# Test-retest of the Developed Evaluation and Training System for Postural Control

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Key words :Test-retest, Postural control, Training, Evaluation

## 1. INTRODUCTION

Human standing posture is a continuous process of posture control with an objective of maintaining stable center of pressure (COP) on the floor. Adequate postural control depends on the spatial and temporal integration of vestibular, visual, and somatosensory information about the motion of the head and the body along with adequate response of related muscles with enough strength. The increased incidences of falls in the older generation suggest that one or more of these components degenerate with age. Diminished visual, vestibular, and somatosensory function and slowed down sensorimotor processing along with degrading muscle strength would all occur with normal aging process [1, 2]. Therefore, constant stimulation of related senses and muscles can possibly strengthen or at least maintain the capability of those senses and functions. In this regard, the training of postural control can help prevent the elderly from falls and reduce the likelihood.

Past studies have reported that postural control is affected by visual stimulation and it is well known that the position of the center-of-gravity (COG) as well as the geometrical configuration of body segments is accurately controlled relative to the feet and to the direction of gravity [3-5]. In our recent studies, postural sway has been measured using an unstable platform, which is a common tool used in Physical Therapy practice, as an index of stability. As a next step, we have developed an effective balance training system and methods that can provide training in all possible directions of sway and provide various schemes to stimulate all related muscles for improving the ability of postural control. In developing the new training system, we have tried to overcome the limitations of the conventional system for postural control, which can easily be monotonous to patients by not providing any visual interactions or providing only limited stimuli [6-8]. Moreover, the conventional system only uses training in just one or two limited directions or limited schemes.

We developed a new evaluation and training system for postural control using an unstable platform. This system can provide combinative stimuli to the visual, vestibular, and somatosensory organ for balance rehabilitation via trainings in various directions and in diverse schemes. To quantify the reliability of the unstable platform, the test-retest experiments were done.

## 2. SYSTEM CONFIGURATION

The hardware part of the system as shown in Fig. 1 consists of an unstable platform, a visual interface, a computer, and a safety frame and harness. The software part consists of an option module, a training module, an evaluation module, and an analysis module. The software provides real time location of the center of pressure (COP) on the platform to the patients along with directed locations and movement directions of the COP through visual interface. The patients are instructed to move his or her COP so that the COP can follow a directed movement path. The shape of directed movement path of COP is devised in a way so that various muscles required for maintaining stable standing posture can be evenly stimulated and activated. Relatively complicated shapes for COP movement are used for evaluation scheme and simple and repeated shapes are used for training scheme. The simultaneous excitation of visual, somatic, and vestibular organs improve the efficiency of postural control training. The combined system is expected to effectively provide visual, vestibular, and somatosensory stimuli to the trainees increasing the efficiency of postural control training.

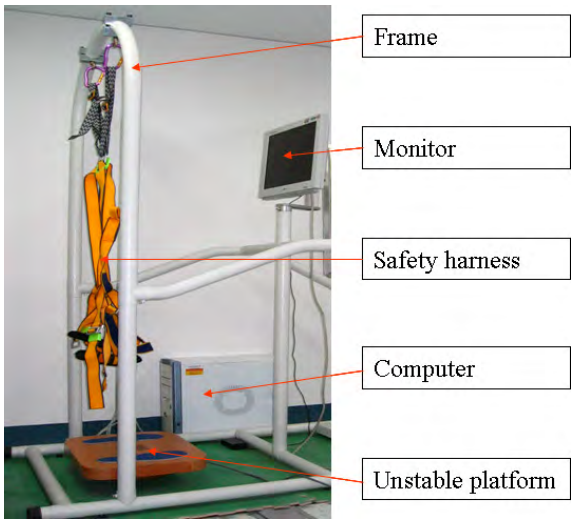


Fig. 1 Evaluation and training system for postural control

## 3. EXPRIMENTAL METHOD

Eight normal subjects who volunteered for the experiment were examined. The age of the subjects ranged from 23 to 28. Before the start of the examination, the subjects were all informed of the details of the experiment and all signed consent forms which were approved by a local ethical committee in the university.

