The Beneficial Effects of a Functional Task Target on Reaching and Postural Balance in Patients With Right Cerebral Vascular Accidents

Hsieh-ching Chen, Keh-chung Lin, Chia-ling Chen, and Ching-yi Wu

This study evaluated the effect of context on the reaching performance of the unaffected arm and postural control while standing in patients with right cerebral vascular accidents (RCVA) and in healthy adults. Fifteen subjects with RCVA and sixteen healthy subjects performed tasks with the right hand under two conditions while standing. One condition involved moving coins forward on a table as far as possible (concrete task) and the other reaching forward without a target (abstract task). Forward reaching distance, forward displacement and lateral shift of center of pressure (CoP), and weight distribution were the dependent variables. The RCVA and control groups achieved significantly greater reaching distances in the concrete task than in the abstract one. The RCVA group showed significantly less lateral shift of the CoP and placed more weight on the affected leg in the concrete than the abstract task, whereas the control group made a greater lateral shift in the concrete task and had a similar mean ratio of weight distribution during both tasks. The results demonstrate that a functional application of task targets may favorably modulate both reaching and posture performance and exert various positive affects on postural control. Such applications may have a place in the therapeutic recovery efforts for patients afflicted with stroke.

Keywords: cerebrovascular accident, reaching, postural balance, kinematics, kinetics

Patients with cerebral vascular accidents (CVAs) often have difficulty controlling their posture and maintaining their balance while standing (Pyörälä, Era, & Talvitie, 2004). They usually display poor postural stability, as reflected in great shifts in the center of pressure (CoP), and bear most of their body weight
over the nonparetic limb during quiet standing postures (De Haart, Geurts, Dault, Nienhuis, & Duysens, 2005; Ikai, Kamikubo, Takehara, Nishi, & Miyano, 2003; Laufer, Sivan, Schwarzmann, & Sprecher, 2003; Maki & McIlroy, 1996; Mudie, Winzeler-Mercay, Radwan, & Lee, 2002; Niam, Cheung, Sullivan, Kent, & Gu, 1999; Pai, Rogers, Hedman, & Hanke, 1994; Prieto, Myklebust, Hoffmann, Lovett, & Myklebust, 1996; Winter, Patla, Prince, Ishac, & Gielo-Perczak, 1998; Winter, Prince, Frank, Powell, & Zabjek, 1996). Deterioration of postural control during standing and reaching tasks restricts the ability to participate in everyday activities and limits certain forms of critically important functioning (Barclay-Goddard, Stevenson, Poluha, Moffatt, & Taback, 2005). Restoring the ability to maintain posture and balance during various forms of activity (e.g., reaching or manipulative tasks) is a significant part of stroke rehabilitation (Carr & Shepherd, 2002). This study examined the impact of functional use of a task target on the reaching performance of the unaffected arm and postural performance.

Rehabilitation research has shown that functional tasks using real-life objects can be of great importance in improving movement performance in individuals with movement disorders as well as healthy persons (Davis, 2006; Kielhofner, 2002; Ricken, Bennett, & Savelsbergh, 2005). The presence of targets for functional use is often incorporated into the task-oriented approach advocated during stroke rehabilitation to enhance the capacity to perform postural tasks with arm movements in a variety of environmental contexts (Carr & Shepherd, 2001; Shepherd & Carr, 2006). The advantage of using concrete targets during the performance of a functional task is to allow the person to incorporate additional visual information about the spatial relationship between him or her and the object to perform smoothly the body movements required for successful completion of the task (Trombly & Wu, 1999; Wu, Trombly, Lin, & Tickle-Degnen, 2000). Several clinical studies have suggested that movements performed in the presence of a functional task target (e.g., reaching forward to take a beverage) are smoother and faster than movements performed in the absence of such objects (e.g., reaching forward to a spot lacking a designated target) during seated reaching tasks (Gasser-Wieland & Rice, 2002; Ma, Trombly, & Robinson-Rodolski, 1999; Trombly & Wu, 1999; Wu et al., 2000).

