Impaired Ipsilateral Upper Extremity Dexterity and Its Relationship with Disability in Post-Stroke Right Hemiparesis

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ABSTRACT

Background: The objectives of this study were to compare manual dexterity (gross and fine) and coordination performance of the ipsilateral upper extremity of the right hemisphere stroke patients with the same side of a healthy group, and to determine the relationship of ipsilateral upper extremity dexterity and disability.

Methods: In a non-randomized analytical study, 30 individuals with a unilateral first-ever stroke from outpatient rehabilitation clinics and 30 age and sex-matched adults without history of neurological disorders were enrolled. Purdue Pegboard, Box and Block, and Finger to Nose tests were used to measure dexterity (fine and gross) and coordination performance of the stroke group compared with the same hand of the healthy group. The Barthel index was also used to assess disability or dependency of stroke patients in basic activities of daily living.

Results: Results showed that stroke individuals with involvement of ipsilateral hand had less coordination and dexterity when compared to the same hand of normal subjects (P=0.001). In addition, the relationship of gross and fine manual dexterity performance of the ipsilateral upper extremity with disability, including dependence in basic activities of daily living, were significant respectively (r=0.376, r=0.391).

Conclusion: People with right stroke had significant ipsilateral upper extremity impairments (manual dexterity and coordination tasks), and this hand dexterity deterioration had an impact on their dependence in basic activities of daily living.

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impariments were important in rehabilitation since they could cause functional disabilities [22]. Coordination is the ability to perform fine and controlled actions accurately [18], and dexterity is the ability to manipulate objects accurately and quickly. Hand dexterity includes fine and gross manual dexterity that refers to respectively finger and overall UE activities [23]. Although previous studies reported these ipsilateral impairments, these studies do not exclude their participants with the following disorders: apraxia, visuospatial and cognitive disorders, ipsilateral sensory dysfunctions, severe contralateral motor impairments, dysphasia, aphasia, and visual neglect. Therefore, in this study, we want to prove that despite eliminating these impairments, ipsilateral upper extremity dexterity and coordination impairments exist, and they affect dependence during BADLs. Some studies reported a relationship between dexterity and disability [6, 22]; however, it is not clear how much of this relationship was related to the fine dexterity and how much of this was related to gross dexterity. Separating these meanings helps us to clarify details of this relationship and rehabilitate better to reduce patients’ dependence during BADLs.

The purpose of the present study was to compare ipsilateral UE dexterity (gross and fine) and coordination performance of the right stroke patients with the same side as the healthy group by clinical assessment tools. We also sought to determine the relationship between the ipsilateral UE dexterity and coordination tasks in individuals with disabilities, including dependence during BADLs in stroke patients. If results indicate that despite eliminating these impairments, ipsilateral upper extremity dexterity and coordination impairments still exist and create dependence during BADLs, then future rehabilitation techniques should focus on reducing these ipsilateral impairments so the patients have more independence with BADLs.

Methods

In this non-randomized analytical study, 60 individuals were enrolled. Participants were divided into two groups (case and control). 30 subjects were healthy (15 male & 15 female), and the rest were individuals with left CVA (right Hemiparesis) that were approved by an expert neurologist. Participants were recruited for the study from public clinics in Shiraz from April 2013 to June 2013. Inclusion criteria were: diagnosis of unilateral left hemiplegic/paresis secondary to a first-time, right middle cerebral artery stroke that occurred between 3 months and 2 years prior to the study (as diagnosed by a physician), between 45 and 75 years of age, able to perform the Box and Block test with the Minnesota Rate of Manipulation Test Placing with a result of r=0.91 [30]. After the tool was placed in front of the subjects and their hands were next to the tool, they were asked to pick up the cubes (2.5×2.5cm) from one side of the box and move them to the other side with their right hand as quickly as possible during a 60-second trial. The number of cubes that a subject could transfer was the score of gross manual dexterity. If the subject’s hand hit the wooden block in the middle of the box, or if the cubes drops from their hand during transferring, errors were recorded, and the test was repeated [4, 6, 23].

