# THE RELATIONSHIP BETWEEN POSTURE STABILITY AND ONE-HAND CATCHING

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The purpose of this study was to examine the influence of posture stability on one-hand catching in skilled adults. Ten female PE major college students participated in the experiment. They practiced the stabilometer task 20 trials a day, 3 days a week for 2 weeks. The balancing time, number of balls caught, as well as the movement kinematics of the pre and post-test data were analyzed. The results show that the time of balance improved through practice, the frequency and the amplitude of the platform changed after practice. The number of balls caught was only perturbed by the stabilometer before practice. Principle component analysis (PCA) on the kinematic data show that the number of components did not decrease after practice, but the content of each component changed through practice. We conclude that postural stability only influences the well-retained motor skills at the beginning of practice; it is the performance of the newly learned skill that suffers from perturbations.

**KEY WORDS:** posture stability, catching, component analysis.

**INTRODUCTION:** Interceptive actions need not only perceive relevant information from the environment, but also control the relevant motor degrees of freedom so that the performer can put her hand at the right place at the right time (Davids, 2005). To attain this purpose, a performer has to maintain her stability of upright posture and adequate body orientation (Peper, Bootma, Merstre, & Bakker, 1994; Davids, 2000; Riccio, 1993). In other words, it requires keeping body balance to successfully complete interceptive actions such as catching balls. Davids and colleagues (2000,2005) studied one-hand catching in children aged nine to ten years; they found posture stability is a key constraint and the performance is markedly affected by the hand they used and also depended on the skill level. Normal adults were able to control their posture stability relatively well, and there is clear evidence of equal performance between right and left hand while performing a variety of novel manual tasks (Bryden, Singh, Steenhuis, & Clarkson, 1994; Harris & Carlson, 1993; Steenhuis & Bryden, 1999; Verfaellie & Heilman, 1990). However, few studies have examined the performance of more complex motor skills that require the precise spatiotemporal control such as one-hand catching. The purpose of this study was to investigate the relationship between postural stability and one-hand catching performance in skilled adults.

## METHOD:

**Data Collection:** Nine right-handed and one left-handed female college students who majored in physical education and had no prior experience in standing on the stabilometer volunteered to participate in this experiment. The time of balance between +5° to -5° degrees of the stabilometer was recorded during the 30-second trial. In the beginning of the experiment, the participants were asked to catch 20 tennis balls in 30 sec with their preferred and non-preferred hand (CP, CN) while standing on the ground (C), the ball was thrown to the participant at about 1 m/s horizontal velocity and from a distance of 5 m in front of the participant. This was used as a baseline of their catching performance. Six 30-second trials were examined for both pre-test (1) and post-test (2) which included 2 trials of standing on the stabilometer only (S) and 4 trials of one-hand catching (preferred, non-preferred hand) while standing on the stabilometer (CPS, CNS). The sequence of catching was counter balanced for hand, thus there were 6 participants starting with their preferred hand and others starting with their non-preferred hand. Post-test was conducted one or two days after the end of practice session; performers had to practice standing on stabilometer 20 trials a day, 3 days a week for two weeks, with each trial lasted for 30sec. The balancing movement were captured by PhaseSpace Motion Digitize System with 60fps. Fourteen active LEDs were attached to the performers' joints (right and left finger, wrist, elbow, shoulder, ankle, knee and hip) and 4 LEDs were on the stabilometer.

**Data Analysis:** The 3-D data from PhaseSpace System were processed with Excel 2000 and Mathematica 5.1 to derive 12 joint angles (right and left wrist, elbow, shoulder, ankle, knee and hip), and frequency and amplitude of the platform. Twelve joint angles were used to run principle component analysis (PCA) to examine the characteristics of the performers' balancing movement. The improvement of balancing time in practice session was tested by One-way repeated measure ANOVA. Two-way ANOVA was used to compare the number of balls caught, the time of balance, the number of principle components, the frequency and amplitude of the platform.

**RESULTS:** Balancing time was significantly improved in post-test $F(1, 9)=87.660$ $p<0.5$, and was statistically longer in the balancing without catching condition $F(2, 18)=16.387$ $p<.05$. The interaction between practice and task conditions (S, CNS, CPS) was also significant $F(2, 18)=23.827$ $p<.05$ (See Figure 1). Further examination of the practice session reveals a significant practice effect, $F(5, 45)=27.723$ $p<.05$ (see Table 1). The results on the number of balls caught showed the significant effect for task conditions (C, CS1, CS2) $F(2, 18)=3.683$ $p<.05$, and the post-hoc paired-comparison revealed a better performance for the ground catching (C) than the pre-test stabilometer catching (CS1). Hand preference effect was not significant $F(1, 9)=.089$ $p=.772$. No significant interaction was found on the number of balls caught (See Figure 2).

