Middle East J Rehabil Health. 2015 October; 2(4): e33274. doi: 10.17795/mejrh-33274
Published online 2015 October 28. **Research Article**

Comparison of Fine Motor Skills in Patients With Chronic Stroke in Final Stages of Bronestrum and Healthy Adults

Mina Sadat Mirshoja,[1] Ali Akbar Pahlevanian,[1,*] and Mohammad Amoozadeh Khalili[1]

[1]Neuromuscular Rehabilitation Research Center, Department of Occupational Therapy, Semnan University of Medical Sciences, Semnan, IR Iran

*Corresponding author: Ali Akbar Pahlevanian, Neuromuscular Rehabilitation Research Center, Department of Occupational Therapy, Semnan University of Medical Sciences, Semnan, IR Iran. Tel: +98-2333654180, E-mail: alipahlevanian@yahoo.com

Received 2015 September 1; **Revised** 2015 September 15; **Accepted** 2015 October 15.

Abstract

Background: One of the main problems of chronic stroke patients is the inability to move the fingers separately despite the passing of an extended period of time since the onset of the disease. Dexterity is a fine motor skill that allows one to manipulate objects through voluntary movement.

Objectives: The aim of this study was to compare the fine motor skills of patients with chronic stroke to those of healthy controls.

Patients and Methods: This analytic and descriptive cross-sectional study was carried out randomly on 50 patients with chronic stroke with a mean age of 57.8 years suffering for 46 - 72 months and on 50 healthy people with a mean age of 51.16 years. Patients did not receive any intervention before or after one week of assessment. The function of both hands of each patient was measured with the nine-holepegtest (NHPT) and the box and block test (BBT).

Results: The results showed that the mean variation of speed in the BBT test (standard deviation [SD]) in the left hands of the patients (recessive limb) was 57.8 (12.75), greater than in their right hand (dominant limb) (54.76 [8.67]). The rate of speed in healthy people's right hands was 68.58 (8.31), greater than in their left hands (63.5 [8.54]). In addition, the results of the NHPT showed that the stroke patients needed more time to manipulate the objects than the healthy ones. For the NHPT, the mean (SD) of the right hand (dominant limb) patients (4.89) and healthy controls 36.7 (14.5) 21.98, mean (SD) of the left hand (dominant limb) patients (4.45) and 30.4 in healthy subjects (4.09) 24.18 respectively. Independent T-test showed $P < 0.05$ in all the results obtained, respectively.

Conclusions: The results showed that the dexterity fingers of patients suffering from stroke at the final stages of Bronestrum is much closer to the dexterity of healthy controls.

Keywords: Fine Motor Skills, Chronic Stroke, Healthy Adults

1. Background

Stroke is one of the most debilitating neurological disorders among adults. It is the third leading cause of mortality (after cardiovascular disease and cancer), and it is the cause of 10% of mortalities in the world. Over 50% of stroke patients suffer from sensory and movement impairment in the limbs of the affected side. One of the main problems of chronic stroke patients is inability to move the fingers separately despite the passing of an extended period of time since the onset of the disease. The function of the upper limbs is very important to maintain quality of life. Two to three years after the onset of chronic stroke, 25% - 45% of patients experience some improvement in motor function. It is reported that 45% of them suffered from poor function of the upper limbs after four years (1).

The function of the upper limbs results from sensory and motor skills. Motor skills are divided into coarse and fine movements. Dexterity is a form of fine motor skill that allows one to manipulate objects through voluntary movements. Manipulation of objects means checking out and transferring the object between the fingers. Yancosek KE et al. showed that dexterity skills are one of the predictors of independence in one's daily activities (2). Subordinate skills allow one to control objects using the fingers (3), which is important because it affects the ability to use fine motor skills in daily activities, such as unscrewing toothpaste cap, knitting, writing, and many other home and work activities. Disability in these activities causes dependence, emotional changes, and depression and leads to reduced quality of life (4).

Various evaluations such as the grooved pegboard test, the Jebsone Taylor test of hand function, the functional dexterity test, and the Moberg pick-up test are used to assess dexterity skills (2). In this study, the box and block test (BBT) and the nine-hole peg test (NHPT) were used. With time and effective rehabilitation, the function of upper limbs after stroke can improve. However, many people may refuse to participate in ongoing rehabilitation programs. Many studies have been carried out to determine the norms of dexterity and the speed of healthy subjects' hands (5). However, no study has been conducted in order to examine the fine motor skills of patients with chronic stroke in the final stages of Bronestrum.