Fine dexterity was assessed using the Purdue Pegboard test. Reliability studies with various and scores on the Purdue pegboard yielded correlations ranging from 0.60 to 0.91. Validity coefficients range from 0.7 to 0.76, depending on the score used, the task, and the criterion [31]. The position of this tool was similar to the previous instrument. While the subjects sat in front of the instrument tool with their hands on the table next to the tool, they were asked to pick up the small shots with two fingers of the right hand (the index finger and thumb) and put them in the holes on the board as quickly as possible during a 30-second trial. The number of small shots that a subject could pick up and put in the holes during a 30 seconds was his fine manual dexterity score. If the small shots dropped from his hand during this period, errors were recorded and then the test was repeated [6, 10, 23,31].

The finger-to-nose test was used to assess eye-hand coordination. While the subjects sat on the chair with the examiner in front of them, they were asked to place the ipsilateral UE in 90 degrees of shoulder abduction and
90 degrees of elbow. They were then asked to reach the index finger of ipsilateral hand to their nose 5 times at their normal speed. The time of this action, measured by a chronometer (ms), was the coordination score. Errors were recorded if the patients could not maintain the position through testing [6, 18].

In order to evaluate Disability (dependency during BADL), The Persian version of Barthel index was applied. The reliability score on this index was 0.989, and the validity coefficient was 0.994 [28]. This index assesses functional independency by executing 10 activities of daily living while being directly observed by an examiner. These activities included feeding, bathing, grooming and dressing, bowel and bladder movement, toilet usage, transferring (bed to chair and back), mobility (on level surfaces), and stair proficiency. The total score on this index ranges from 0 (-dependent) to 100 (independent). More profound disabilities correlated with higher scores on this scale [19, 28].

Statistical Analysis
To compare mean scores of dexterity and coordination between the stroke and healthy groups, we used the independent sample t-test. The relationship between dexterity and dependency in BADLs, was analyzed by Pearson’s product moment correlation coefficient. The significance level was set at 0.05. All analyses were done using the SPSSa for Windows.

Results
During the inclusion period, 30 left stroke patients were enrolled to the study. The mean age of patients and the average post onset CVA period were respectively 61.33 years (S.D=2.07) and 8.6 months (S.D=1.27). Among patients, 23 subjects suffer from ischemic and 7 from hemorrhagic stroke. In table 1, we present the patients characteristics. The location of stroke defined based on the computed tomography or magnetic resonance imaging scans.

In total, 30 people were participated as normative controls. The control group consisted of 15 men and 15 women, with a mean age of 60.76 ±1.73 years (range 45-75 y) and a mean BMI of 24.41±3.58kg/cm². All of the participants in this study were right-handed.

The ipsilateral UE manual dexterity (gross and fine) and eye hand coordination scores of stroke group was significantly lower compared with those of the stroke patients (Table 2).

In addition, there was correlation between ipsilateral hand dexterity (gross and fine) and disability (P=0.02) however no correlation was found between ipsilateral coordination and dependence in BADLs (Table 3).

Discussion
In our study, we found that the ipsilateral UE dexterity (gross and fine) and coordination performance of the right stroke group was impaired. It could be due to distribution of cortico-spinal neural pathways that do not cross at the brain stem level, and transverse callousal fibers that control both side of the body. This indicates that when a hemisphere is damaged due to stroke, these tracts in the ipsilateral side would be affected as well, though to

Table 1: Patient Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>Female</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>Type of stroke</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infarction</td>
<td>23</td>
<td>76.6</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>7</td>
<td>23.33</td>
</tr>
<tr>
<td>CT/MRI scan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parietal</td>
<td>5</td>
<td>16.66</td>
</tr>
<tr>
<td>Parietal and posterior frontal</td>
<td>8</td>
<td>26.66</td>
</tr>
<tr>
<td>Parietal, posterior frontal and sub-cortical</td>
<td>10</td>
<td>33.33</td>
</tr>
<tr>
<td>Parietal, posterior frontal and temporal</td>
<td>4</td>
<td>13.33</td>
</tr>
<tr>
<td>Parietal, posterior frontal, temporal and sub-cortical</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Age (y)*</td>
<td>61.33±2.07</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/cm²)</td>
<td>24.9±3.81</td>
<td></td>
</tr>
<tr>
<td>Time since stroke(month)**†</td>
<td>8.6±12.27</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: CT, computed tomography; MRI, magnetic resonance imaging; BMI, Body mass index. *values are mean±standard deviation (SD). †Time between stroke and admission to rehabilitation center.