A few studies (Chern, Yang, & Wu, 2006; Stapley, Pozzo, & Grishin, 1999) have used reaching tasks to examine the effects of task targets on subjects in a standing position and focused on the impact of distance-to-target. There is one study (Chevan et al., 2003) assessing the standing and reaching task with a target present (a concrete task) on the reaching performance of older adults. Chevan et al. (2003) found that a concrete task induced a furthering of the reaching distance compared with the task without the target present (an abstract task). The findings suggested that abstract tasks (e.g., the functional reach test; Duncan, Weiner, Chandler, & Studenski, 1990) cannot be used to substitute concrete tasks (e.g., reaching for a real target) in the assessment of forward reach during standing.

Several studies (Gasser-Wieland & Rice, 2002; Chevan et al., 2003; Ma et al., 1999; Trombly & Wu, 1999; Wu et al., 2000) have employed reaching tasks in which the arm moved through space toward a target. But in daily life, we are not restricted to reaching toward a task target. We may hold a target object and/or move the target forward and pass it to another person, among numerous possibilities. For example, we may place coins on a table or counter top and then move the coins forward to make a payment. Moving a target forward not only provides visual information on the spatial relationships entailed but also light contact cues at the...
level of the fingertips. Fingertip contact with an object can provide somatosensory information regarding the alignment of the finger, hand, and the arm with respect to the environment, which may, in turn, reduce postural instability (Nagano, Yoshioka, Hay, & Fukashiro, 2006). Previous studies have shown that finger contact with an external object or body part reduces postural sway during quiet standing in healthy adults (Clapp & Wing, 1999; Nagano et al., 2006), older people (Baccini et al., 2007; Menz, Lord, & Fitzpatrick, 2006), and stroke patients (Hillier & Dunsford, 2006). Further study of touching a target and moving it forward during standing is needed since it may add information about whether target use in functional tasks modulates postural control as well as reaching performance and may suggest ways to improve balance control during daily functional tasks in stroke patients.

Given that visual-spatial integration is essential for coordinated postural responses and that this is predominantly controlled by the right brain hemisphere (Laufer et al., 2003), patients with right CVA (RCVA) have poorer postural control than patients with left CVA (LCVA) (Niam et al., 1999; Rode, Tiliket, & Boisson, 1997). Accordingly, a concrete functional task such as reaching forward for an object and transporting it to another place, as is typically done in the course of daily living, may be an appropriate therapeutic task to enhance the reaching and postural responses in patients with RCVA.

The purpose of this study is to assess the performance of reaching with the nonaffected (right) arm and the corresponding postural response while standing by comparing a functional reaching task involving a concrete target (i.e., a concrete task) with a task that did not involve a concrete object (i.e., an abstract task) in persons with and without RCVA. The rationale for studying neurologically intact adults is to provide a basis for establishing normal patterns of task performance during different task demands. We hypothesized that a concrete task would elicit better performance than an abstract task in both the RCVA and the control groups. In addition, the performance of patients with RCVA would be expected to be different from that of the healthy adults.

Methods

Research Design

A counterbalanced repeated-measures design was used. The order of two experimental tasks (the concrete and abstract tasks) was counterbalanced and randomized across the subjects in each group.

Subjects

Fifteen patients with RCVA (7 men and 8 women with a mean age of 58.2 ± 8.8 years) and 16 healthy subjects (8 men and 8 women with a mean age of 60.1 ± 9.2 years) volunteered for this study. The body weight and height of the RCVA patients were: 61.2 ± 8.9 kg, 161.3 ± 8.9 cm, and those of the healthy subjects were: 61.0 ± 7.8 kg, 162.5 ± 9.0 cm. All the subjects were right-handed and signed the informed consent forms approved by the Institutional Review Board. The patients with RCVA, who were attending a rehabilitation program at a medical center, were recruited by convenience sampling. The healthy subjects were recruited from a community near the medical center.
The RCVA patients were first-ever stroke patients, as shown by computed brain tomography; able to understand and follow five verbal instructions given by the examiner; and able to use the unaffected arms to perform standing and reaching tasks without support. No patient received medication or presented with another diagnosis known to affect movement performance. The duration period of post onset ranged from 26 to 40 months (mean 34.3 ± 10.3 months). The Brunnstrom stage of recovery of the lower extremities ranged from 3 to 6 (median stage 4.0) and that of the proximal part of the upper extremities ranged from 1 to 6 (median stage 4.5) (Brunnstrom, 1970). The Berg Balance Scale score ranged from 32 to 51 (mean score 40.8 ± 8.9) (Berg, Wood-Dauphinee, Williams, & Gayton, 1989). The healthy subjects had no prior musculoskeletal, neurologic, or cardiovascular conditions that would limit their ability to participate in the standing and reaching forward tasks.