2. Objectives

This study compared fine motor skills in patients with chronic stroke in the final stages of Bronestrum with those of healthy adults. The aim of this study was to investigate whether the dexterity of chronic stroke patients in the final stages of Bronestrum is sufficient to independently perform daily fine motor activities, to the point that rehabilitation programs may not be necessary.

3. Patients and Methods

This is a descriptive, cross-sectional, randomized study carried out on patients referred to clinics in Tehran. Inclusion criteria were as follows: patient has experienced their first stroke, at least five years have passed since the initial injury, the patient has no unilateral spatial neglect (Star – cancellation > 44), the patient meets minimum standards for mobility of the upper limbs basedon the Bronestrum test (stage five or higher), and the patient is between 45 and 60 years old. Exclusion criteria were as follows: a muscle tone score for the disabled hand of greater than one based on the Ashworth scale (6), presence of pathology according to the Mini-Mental State Examination (MMSE) (score of higher than 21), absence, and lack of desire to continue the treatment.

Participants gave written consent in accordance with the standards of the Ethics Committee of the Shahid Beheshti University of Medical Sciences. The participants were then informed of the purpose of the study and of how the tests would be performed. The performance of both hands in each participant was measured using the nine-hole peg test (NHPT) and the box and block test (BBT).After doing one practice session, the patients were asked to perform the BBT followed by the NHPT as much as possible at a high speed in one session. After the scores were recorded, they were announced to the participants.

The BBT assesses the functional ability and the speed of the hand in picking up and dropping beads on the other side of the box. In this study, when the first bead was picked up, the therapist started the stopwatch. After 60 seconds, the beads that had been moved to the other side of the box were counted (7, 8). A reliability test retesting these tools was conducted in patients with stroke (results: 0.97 - 0.89) (6).

The NHPT assesses fine motor skills and performance speed. In this study, the participant was asked to put nine small beads in particular locations on the pegboard as quickly as possible. As soon as the last bead was put in place, the participant removed them one by one. The reaction time (from picking up the first bead to placing the last one) was recorded by the therapist (9). The test-retest reliability of the test was obtained (0.83 - 0.99) in the chronic stroke participants (6).

3.1. Data Analysis

A T-test was used to compare the means of the data. All data were analyzed using SPSS, version 18.

4. Results

In this study, 50 patients with chronic stroke and in the final stages of Bronestrum, with a mean age of 57.8years and a duration of suffering of 46 - 72 months were evaluated alongside50 healthy controls with a mean age of 51.16 years. Equality of variables, the Chi-square test for uniformity between patients and healthy cases in terms of gender distribution, disabled hand and healthy one andan independent T-test were used to investigate the consistency of two groups of patients and healthy ones in age, duration of suffering from stroke and cognitive status was done. Because P < 0.05, the results show that both groups were equal in the above variables. Demographic information for each group is displayed in Tables 1 and 2.

Table 1. Distribution of Demographic Information for Patients (N = 50)

Variable	Chronic Stroke Participants	Normal Participants	P Value
Gender			< 0.001
Male	28 (56)	28 (56)	
Female	22 (44)	22 (44)	
Total	50 (100)	50 (100)	
Dominant hand			< 0.001
Right	49 (98)	49 (98)	
Left	1 (2)	1 (2)	
Total	50 (100)	50 (100)	

Table 2. Mean and Standard Deviations of Age, Duration of Disease, and Cognitive Tests Between the Two Groups (N = 50)

Variable	Chronic Stroke Participants	Normal Participants	P Value
Age, y	57.8 ± 9.45	51.16 ± 7.78	< 0.001
Mini-Mental State Examination (MMSE)	25.5 ± 2.77	29.4 ± 6.3	< 0.001
Total	50	50	

Table 3. Mean and Standard Deviation of the Variables in BBT and NHPT Between the Two Groups (N = 50)

