JRSR 1 (2014) 47-51

Journal of Rehabilitation Sciences and Research

Journal Home Page: jrsr.sums.ac.ir

Original Article

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

Maryam Parsaee[1], Shohreh Noorizadeh Dehkordi[1*], Mehdi Dadgoo[1], Malahat Akbarfahimi[2]

[1]Department of Physical Therapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran
[2]Assistant Professor, Department of Occupational Therapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran

ARTICLE INFO

Article History:
Received: 27/4/2014
Revised: 17/7/2014
Accepted: 20/7/2014

Keywords:
Coordination impairmen
Upper extremity dexterity
Post-stroke

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.

Introduction

Disability is an inability to engage in any substantial gainful activity because of any medically determinable physical or mental impairment which can be expected to last or has lasted for continuous periods of no less than 12 months [1]. Post-cerebral vascular accidents (CVA) and sensorimotor impairments can cause disabilities that increase dependency during basic activities of daily livings (BADLs) [2]. Although the non-affected upper extremity (UE) was assumed to be normal, numerous studies reported some abnormalities in sensorimotor function of uninvolved UE [2-17]. These impairments include reduction of grip strength [2-4, 10, 12], speed of movement [11, 13-20], range of motion [9, 12], difficulties in reaching and manipulative tasks [12, 17], lack of dexterity [2, 4, 6, 11, 12, 15, 17], incoordination [5, 6, 8, 11, 15, 17, 21], abnormal timing of muscle action [15], and difficulty in execution of complex manual tasks [12, 17]. Individuals post-stroke used the ipsilateral UE to compensate, and specialists used it as a reference for retraining affected UE function [12]; therefore, these

**Corresponding author:* Shohreh Noorizadeh Dehkordi, Assistant Professor, Department of Physical Therapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Mirdamad, Mother Square, Shahnazari Street, Tehran, Iran, Tel: +98-21-22227124,
E-mail: Noorizadeh@razi.tums.ac.ir

impairments 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). 30subjects 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 respond to a superficial pain stimulus (by the Pin Prick test), right-handed (by the Edinburg questioner) [24], and no history of any neurological conditions (including neuropathy, myopathy, and multiple sclerosis). Subjects were excluded if they had apraxia (by Action Imitation test [25] and Benton line test) [26], perception aphasia (by token test) [27], history of pain, injury or surgery of the ipsilateral UE, a score of less than 16 on the Persian version of the Folestein Mini-Mental Status [28], and a score of more than 62 on Fugle-Meyer scale [28].

Healthy subjects for the control group were chosen after being matched for exact age, sex, and hand dominance with the stroke subjects from patients' entourages. They were recruited for this study if they were independent in their activities of daily living and did not have any neurological disease or orthopedic problems in either of their UEs.

The ethic committee of the Tehran University of Medical Sciences approved the study. (Ref. number: 130-3426). Informed consent was obtained from all the participants.

A physiotherapist completed all assessments during a single session; however, each participant was given a familiarization trial before the assessment session. The position of subjects for all assessments was sitting in a chair/wheelchair with back support [29]. The assessment tools were placed at a 10 cm distances in front of the participants. These tests were performed on a rectangular baseboard (75×35 cm), located on a tabletop and centered at the midline of each subject's body. Instructions were given twice, both verbally and by demonstration. To determine gross manual dexterity, the Box and Block test was used. Test-retest reliability scores at six-month intervals were reported as rho coefficient of 0.976 for the right hand. Validity of the Box and Block test has been established by correlating 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 the 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 SPSS[a] 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/cm^2. 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

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

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

Variables	Controls(n=30)	Patients(n=30)	Mean differences	P value	95% Confidence interval of difference	
					Lower	Upper
Gross dexterity	40.3±1.70*	28.9±0.94	11.2	0.000	-15.29	-7.50
Fine dexterity	12.9±0.47	9.2±0.38	3.7	0.000	-4.92	-2.47
Coordination	4.66±0.13	6.61±0.28	1.95	0.000	1.31	2.58

*Standard Deviation (SD)

Table3: Pearson correlation coefficients between dexterity and coordination performance of 30 stroke patients and disability

Variables	Disability
Gross dexterity	r=0.376*
Fine dexterity	r=0.391**
Coordination	r=-0.241***

*P=0.02, **P=0.016, ***P=0.10

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 dominancy 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], Hermesd Öfere 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.

References

1. Jette AM. Toward a common language for function, disability, and health. Physical Therapy. 2006;86(5):726-34.
2. Sunderland A, Bowers MP, Sluman SM, Wilcock DJ, Ardron ME. Impaired dexterity of the ipsilateral hand after stroke and the relationship to cognitive deficit. Stroke. 1999;30(5):949-55.
3. Alagesan J, Devi SL, Anandh V. Comparative Study on the Strength of Ipsilateral Upper Extremity of Stroke Subjects and Normal Individuals.
4. Brasil-Neto JP, de Lima ÂC. Sensory deficits in the unaffected hand of hemiparetic stroke patients. Cognitive and Behavioral Neurology. 2008;21(4):202.
5. Debaere F, Van Assche D, Kiekens C, Verschueren S, Swinnen S. [Without Title]. Experimental brain research. 2001;141(4):519-29.
6. Desrosiers J, Bourbonnais D, Bravo G, Roy PM, Guay M. Performance of the 'unaffected'upper extremity of elderly stroke patients. Stroke. 1996;27(9):1564-70.
7. Haaland KY, Harrington DL. Limb-sequencing deficits after left but not right hemisphere damage. Brain and Cognition. 1994.
8. Hermsdörfer J, Laimgruber K, Kerkhoff G, Mai N, Goldenberg G. Effects of unilateral brain damage on grip selection, coordination, and kinematics of ipsilesional prehension. Experimental brain research. 1999;128(1):41-51.
9. Niessen M, Janssen T, Meskers C, Koppe P, Konijnenbelt M, Veeger DJ. Kinematics of the contralateral and ipsilateral shoulder: a possible relationship with post-stroke shoulder pain. Journal of Rehabilitation Medicine. 2008;40(6):482-6.
10. Smutok MA, Grafman J, Salazar AM, Sweeney JK, Jonas BS, DiRocco PJ. Effects of unilateral brain damage on contralateral and ipsilateral upper extremity function in hemiplegia. Physical therapy. 1989;69(3):195-203.
11. Spaulding S, McPherson J, Strachota E, Kuphal M, Ramponi M. Jebsen Hand Function Test: performance of the uninvolved hand in