**Materials and Instrumentation**

Coins 2.8 cm in diameter and 0.45 cm in thickness were used as the task target during the concrete task. The laboratory instrumentation involved a video motion analysis system and force plates used to measure reaching performance, center of pressure (CoP) displacements, and weight distribution during the two types of tasks performed by both the RCVA patients and the healthy subjects.

**Kinematics.** A six-camera motion analysis system (VICON 370 three-dimensional, Oxford Metrics Inc.), which sampled at a rate of 60 Hz, was used to capture the standing and reaching movements using two passive infrared-reflective markers 12 mm in diameter. One marker was attached over the head of the ulna and another was placed on the edge of table (Figure 1) opposite to the hand switch. Each camera was calibrated before data acquisition so that averaged residual errors did not exceed 3 mm.

![Figure 1](image.png) — Diagram illustrating the experimental setup. The black dots represent the infrared reflective markers.
The motion analysis system also collected one channel of the analog signal from a hand switch that was used to indicate the start of the movement. Prior to movement initiation, the subject’s hand rested on the switch. The beginning of movement was recorded when the hand moved off the switch. The end of the movement was determined as the time when the distance between the marker attached to the head of the ulna and the second marker located on the table was at its minimum value.

**Kinetics.** Two separate force plates (AMTI, Advanced Mechanical Technology Incorporation, model Or6–5-1000, size 510 × 460 mm), which sampled at a rate of 60 Hz with an accuracy of 0.25N, were mounted side by side. A trial without load on the force plates was collected before the experiment. A software package was used to calibrate the force plate data by subtracting the offsets of the no-load trial so that each force plate recorded the forces and moments generated by each foot in the anterior-posterior, medial-lateral (M-L), and vertical axes.

**Procedures**

The patients with RCV A used their unaffected (right) hand to perform the reaching task. The matched control subjects also used the right arm. The purpose of using the unaffected arm was to ensure that all patients could perform the task, which is particularly relevant given that some patients had poor Brunnstrom scores of the upper extremities. Moreover, therapists often teach persons with stroke compensatory strategies to use their unaffected arm for standing-and-reaching tasks in daily life situations (Shumway-Cook & Woollacott, 2007).

The subjects stood barefoot with each foot on separate force plates, and the unaffected arm rested on the hand switch adjacent to the edge of the table (Figure 1) located at the subject’s midsagittal plane. The coins were placed within a zone of 10 cm width marked by strap tape on the midline of the table (Figure 1). The assigned zone was designed to allow the coins to be moved in one direction. The heights of the switch and table were modified in accordance with the length of the lower extremity (from the anterior superior iliac spine to the floor) of the standing subject (Figure 1). One investigator stood nearby to ensure safety, and the subjects were allowed to rest at any time between trials. A tone signal indicated the start of each trial. The subjects were asked to perform two experimental tasks and performed each task in three trials.

**The Concrete Task.** Two coins were placed within the described width range near the subject. The subject was instructed to place the fingertip on the coins gently and move the two coins at once forward as far as possible at a comfortable speed. Subjects were permitted to flex their trunk during the forward reach. However, they were not allowed to lift their heels off the ground or take a step during the experiment. No one lifted his or her heels during the experiment. Gentle touch was emphasized to preclude using the table for balance.

**The Abstract Task.** The subjects were required to move the arm in the air forward along the zone as far as possible at a comfortable speed, while not lifting their heels off the ground or taking a step.
Data Reduction

The three-dimensional kinematic and kinetic data were reduced to characterize the reaching performance and postural control. Reaching performance was expressed by reaching distance and postural control by derivatives of CoP and weight distribution. The derivatives of CoP used in this study included forward displacement (FD) and medial-lateral (M-L) shift. Weight distribution was represented by the loading symmetry index (LSI), derived from the ratio of the mean load on the affected, or the left, leg compared with that of the unaffected, or the right, leg.

Reaching Kinematics. The three-dimensional data from the marker on the head of the ulna was used to calculate forward reaching distance. The data were processed using customized software coded by LabView (National Instruments, Austin, TX, USA) employing a second-order Butterworth filter with forward and backward pass at a frequency of 5 Hz.