Variable	Chronic Stroke Participants		Healthy Participants		P Value
	Mean	Range	Mean	Range	
Box and blocktest (BBT)					
Dominant hand (right)	54.76 ± 8.67	34 - 81	68.58 ± 8.31	47 - 80	< 0.001
Non-dominant hand (left)	57.8 ± 12.75	30 - 82	63.5 ± 8.54	44 - 85	< 0.001
Nine-hole peg test (NHPT)					
Dominant hand (right)	36.7 ± 4.89	25 - 48	21.98 ± 5.14	14 - 37	< 0.001
Non-dominant hand (left)	30.4 ± 4.45	18 - 43	24.18 ± 4.09	16 - 30	< 0.001

According to the results displayed in Table 3 (below), the mean difference BBT in the speed of patients hands with the left hand (recessive limb) was higher than their right one (dominant limb). This is most likely because, with the exception of one participant, all participants were right handed, and the stroke patients' dominant hands had been affected by disease. In addition, the mean difference of BBT in speed of healthy people's hands in the right hand was higher than in the left hand. As in BBT, the number of beads thrown beyond the box were counted, the larger the figures the more BBT test beads will be. Thus, in stroke patients, it can be said that the non-affected hand, despite being the recessive limb, had better performance than the right hand (the dominant limb).This reflects the impact of the disease on upper limb function and especially on fine motor skills. On the other hand, in healthy participants, the right hand (dominant limb) performed better than the left hand (recessive limb), which was the expected result.

The results of this study also showed that the hand speed of normal participants was higher than that of chronic stroke participants. The results of mean difference in NHPT showed that stroke patients needed more time to manipulate the objects than healthy participants. In chronic stroke participants, the speed of their unaffected limb was faster than that of their affected limb. The results of this test confirm the findings of the BBT test. In addition, in healthy participants, the speed of the dominant hand was greater than that of the recessive hand, as expected.

5. Discussion

Fine motor skills involve the small muscles of the hand. Musculoskeletal integration and coordination among the fingers are required for powerful and precise movements. The keys to restoring the fine motor skills of the fingers are exercises and repetitive activities. After passing the acute phase and separating out the parts of the synergistic pattern, fine and elegant skills of the arm, wrist, and fingers are started. Based on the results displayed in Table 3 and the obvious difference in upper extremity function between chronic stroke patients and healthy individuals, it cannot be claimed that lack of treatment is a cause of improvement. On the contrary, this study showed that time, rehabilitation activities, and performing repetitive daily activities improved patient hand performance. Patient fears of dependency and of lack of effective hand use were also reduced.

Fine motor skills are enhanced in various ways. In addition to rehabilitation activities, daily activities such as buttoning a shirt and peeling fruit aid in recovery. Stabilizing the muscles around the joint and improving hand-eye coordination are also very important for accurate motion (4, 9). The results of this study showed that although stroke affects the upper limbs, effective use of the affected limb can be restored through rehabilitation and daily activities. Higgins et al. also concluded that damage to the fine motor skills of the hand after stroke can be remedied by timely treatment (10). In a review study, Oujamaa et al. also showed that rehabilitation interventions after stroke improve the function of upper limbs (11).

Repeated and intentional performance of exercises, receiving visual feedback on how to move, learning by imitation, learning under supervision, trial and error, and eventually reinforcement learning lead to changes in muscle memory. Self-organization in neuromotor learning, improved hand movements, and repetition training lead to reduced activity of the spastic muscles (12).

A study carried out on 39 people with chronic stroke, Paquin et al. investigated the effects of computer games on fine motor skills during 16 sessions conducted twice a week for 15 minutes at a time. They discovered that computer games contribute to finger dexterity and enhance movement speed (13). Applicable tools are also found in the home. This study showed that doing many daily activities and using appliances improved hand function. Therefore, if a stroke patient refuses rehabilitation services ordered by a rehabilitation specialist or physician, there may be no cause for concern if they use home activities to aid in recovery.

Villeneuve et al. found that playing the piano also provides rehabilitation (14). In another study, Sunderland investigated unilateral dexterity skills after stroke. He found that spontaneous recovery often occurs after six months. However, those with damage to the right hemisphere of the brain tend to have significantly better recovery than those with damage to the left hemisphere (13). Chen et al. examined differences in five functions in stroke patients: picking up, dropping, and manipulating. They measured the hand performance of 62 individuals, conducting tests three times over three to seven days using the BBT and NHPT tests. They found that errors were reduced with repetition. However, the ability of the affected hand was still found to be less than that of the normal hand (15).