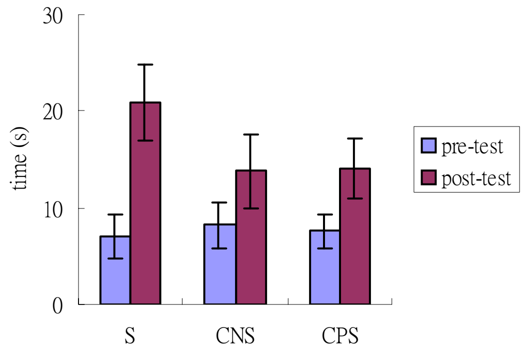


Figure 1: The time of balance

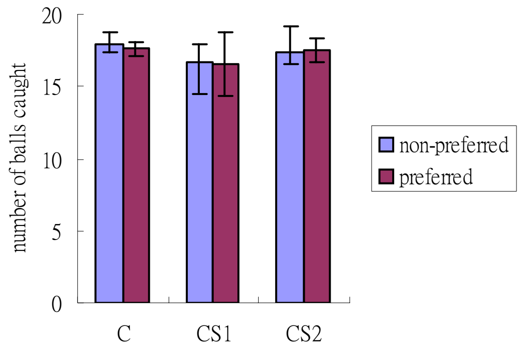


Figure 2: The number of ball caught

Table 1 P-value of paired comparisons results on balancing time in practice session

| | Day1 | Day2 | Day3 | Day4 | Day5 | Day6 |
|---|---|---|---|---|---|---|
| Day1 | ---- | .002* | .001* | .006* | .001* | .000* |
| Day2 | | ---- | .455 | .187 | .029* | .017* |
| Day3 | | | ---- | 1.000 | .131 | .030* |
| Day4 | | | | ---- | .900 | .275 |
| Day5 | | | | | ---- | 1.000 |
| Day6 | | | | | | ---- |

For the frequency of the platform, pre-test result was significantly less than post-test $F(1, 9)=46.359$ $p<.05$, and the task conditions (S, CNS, CPS) also showed significant difference $F(2, 18)=5.413$ $p<.05$. Post-hoc paired-comparison results revealed the only significant difference was between S and CPS. No interaction was found (See Figure 3). For the amplitude of the platform, a significant practice effect was found for amplitude which was smaller at post-test $F(1, 9)=5.462$ $p<.05$. There was also a significant difference among task conditions (S, CNS, CPS) $F(2, 18)=14.135$ $p<.05$, post-hoc paired-comparison showed that the amplitude was smaller in the condition without catching task. There was significant interaction between practice and conditions F (2, 18) =11.136 p<.05 (See Figure 4).

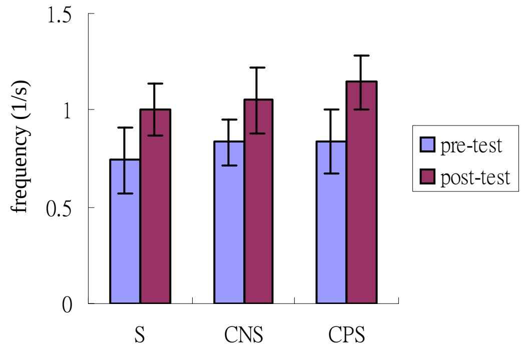


Figure 3: The frequency of the platform

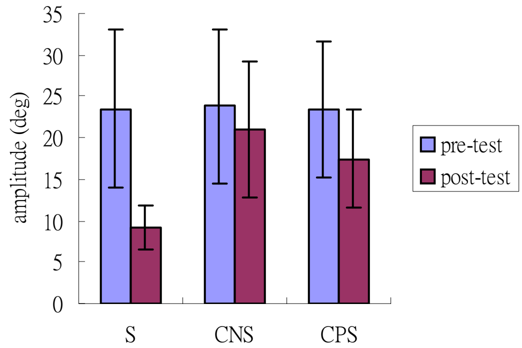


Figure 4: The amplitude of the platform

Although the results of principle component analysis did not show a significant reduction of the number of principle component through practice, the content of components changed from pre-test to post-test. Table 2 and Table 3 list the content of each component for individual participants, the variables were numbered from 1 to 12 (r-wrist, r-elbow, r-shoulder, l-wrist, l-elbow, l- shoulder, r-ankle, r-knee, r- hip, l-ankle, l-knee and l-hip, respectively). These results demonstrate a change of strategies in the balancing task through practice.