Displacement of CoP. The force plate signals were digitally filtered with a cut-off frequency of 5 Hz and transformed using customized software, also coded by LabView, to obtain CoP displacement including the FD and M-L shift of CoP. Since each subject performed the task with different forward reaching distances, the M-L shift of CoP was normalized to correct for reaching distance.

The CoP displacement in the forward direction indicates the extent to which the upper extremity and the trunk move forward without the loss of balance, since the CoP follows a path approximately parallel to the line of movement when standing and reaching (Gillette & Abbas, 2003; Stapley et al., 1999). The CoP distance in the M-L direction indicates the extent of instability of the trunk during task performance because a greater M-L shift of the CoP is associated with a higher incidence of falling (Maki, Holliday, & Topper, 1994). A better balance control is defined by a further FD and decreased M-L shift of the CoP.

Weight Distribution. Weight distribution for each trial was expressed as the LSI. A higher value represents a higher mean load on the affected or the left leg, while 1 represents an even load on both legs.

The task of reaching forward along the body’s midline was expected to induce symmetrical weight distribution. The use of real targets was expected to provide a concrete cue associated with the movement direction and, thus, induce a more symmetrical weight distribution (LSI ~ 1) than when no target was used.

Statistical Analysis

The values of each dependent variable were averaged across three trials for each test condition for use in the statistical analysis. Analyses were performed in two steps. First, to determine whether the order of the two experimental tasks influenced the results, repeated-measures analyses of variance (ANOVAs) were applied for each dependent variable in each group. The analyses revealed no significant order effects ($p = .21 \sim .82$), and, thus, differences between the conditions may not be attributed to the test order. The second step was to test for the task effects (the concrete versus abstract task) and group differences (RCVA patients versus healthy adults). Given that there were no significant order effects, the $2 \times 2$ mixed
(i.e., one between-factor [group] and one repeated-factor [task]) ANOVA with Scheffe’s multiple-comparison procedures were conducted to test the experimental hypotheses. The level of significance criterion was set at $p < .05$.

Results

Table 1 lists the mean and standard deviation associated with reaching distance, $FD$, normalized $M-L$ shift of the $CoP$, and $LSI$ under the two experimental conditions for the two groups. Table 2 shows the results of the ANOVA.

Reaching Performance

A two-way mixed ANOVA showed a significant main effect for group ($p = .001$) and task ($p < .0001$), and a significant effect for Group $\times$ Task ($p = .012$). The concrete task elicited significantly greater reaching distance than the abstract task in both groups. However, the effect of the concrete task was more notable in the RCVA patients than in the healthy controls. The healthy controls elicited significantly greater reaching distance than the RCVA group regardless of task. Both hypotheses were supported.

Displacement of $CoP$

The mixed two-way ANOVA of the $FD$ of $CoP$ showed a significant effect for group ($p < .0001$) but no effect for task ($p = .113$) or Group $\times$ Task ($p = .084$). The healthy

Table 1  Descriptive Statistics for Test Conditions in Both Right Cerebral Vascular (RCVA) and Control Groups

<table>
<thead>
<tr>
<th></th>
<th>RCVA group ($n = 15$)</th>
<th>Control group ($n = 16$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concrete task</td>
<td>Abstract task</td>
</tr>
<tr>
<td></td>
<td>(mean ± SD)</td>
<td>(mean ± SD)</td>
</tr>
<tr>
<td>Reaching performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaching distance (cm)</td>
<td>52.85 ± 8.62</td>
<td>48.91 ± 6.65</td>
</tr>
<tr>
<td>CoP displacement (cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$FD$</td>
<td>5.47 ± 2.19</td>
<td>4.46 ± 1.84</td>
</tr>
<tr>
<td>$M-L$ shift</td>
<td>4.11 ± 1.43</td>
<td>4.88 ± 1.93</td>
</tr>
<tr>
<td>Weight distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$LSI^*$</td>
<td>1.14 ± 0.19</td>
<td>0.93 ± 0.12</td>
</tr>
</tbody>
</table>

Note. RCVA: right cerebral vascular accidents; CoP: center of pressure; FD: forward displacement; M-L shift: normalized medial-lateral shift; LSI: loading symmetry index.