hemiplegia and of right-handed, right and left hemiplegic persons. Archives of physical medicine and rehabilitation. 1988;69(6):419.
12. Sunderland A. Recovery of ipsilateral dexterity after stroke. Stroke. 2000;31(2):430-3.
13. Winstein C, Pohl P. Effects of unilateral brain damage on the control of goal-directed hand movements. Experimental brain research. 1995;105(1):163-74.
14. Wyke M. The effects of brain lesions on the performance of bilateral arm movements. Neuropsychologia. 1971;9(1):33-42.
15. Yarosh CA, Hoffman DS, Strick PL. Deficits in movements of the wrist ipsilateral to a stroke in hemiparetic subjects. Journal of neurophysiology. 2004;92(6):3276-85.
16. Yelnik A, Bonan I, Debray M, Lo E, Gelbert F, Bussel B. Changes in the execution of a complex manual task after ipsilateral ischemic cerebral hemispheric stroke. Archives of physical medicine and rehabilitation. 1996;77(8):806-10.
17. York Haaland K, Delaney HD. Motor deficits after left or right hemisphere damage due to stroke or tumor. Neuropsychologia. 1981;19(1):17-27.
18. O'sullivan SB, Schmitz TJ, Behr DW. Physical rehabilitation: assessment and treatment: FA Davis; 1994.
19. Oveisgharan S, Shirani S, Ghorbani A, Soltanzade A, Baghaei A, Hosseini S, et al. Barthel index in a Middle-East country: translation, validity and reliability. Cerebrovascular Diseases. 2006;22(5-6):350-4.
20. Wyke M. The effect of brain lesions in the performance of an arm-hand precision task. Elsevier; 1968. p. 125-34.
21. Swinnen S, Debaere F, Puttemans V, Vangheluwe S, Kiekens C. Coordination deficits on the ipsilesional side after unilateral stroke: the effect of practice on nonisodirectional ipsilateral coordination. Acta psychologica. 2002;110(2):305-20.
22. de Groot-Driessen D, van de Sande P, van Heugten C. Speed of finger tapping as a predictor of functional outcome after unilateral stroke. Archives of physical medicine and rehabilitation. 2006;87(1):40.
23. Yancosek KE, Howell D. A narrative review of dexterity assessments. Journal of Hand Therapy. 2009;22(3):258-70.
24. Lend G, Fowkes F. The Edinburgh Claudication Questionnaire: an improved version of the WHO/Rose Questionnaire for use in epidemiological surveys. Journal of clinical epidemiology. 1992;45(10):1101-9.
25. Kimura D, Archibald Y. Motor functions of the left hemisphere. Brain. 1974;97(2):337-50.
26. Benton AL. Contributions to neuropsychological assessment: A clinical manual: Oxford University Press; 1994.
27. Boller F, Vignolo L. Latent sensory aphasia in hemisphere-damaged patients: An experimental study with the Token Test. Brain. 1966;89(4):815-30.
28. katherine Salter JJ, Robert T , Robert Teasell. Evidence-Based Rewiew of Stroke Rehabilitation : Outcome Measures in Stroke Rehabilitation. Heart and Stroke Fundation of ONTARIO. 2004.
29. Taub E, Morris DM, Crago J, King DK, Bowman M, Bryson C, et al. Wolf Motor Function Test (WMFT) Manual. 2011.
30. Mathiowetz V, Volland G, Kashman N, Weber K. Adult norms for the Box and Block Test of manual dexterity. The American Journal of Occupational Therapy. 1985;39(6):386-91.
31. Tiffin J. Purdue pegboard test. Chicago: Science Research. 1948:194.
32. Canning CG, Ada L, O'Dwyer N. Slowness to develop force contributes to weakness after stroke. Archives of physical medicine and rehabilitation. 1999;80(1):66-70.
33. Kim SH, Pohl PS, Luchies CW, Stylianou AP, Won Y. Ipsilateral deficits of targeted movements after stroke. Archives of physical medicine and rehabilitation. 2003;84(5):719-24.
34. Nowak DA, Grefkes C, Dafotakis M, Küst J, Karbe H, Fink GR. Dexterity is impaired at both hands following unilateral subcortical middle cerebral artery stroke. European Journal of Neuroscience. 2007;25(10):3173-84.
35. Meskers CGM, Koppe PA, Janssen TWJ. Kinematic alterations in the ipsilateral shoulder of patients with hemiplegia due to stroke. American journal of physical medicine & rehabilitation. 2005;84(2):97-105.
36. Geyh S, Cieza A, Schouten J, Dickson H, Frommelt P, Omar Z, et al. ICF Core Sets for stroke. Journal of Rehabilitation Medicine. 2004;36(0):135-41.