Table 2 The content of 4 components in pre-test for 7 participants

| | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
|---|---|---|---|---|---|---|---|
| 1 | 2,5,4,8,1 | 11,12,10,7,3, 5,2,1, 6 | 11,8,7,10 | 7,10,8,11,3,9 ,12 | 7,11,10,3,6,1 2,8 | 10,7,9,8,5 | 8,7,6,5 |
| 2 | 12,10 | 9,8,1 | 1,2,5,6,4,3 | 2,5,4,6 | 4,1,9,2,5 | 11,1,4,12,6,2,3 | 1,3 |
| 3 | 7,9,3 | | 9,12 | | | | 12,10,11 |
| 4 | 6,11 | | | | | | 2,4,9 |

Table 3 The content of 4 components in post-test for 7 participants

| | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
|---|---|---|---|---|---|---|---|
| 1 | 8,7,10,3,11,9 | 10,7,8,3,9,11 ,12 | 7,8,10,11,12, 9 | 10,5,7,1,6,5, 3 | 10,11,7,8,6,2 | 5,6,2,7,10,3 | 9,1,6,10 |
| 2 | 5,6,4,12 | 2,1 | 6,2,1 | 11,12,4,9,8 | 1,5,4,9,12,3 | 1,9,8,12 | 5,2,7,8,3,12 |
| 3 | 5,1 | | 5,3 | | | 4,11 | 4,11 |
| 4 | | | 4 | | | | |

**DISCUSSION:** When postural stability was perturbed, the catching performance was affected significantly. This was evidenced in the pre-test results of the experiment. However, after practice, the newly learned stabilometer task was significantly affected by the catching tasks resulting in a significant reduction in performance. This result is in agreement with those of Davids et al. (2000, 2005) claiming that posture stability is a key constraint for one-hand catching. Although one hand catching is a complicated movement that involves multiple segments, the examination of catching ability between preferred and non-preferred hand provided evidence to support the claim that adults are able to successfully perform a variety of motor tasks to a similar level with their preferred and non-preferred hands (Bryden, Singh, Steenhuis, & Clarkson, 1994; Harris & Carlson, 1993; Steenhuis & Bryden, 1999; Verfaellie & Heilman, 1990).

Practicing on the stabilometer enables the participants to respond to the loss-of-balance condition faster and with a smaller amplitude. This was evidenced in the faster frequency and the smaller amplitude of the stabilometer movement observed after practice
The results of PCA showed that the number of principle components didn't reduce significantly as other learning studies have found, but the content of each component changed through practice. This finding suggests that a change of strategies in the balancing task has occurred after 2 weeks practice, but a longer practice duration may be needed in order to observe a more constrained coordination pattern in the balancing task.

**CONCLUSION:** Dynamic postural control plays an important role in performing motor tasks such as one hand catching. By perturbing the postural stability, the performance of a well learned catching skill was degraded. Many sport skills are performed under a dynamic postural control condition such as running to catch a baseball and move to hit a tennis ball. Without the ability of maintaining a dynamically stable posture, the performance of the main skill will be severely affected. However, in the dual task situation, it is the performance of the less practiced skill (such as balancing on the stabilometer) that suffers from the interaction. Most sport skills involve multiple components that are usually carried out simultaneously. It is important to practice equally for all components of the skill in order to produce the optimal performance of the task. The results of the study provide a practical advice for coaches and activity instructors, namely to stress the importance of dynamical postural stability in any sport skill. Consequently, the equal amount of practice in every component of the skill will help to bring about an optimal performance.

**REFERENCES:**

Angelakopoulos, G. T., Davids, K., Bennett, S. J., Tsorbatzoudis, H., & Grouios, G. (2005). Postural Stability and Hand Preference as Constraints on One-Handed Catching Performance in Children. *Journal of Motor Behavior,* 37, 377-385.

Bryden, M. P., Singh, M., Steenhuis, R. E., & Clarkson, K. L. (1994). A behavioural measure of hand preference as opposed to hand skill. *Neuropsychologia*, 32. 991-999.

Davids, K., Bennett, S. J., Kingsbury, D., Jolley, L., & Brain, T. (2000). Effects of postural constraints on children's catching behavior. *Research Quarterly for Exercise and Sport,* 71, 69-73.

Harris, L. J., & Carlson, D. F. (1993). Hand preference for visually-guided reaching in human infants and adults. In J. P. Ward & W. D. Hopkins (Eds.), *Primate laterality: Current behavioral evidence of primate asymmetries* (285-305). New York: Springer-Verlag.

Peper, L., Bootsma, R. J_, Mestre, D. R., & Bakker, F. C. (1994). Catching balls: How to get the hand to the right place at the right time. *Journal of Experimental Psychology: Human Perception and Performance,* 20, 591-612.

Riccio, G. E. (1993). Information in movement variability about the qualitative dynamics of posture and orientation. In K. M. Newell & D. M. Corcos (Eds.), Variability and motor control (317-357). Champaign, IL: Human Kinetics.

Steenhuis, R. E., & Bryden, M. P. (1999). The relationship between hand preference and hand performance: What you get depends on what you measure. *Lateralily* 4, 3-26.

Verfaellie, M., & Heilman, K. M. (1990). Hemispheric asymmetries in attentional control: Implications for hand preference in sensorimotor tasks. *Brain and Cognition,* 14, 70-80.