*Values indicate the ratio of loading on the affected (or left) leg compared with the unaffected (or right) leg: 1.0 = equal loading on each leg; > 1.0 = greater loading on the affected (left) leg; < 1.0 = greater loading on the unaffected (right) leg.
**Table 2  Results of the Two-Way ANOVAs in Right Cerebral Vascular Accident (RCVA) and Control Groups**

<table>
<thead>
<tr>
<th></th>
<th>Group F (1, 29)</th>
<th>p</th>
<th>Task F (1, 29)</th>
<th>p</th>
<th>Interaction F (1, 29)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaching performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaching distance</td>
<td>14.15</td>
<td>.001</td>
<td>22.59</td>
<td>&lt;.0001</td>
<td>7.24</td>
<td>.012</td>
</tr>
<tr>
<td>CoP displacement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FD</td>
<td>109.23</td>
<td>&lt;.0001</td>
<td>2.67</td>
<td>.113</td>
<td>3.21</td>
<td>.084</td>
</tr>
<tr>
<td>M-L shift</td>
<td>8.03</td>
<td>.008</td>
<td>.17</td>
<td>.69</td>
<td>12.60</td>
<td>.001</td>
</tr>
<tr>
<td>Weight distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSI*</td>
<td>18.50</td>
<td>&lt;.0001</td>
<td>18.17</td>
<td>&lt;.0001</td>
<td>4.407</td>
<td>.045</td>
</tr>
</tbody>
</table>

*Note. RCVA: right cerebral vascular accident; CoP: center of pressure; FD: forward displacement; M-L shift: normalized medial-lateral shift; LSI: loading symmetry index.

Values indicate the ratio of loading on the affected (or left) leg compared with the unaffected (or right) leg: 1.0 = equal loading on each leg; > 1.0 = greater loading on the affected (left) leg; < 1.0 = greater loading on the unaffected (right) leg.

controls demonstrated greater FD than the RCVA group under both conditions. The results on the M-L shift of the CoP showed a significant effect for group (p = .008) and Group × Task (p = .001) but no effect for task (p = .69). The RCVA group showed a significantly decreased amount of lateral shift of the CoP (better balance) on the concrete task than the abstract task (p = .017) as hypothesized. However, the control group showed a significantly greater lateral shift on the concrete than the abstract task (p = .026) opposite from the hypothesis. The control group showed a significantly decreased amount of M-L shift of the CoP than the RCVA group, irrespective of task, as hypothesized.

**Distribution of Body Weight**

ANOVA for LSI showed a significant main effect for group (p < .0001) and task (p < .0001) and a significant effect for Group × Task (p = .045). The concrete task elicited greater LSI (more weight shifted toward the affected, left, leg) than the abstract task in RCVA patients (p < .0001) but not in healthy controls (p = .22), inconsistent with our a priori hypothesis. The mean LSI in the healthy controls was significantly greater than the RCVA patients regardless of task. The greater the LSI, the more mean weight that was loaded on the affected leg.

**Discussion**

The results of this study support the notion that the functional use of a task object can influence the performance of both the reaching activity of the unaffected arm and postural control (Kielhofner, 2002; Ricken et al., 2005), in agreement with previous studies looking at the effects of target use on reaching (Gasser-Wieland & Rice, 2002; Ma et al., 1999; Trombly & Wu, 1999; Wu et al., 2000) or postural control.
The results of this study are consistent with our a priori hypotheses for both groups with regard to reaching distance and for the RCVA group in the lateral shift of the CoP and LSI. The findings suggest that both the RCVA and the control groups achieved greater reaching distances in the concrete task than in the abstract one, but that they might use different control techniques for posture, as expressed by the CoP displacement and LSI, to move the targets away from the body. The RCVA group showed a less pronounced lateral shift of the CoP and placed more weight on the affected leg in the concrete task than in the abstract one, whereas the control group enacted a greater lateral shift in the concrete task and had a similar mean ratio of weight distribution during both tasks.