Lateralization priority of an organ refers to repeated application of the one-sided organs such as hands, feet, eyes, and ears in daily activities. Priority of lateralization is related to mental, verbal, and motor development (16). Thus the involvement of one of the brain hemispheres, each of which is the base of functioning for the opposite side of the body, affects manual skills.

It is obvious that hand skills are better when using the fingers of the dominant side. However, some forms of damage such as fractures, burns, and diseases of the peripheral and central nervous system may affect the function of the limbs on one side of the body. Stroke is one of these forms of damage. This study showed that the dominant hand performs better than the recessive hand in healthy people, but that this may not be the case in chronic stroke patients. Inspite of the priority of the limb due to motor-sensory involvement, coordination, motion range and other factors affecting the hand, due to the damage resulting from the individual's disease, stroke patients may prefer to use the recessive hand, therefore leading to better performance in the recessive limb. Unnatural tone and limited range of motion also affect the performance of the dominant hand. However, the average scores obtained in comparison with healthy people are not very different, which shows that they can become depend chronic dentin their many daily activities. Many people believe that if stroke becomes chronic, there is no need for rehabilitation services. However, some people tend to do the finer performance in their hands. People who took part in this study were in the final stages of hand performance on the basis of the Bronestrum criteria, and they had not received any treatment for a long time. At first glance, it is obvious that the upper limb function of stroke patients is compromised. However, this study showed that with time, rehabilitation activities, and repeated daily activities, upper limb function can improve. Patient fears of dependency and of lack of effective hand use can also be reduced.

In one study by Mathiowetz et al. they evaluated the norms of fine motor skills in the fingers using the NHPT (17), and in another study, they evaluated the norms of fine motor skills in the fingers using the BBT (5). They also showed that mean scores of hand performance vary by age. The mean scores obtained in healthy people in this study are consistent with those found in previous studies. Unfortunately, the exact number was not available by age in people with stroke and this affected the ability to compare the results. The test-retest reliability was not measured for all people in this study. Therefore, it is suggested that the tests used in this study be more thoroughly evaluated in future studies.

This study showed that there were differences in dexterity between patients in the final stages of stroke recovery and healthy people. However, the chronic stroke patients evaluated in this study were able to function independently in their daily activities unless further neurological damage occurred. This study used tools that measure the most delicate motor skills of the fingers, including the opposition of the thumb with the other fingers. These tools were also used to assess the speed of hand performance. Hence, the caregivers and even patients could see that the manual dexterity of the chronic stroke patients was for some reason closer to that of healthy ones. In addition, the probability of these chronic stroke patients requiring treatment is low. It could also be that in these chronic stroke patients, the motor skills of the recessive hand became more similar to those of the dominant limb in healthy patients because stroke patients often have to use their non-dominant hand.

Acknowledgments

This study is part of a post graduate thesis (2013 - 2014) in thefield of occupational therapy (MSc.). I would like to offer my thanks to all who helped me in this study.

Footnotes

Authors' Contribution: Study concept and design: Mina Sadat Mirshoja; acquisition of data: Mina Sadat Mirshoja, Ali Akbar Pahlevanian; analysis and interpretation of data: Mina Sadat Mirshoja; drafting of the manuscript: Mina Sadat Mirshoja, Mohammad Amoozadeh Khalili; critical revision of the manuscript for important intellectual content: Mina Sadat Mirshoja; statistical analysis: Mina Sadat Mirshoja, Mohammad Amoozadeh Khalili; administrative, technical, and material support: Mina Sadat Mirshoja; study supervision: Mina Sadat Mirshoja.

Funding/Support: Funding was provided by neuromuscular research center, school of rehabilitation, Semnan University of Medical Sciences.

