated for comparison between the clinical tests and the laboratory measurements (force platform). In summary, the clinical assessment of functional balance showed moderate and low correlations with the COP parameters in the NFEPTC. Therefore, the TOLS test is more appropriate than the TUG test for measuring balance in this population.

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