Our results corroborate previous findings (Chevan et al., 2003) in the elderly showing that a standing and reaching task performed with a concrete target facilitates reaching performance, as demonstrated by the farther reaching distance, than in similar tasks performed without a concrete target. The concrete task provided a performance context that included the focusing of spatial characteristics of the target size, shape, and location. Such a context may promote an integrated form of information processing that facilitates better-oriented reaching behavior in executing the goal of the task (Gentile, 2000; Wu et al., 2000). In addition, the concrete task represents a more meaningful and familiar task and, thus, provides a greater understanding of the task goals, which, in turn, may also facilitate enhanced performance (Wu, Wong, Lin, & Chen, 2001).

The variations in responses to task concreteness/abstractness did not occur in the FD of the CoP, but it did occur in the lateral shift. A possible explanation of this result is that the standing and reaching task using one arm to reach forward along the body midline involved an asymmetric movement so that a lateral CoP shift occurred (together with the weight shift), and this asymmetry varied in accordance with task concreteness/abstractness (Jonsson, Henriksson, & Hirschfeld, 2003).

Task concreteness/abstractness induced a different M-L shift of the CoP, suggesting that spatial uncertainty about the task target was relevant not only for control of the arm, but also for postural control. The patterns of the lateral CoP shift during both tasks differed between the RCVA and the control groups, suggesting that task concreteness has a different influence on control of the CoP in the groups. The RCVA group showed less lateral shift of the CoP in the concrete task than in the abstract task, indicating that this group had better stability in the concrete task than in the abstract one. The RCVA patients might rely more heavily on visual information in the M-L control of postural sway than the healthy adults (Marigold & Eng, 2006). Presence or absence of a concrete visual cue might exert a greater impact on postural sway in the RCVA patients than in the healthy adults. In the RCVA group, visual cues provided by the concrete target, thus, could be used to generate visually evoked postural responses to facilitate better medial-lateral balance than those used for the abstract target.

The finding of less lateral shift of CoP in the RCVA group during the concrete task is consistent with previous studies (Baccini et al., 2007; Clapp & Wing, 1999; Nagano et al., 2006; Hillier & Dunsford, 2006; Johannsen, Wing, & Hatzitaki, 2007) that have reported that light touch stimuli resulted in reduced CoP variability in the M-L direction and verifies that light touch has a similar effect for a variety of tasks (e.g., quiet standing or self-initiated movement). Light contact with a surface
serves to enhance the proprioceptive feedback from muscle and joint receptors that provide information on the alignment of the arm, trunk, and lower limbs for detection of movement. Such information allows anticipatory innervation of musculature to reduce body sway (Menz et al., 2006). The finger’s role in postural control may be related to the high density of sensory units in the finger and to the large amount of cortex devoted to the sensory and motor aspect of hand function (Vuillerme & Nougier, 2003). Cutaneous input in terms of light finger contact can be used by the brain to control posture (Menz et al., 2006). The RCVA patients might, thus, use the somatosensory information obtained from light finger touching during the concrete task to reduce postural instability.

In contrast, the control group showed a greater lateral shift of the CoP in the concrete task than in the abstract task. The finding on the control group is inconsistent with previous studies reporting that light touch stimuli resulted in reduced M-L sway of CoP (Baccini et al., 2007; Clapp & Wing, 1999; Nagano et al., 2006; Hillier & Dunsford, 2006; Johannsen et al., 2007), suggesting that effect of light touch on postural control might not be generalized from a quiet standing position to self-initiated movement in healthy adults. Postural control requires the cooperative activity of different sensory information. Under different task demands (stand quietly or reach forward while standing) or subject conditions (e.g., stroke or healthy adults), the information needed to regulate posture may be weighted differently. For healthy adults and patients standing quietly or patients reaching forward as far as possible while standing, somatosensory information via light contact and/or visual cues are important for reducing postural sway. However, the visual cues and somatosensory feedback might not play as critical a role in the healthy controls. Since the lateral shift of the CoP during both tasks was less in the control group than in the RCVA group, the control group used the strategy of decreased M-L sway (i.e., better lateral stability) to perform both tasks. Under limited M-L sway the healthy controls achieved greater reaching distance in the concrete task by means of transferring the CoP to either limb to increase transverse and frontal plane motion than in the abstract task.