References

1. Au-Yeung SS, Hui-Chan CW. Predicting recovery of dextrous hand function in acute stroke. *Disabil Rehabil.* 2009;**31**(5):394–401. doi: 10.1080/09638280802061878. [PubMed: 18608431]
2. Yancosek KE, Howell D. A narrative review of dexterity assessments. *J Hand Ther.* 2009;**22**(3):258–69. doi: 10.1016/j.jht.2008.11.004. [PubMed: 19217254]
3. Oxford Grice K, Vogel KA, Le V, Mitchell A, Muniz S, Vollmer MA. Adult norms for a commercially available Nine Hole Peg Test for finger dexterity. *Am J Occup Ther.* 2003;**57**(5):570–3. [PubMed: 14527120]
4. Pendleton HM, Schultz-Krohn W. *Pedretti's occupational therapy: practice skills for physical dysfunction.* New York: Elsevier Health Sciences; 2013.
5. Mathiowetz V, Volland G, Kashman N, Weber K. Adult norms for the Box and Block Test of manual dexterity. *Am J Occup Ther.* 1985;**39**(6):386–91. [PubMed: 3160243]
6. Borstad AL, Bird T, Choi S, Goodman L, Schmalbrock P, Nichols-Larsen DS. Sensorimotor training and neural reorganization after stroke: a case series. *J Neurol Phys Ther.* 2013;**37**(1):27–36. doi: 10.1097/NPT.0b013e318283de0d. [PubMed: 23399924]
7. Slota GP, Enders LR, Seo NJ. Improvement of hand function using different surfaces and identification of difficult movement post stroke in the Box and Block Test. *Appl Ergon.* 2014;**45**(4):833–8. doi: 10.1016/j.apergo.2013.10.014. [PubMed: 24239565]
8. Lang CE, Bland MD, Bailey RR, Schaefer SY, Birkenmeier RL. Assessment of upper extremity impairment, function, and activity after stroke: foundations for clinical decision making. *J Hand Ther.* 2013;**26**(2):104–14. doi: 10.1016/j.jht.2012.06.005. [PubMed: 22975740]
9. Earhart GM, Cavanaugh JT, Ellis T, Ford MP, Foreman KB, Dibble L. The 9-hole PEG test of upper extremity function: average values, test-retest reliability, and factors contributing to performance in people with Parkinson disease. *J Neurol Phys Ther.* 2011;**35**(4):157–63. doi: 10.1097/NPT.0b013e318235da08. [PubMed: 22020457]
10. Higgins J, Mayo NE, Desrosiers J, Salbach NM, Ahmed S. Upper-limb function and recovery in the acute phase poststroke. *J Rehabil Res Dev.* 2005;**42**(1):65–76. [PubMed: 15742251]
11. Oujamaa L, Relave I, Froger J, Mottet D, Pelissier JY. Rehabilitation of arm function after stroke. Literature review. *Ann Phys Rehabil Med.* 2009;**52**(3):269–93. doi: 10.1016/j.rehab.2008.10.003. [PubMed: 19398398]
12. Motamedvaziri P, Bahrpeyma F, FiroozAbadi M, Shamili A, Forough B. Comparision of rehabilitation plus joystick verses routine rehabilitation treatment on hand muscles stiffness in hemiplegic patients. *J Gorgan Univ Med Sci.* 2014;**16**(3):1–8.
13. Paquin K, Ali S, Carr K, Crawley J, McGowan C, Horton S. Effectiveness of commercial video gaming on fine motor control in chronic stroke within community-level rehabilitation. *Disabil Rehabil.* 2015;**37**(23):2184–91. doi: 10.3109/09638288.2014.1002574. [PubMed: 25586794]
14. Villeneuve M, Lamontagne A. Playing piano can improve upper extremity function after stroke: case studies. *Stroke Res Treat.* 2013;**2013**:159105. doi: 10.1155/2013/159105. [PubMed: 23533954]
15. Chen HM, Chen CC, Hsueh IP, Huang SL, Hsieh CL. Test-retest reproducibility and smallest real difference of 5 hand function tests in patients with stroke. *Neurorehabil Neural Repair.* 2009;**23**(5):435–40. doi: 10.1177/1545968308331146. [PubMed: 19261767]
16. Faiazi Barjini L, Zandi B. The Relationship between laterality and the situation with regard to academic performance of students with autism. *Modern Rehabil.* 2013;**6**(4):58–64.
17. Mathiowetz V, Weber K, Kashman N, Volland G. Adult Norms for the Nine Hole Peg Test of Finger Dexterity. *Occup Participat Health.* 1985;**5**(1):24–38. doi: 10.1177/153944928500500102.