Table 2: Comparing performance scores of right stroke patients with healthy subjects by independent sample t test

<table>
<thead>
<tr>
<th>Variables</th>
<th>Controls(n=30)</th>
<th>Patients(n=30)</th>
<th>Mean differences</th>
<th>P value</th>
<th>95% Confidence interval of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>Gross dexterity</td>
<td>40.3±1.70*</td>
<td>28.9±0.94</td>
<td>11.2</td>
<td>0.000</td>
<td>-15.29</td>
</tr>
<tr>
<td>Fine dexterity</td>
<td>12.9±0.47</td>
<td>9.2±0.38</td>
<td>3.7</td>
<td>0.000</td>
<td>-4.92</td>
</tr>
<tr>
<td>Coordination</td>
<td>4.66±0.13</td>
<td>6.61±0.28</td>
<td>1.95</td>
<td>0.000</td>
<td>1.31</td>
</tr>
</tbody>
</table>

*Standard Deviation (SD)
a lesser extent than the contralateral side [2, 3, 5, 6, 15, 21, 32-34].

Insufficient postural stabilization because of contralateral side weakness [6], impaired ipsilateral pattern of muscle activities [35], sensory dysfunction [5, 6, 21, 33, 34], impaired proximal stability of ipsilateral UE (reduction of external rotation of the scapula and arm elevation) in chronic phase of recovery, and cerebral edema in acute phase of recovery [35] may cause ipsilateral dexterity and coordination impairments [6, 8, 15, 21]. Furthermore, accurate performance of dexterity and coordination tasks need accurate perception of an object’s shape and two stage commands [2]. Since left hemisphere damage impairs the ability to determine an object’s shape, and right hemisphere damage impairs visuospatial perception, dexterity and coordination were also deteriorated [2, 8]. Many factors including kinesthesia [6], spinal reflexes [3], affected UE motor function, functional independence, time between stroke and admission to rehabilitation center, self-perceived health status, activity and depression level, age, gender, stroke severity, and stroke side and dominance have an impact on ipsilateral hand dexterity and coordination performance [6].

Our results were in consistent with the work of Sunderland et al in 1999-2000 [2, 12], Brasil-Neto et al in 2008 [4], Yarosh et al in 2004 [15], York Haaland et al in 1981 [17], Desrosiers et al in 1996 [6], Hermsdörfer J et al in 1999 [36], Debaere et al in 2001, and Sowinnen et al in 2002 [5, 21]. They reported that ipsilateral hand dexterity and coordination performance of healthy subjects were better than stroke group; however, Maria Wyke et al reported there were no differences between stroke patients and a healthy group [14]. This discrepancy could be related to differences in sample size, kind of sampling populations, research methodologies, definition of variables, time between stroke and admission to rehabilitation center, and inclusion criteria such as presence of apraxia.

According to inclusion criteria, eliminating individuals with cognitive and visuospatial problems and assessing patients in chronic phase after stroke, factors like cognitive and visuospatial disorders, apraxia and cerebral edema, could not justify these differences existed between two groups.

Another finding of this study was the significant relationship between ipsilateral hand dexterity (fine and gross) and disability. Our results were consistent with the work of Daniel de Groot et al in 2006 whom reported that ipsilateral speed of finger tapping was related to functional outcome (Barthel Index, FAI) [22]. However, Sunderland and Smutok et al reported the opposite. They found that ipsilateral dexterity and UE function did not influence functional independence. This discrepancy could be related to differences in the measurement tool and recovery phase variation of participations, inclusion criteria (they did not eliminate subjects with cognitive and apraxia disorders), and culture. The reason for the loss of relationship between ipsilateral coordination performance and disability could be how they performed the Finger to Nose test. We asked individuals to do this test at a normal rate. On one hand, subjects’ normal rates varied, and on the other, correct performance of different activities of daily living needed different rates of coordination, so we did not find any relationship between ipsilateral eye-hand coordination movements and disability.

Convenience sampling and relatively small sample size may be factors affecting the interpretation of the findings. We cannot generalize our results to CVA due to other arteries’ involvement.

**Conclusion**

From a theoretical point of view, both hemispheres cooperate in a unilateral brain lesion. Apparently, the unaffected hemisphere is involved in the damage of the brain. This study supports impairments in ipsilateral hand dexterity and coordination tasks regardless of post-stroke onset period and the presence or lack of cognitive and visuospatial disorders. In addition, if ipsilateral hand dexterity of stroke patients lessened, they were more disabled. This study implies that clinicians should take into account the performance of the both the affected and less affected UEs in their interventions.

**Conflict of Interest:** None declared.

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