The mean magnitude of the LSI was greater than 1 in both groups by itself, indicating that the subjects put more weight on the affected left leg than on the unaffected or right leg to perform the reaching tasks using the unaffected right arm. Kaminski (2007) suggests the upper extremity, trunk, and lower extremities work together as a single functional unit during standing and reaching tasks. The lower extremities become more strongly coupled to the upper extremity when reaching than when only raising an arm. To increase the stability of the performer’s posture, reaching forward with the unaffected right arm should be accompanied by shifting more weight to the affected left leg (Messier, Bourbonnais, Desrosiers, & Roy, 2005).

Although the control group did not demonstrate a significant effect of task concreteness on the LSI, the RCVA group demonstrated a significant effect on the LSI. Since the LSI in the healthy controls was greater overall (more weight on the left, diagonal, leg under both conditions) than in the RCVA patients, the healthy controls showed the capacity to shift weight to the left leg more to increase the stability irrespective of task when executing a reaching forward task with the right arm. For the RCVA group, patients loaded weight on the affected leg more in the concrete task than in the abstract task. That is, the LSI performance of the RCVA
group in the concrete task is more similar to the performance of the healthy controls in both tasks than is the performance of the RCVA group in the abstract task. The concrete task might provide visual cues and somatosensory information via light contact to increase the postural stability of the RCVA group. The concrete task, accordingly, led to weight bearing on the affected leg more than did the abstract task. This finding suggested that the concrete task might be used to restore the patient’s technique for standing and reaching (i.e., shift more weight to the affected side opposite the active upper extremity).

To sum up, the findings of this study might further our understanding of how the nature of the task modulates reaching and trunk control. The concrete task facilitated the performer to better achieve the task goal, that is, to reach further than did the abstract task in both the RCVA patients and healthy controls. Although posture and lower extremity controls are coupled with arm control, different strategies of postural control in response to task demands were employed in the RCVA and the control subjects. The greater reaching distance was accompanied by greater lateral stability of CoP and by weight shifting onto the affected leg more in the RCVA group, possibly because of the concrete visual cues and somatosensory information via light contact for the patients. Given the fact that the healthy subjects demonstrated less lateral shift of the CoP during both tasks than the RCVA patients, the greater reaching distance was achieved by exaggerating the lateral shift of CoP to increase the transverse and frontal plane motion in the healthy subjects.

An implication of these findings for stroke rehabilitation is that training for postural control may usefully incorporate a focused concrete task involving reaching performance of the unaffected arm to decrease postural instability and/or sway for patients with RCVA or increase weight bearing of the affected leg. Such a task may help increase reaching distance, achieve better postural stability in the lateral plane, and induce patients to put more weight on their paretic foot. In addition, these findings have implications for evaluation of stroke patients because, as indicated by Chevan et al. (2003), the functional reach test using a target is not equivalent to the standardized functional reach test (no use of any target) in stroke patients.

One limitation of this study that should be addressed in future work is a lack of fingertip force data to provide some insight into whether the touch of the coins actually did exert an effect as postulated. The study is also limited to investigating the effects of standing and reaching tasks on forward reach and postural control by the unaffected arm. To test the robustness of these findings, future research may have patients use the affected arm or employ patients with different characteristics (e.g., side of lesion, onset time, motor recovery stage, and perceptual abilities). Such research may reveal which types of stroke patients can likely optimize their movement performance in terms of the functional use of task objects, thus allowing identification of the patient population(s) indicated for such training. Standing and reaching studies combining electromyographic and kinematic analyses of the trunk and limbs during various task demands, such as object presence, location, or perturbation, would also significantly add to the findings obtained in this study.

Conclusion

This study was designed to assess whether an application of a functional focused task affects reaching and postural performance. One of the major findings of this study was that task concreteness contributed to the performance of both the
unaffected arm and control of posture in patients with RCVA as well as healthy subjects. Furthermore, task concreteness had a different influence on control of the CoP for the RCVA versus the control groups. The concrete task decreased postural stability in the M-L plane and shifted more weight onto the affected left leg in the RCVA patients because of visual cues and somatosensory information. The healthy subjects used the strategy of increasing transverse and frontal motion in terms of greater lateral shift in the concrete task under the situation that the healthy subjects had maintained greater lateral stability in both tasks than the RCVA patients. The clinical implication is that the use of standing and reaching tasks with functional targets may facilitate greater reaching distance, decrease postural instability, and restore the capacity to shift weight in response to environmental task demands for persons with stroke.

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**References**