We evaluated the ability of postural control of the subjects using the developed software with the unstable platform. The first evaluations of equilibrium sense were done before the beginning. After four days, the second evaluation was done. After four days, the third evaluation was done. After four days, the fourth evaluation was done. To quantify the reliability of the unstable platform, the same evaluation programs were used. All of the evaluations were repeated twice. We investigated the parameters the mean absolute deviation of different trace modes of the 4 times evaluation. The trace modes include COP movement in anterior-posterior direction, COP movement in lateral-medial direction, COP movement in 45° direction and COP movement in -45° direction. Through the comparison of the parameters of the 4 times evaluation, we were able to quantify the reliability of the unstable platform.

## 4. RESULTS AND DISCUSSIONS

We performed the experiments on quantifying the reliability of the unstable platform. Through the comparison of the parameters obtained from the 4 times evaluation, the reliability of the unstable

platform was assessed. The experimental data was analyzed using one sample T-test analysis and one way ANOVA analysis in SPSS 12.0. The followings are the findings from our experimental results.

**4.1 Results of the one sample T-test analysis**

To quantify the reliability of the unstable platform, we investigated the consistency of the 4 times evaluation of the different trace mode using one sample t-test analysis method. The analysis results showed that the experimental results of the 4 times evaluation are consistent ($p<0.01$). Table 1 and 2 showed the sample analysis results of the one sample T-test. For all of the subjects, the experimental results showed that the consistency is very good. The experimental results assessed the reliability of the unstable platform.

Table 1 One sample T-test of subject 3

| Trace mode | Test Value = 0 | | |
|---|---|---|---|
| | t | df | Sig. (2-tailed) |
| COP movement in lateral-medial direction trace mode | 17.559 | 7 | 0.000000478 |
| COP movement in anterior-posterior direction trace mode | 12.708 | 7 | 0.000004323 |
| COP movement in 45° degrees direction trace mode | 16.456 | 7 | 0.000000746 |
| COP movement in -45° degrees direction trace mode | 10.152 | 7 | 0.000019366 |

Table 1 One sample T-test of subject 6

| Trace mode | Test Value = 0 | | |
|---|---|---|---|
| | t | df | Sig. (2-tailed) |
| COP movement in lateral-medial direction trace mode | 15.726 | 7 | 0.000001017 |
| COP movement in anterior-posterior direction trace mode | 20.939 | 7 | 0.000000142 |
| COP movement in 45° degrees direction trace mode | 14.468 | 7 | 0.000001796 |
| COP movement in -45° degrees direction trace mode | 21.076 | 7 | 0.000000136 |

**4.2 Results of the one way ANOVA analysis**

To quantify the reliability of the unstable platform, we investigated the difference of the 4 times evaluation of the different trace mode using one way ANOVA analysis method. The analysis results showed that the experimental results of the 4 times evaluations do not have obvious difference ($p>0.05$). Table 3 and 4 shows the sample analysis results of the one way ANOVA. For all of the subjects and trace mode, the analysis results showed that there is no obvious difference in the 4 times evaluation. The experimental results also assessed the reliability of the unstable platform.

Table 3 One way ANOVA analysis of subject 1

| Trace mode | Mean Square | F | Sig. |
|---|---|---|---|
| COP movement in lateral-medial direction trace mode | 0.03825 | 0.418 | 0.542 |
| COP movement in anterior-posterior direction trace mode | 0.01298 | 0.094 | 0.770 |
| COP movement in 45° degrees direction trace mode | 0.07383 | 0.968 | 0.363 |
| COP movement in -45° degrees direction trace mode | 0.05917 | 0.325 | 0.589 |

Table 3 One way ANOVA analysis of subject 8

| Trace mode | Mean Square | F | Sig. |
|---|---|---|---|
| COP movement in lateral-medial direction trace mode | 0.004449 | 0.927 | 0.373 |
| COP movement in anterior-posterior direction trace mode | 0.002056 | 0.675 | 0.443 |
| COP movement in 45° degrees direction trace mode | 0.000142 | 0.041 | 0.846 |
| COP movement in -45° degrees direction trace mode | 0.000003 | 0.000 | 0.985 |

## 5. CONCLUSIONS

The experimental data was analyzed using one sample T-test analysis and one way ANOVA analysis. The results showed that this system has the high reliability for the training and evaluation for postural control.

## ACKNOWLEDGEMENTS

This research was supported by the Korean Ministry of Commerce, Industry and Energy through development of the core technology of medical devices for elderly.

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