Relationship and Responsiveness of Three Outcome Measures of Upper Limb Motor Function after Stroke Rehabilitation

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Ethics approval: Institutional Ethics Committee for Human Research (IECHR) Medical College & SSG Hospital, Baroda approved this study. All participants gave written informed consent before data collection began.

Abstract: ***Objective:*** ***To find the assessment tool which can be incorporated as a part of regular assessment by which therapist can plan their treatment protocol effectively as well as measure the recovery of intervention.*** ***Subjects and Methods:*** ***45 subjects diagnosed with stroke onset at least 6 months previously were assigned to study. Intervention in form of Conventional, bilateral arm training and task specific training were given for 3 weeks. Upper extremity function tests were evaluated by Wolf Motor Function Test (WMFT), Chedoke Arm and Hand Activity Inventory (CAHAI) and Action Research Arm Test (ARAT) pre-and post-treatment. Relationship and responsiveness of all clinical tests were performed by Spearman's correlation coefficient and Paired-t test respectively.*** ***Result:*** ***All correlations were significant at 95% C.I. at baseline as well as three-week time. The highest correlation was found between CAHAI and WMFT which was 0.637. Responsiveness of all three outcomes was significant at 95% C.I. The responsiveness of CAHAI was significantly higher of mean difference 10.533 at 95% C.I (10.06to10.99) compared to WMFT and ARAT.*** ***Conclusion:*** ***CAHAI can be included in regular part of assessment which is having good clinimetric properties and assesses bilateral arm activities and actual performance of patient.***

Keywords: stroke, upper extremity, outcome measure, rehabilitation

1. Introduction

Most stroke survivors suffer persistent impairment of upper extremity (UE) movement. At 6 months, post-stroke, 38% of patients regained some dexterity in manipulative task but only 11.6 % reached a complete recovery in dexterity of paretic hand. [1]Reaching and grasping objects is a component of many daily activities that require use of the upper extremity. At the shoulder-elbow, post stroke impairments include decreased muscle activation and weakness[2],[3],[4],[5],[6],[7],[8],[9],[10],[11]abnormal neural synergies between shoulder and elbow muscles that limit range of motion (ROM) [12],[13],[14]disrupted interjoint coordination, [15],[16].[17],[18] decreased smoothness of movement,[19],[20],[21] and dyscoordination between reach and grasp movements.[22] Therefore; improvement in dexterous function to promote functional recovery is major goals of stroke rehabilitation. Accurate assessment of motor function is important for documenting the outcome of rehabilitation programs and is also used to match patients to appropriate interventions, to compare the results of interventions across patients and among facilities, to improve resources and to determine personnel needs.[23]Therefore,aim of the study was to find the assessment tool which can be incorporated as a part of regular assessment by which therapist can plan their treatment protocol effectively as well as measure the recovery of intervention

2. Literature Survey

Various contemporary rehabilitation strategies which aim to improve upper extremity motor deficits after stroke based on repetitive practice, such as task specific training(TST)[24],[25] and bilateral arm training (BAT)[26],[27]have come into wide use. Critical evaluation of the effects of these intervention strategies requires measures that have good clinimetric properties (eg. reliability, validity, and responsiveness) in assessing upper extremity motor function[28]; but it is essential that clinicians and researchers need to identify appropriate measures that have sound clinimetric properties to determine the effects of UE training on dexterity of the paretic hand. The Chedoke Arm and Hand Activity Inventory test (CAHAI), Action Research Arm Test (ARAT), and Wolf Motor Function Test (WMFT) have been widely used as assessment tool of motor recovery in stroke rehabilitation research, including TST and BAT trials. However, responsiveness i.e. sensitivity to change among these clinical tests after interventions remains imprecise, and there is no gold standard outcome measure for UE motor function in stroke patients.

Till now relative capacity among CAHAI, ARAT and WMFT to detect a change in dexterous function of patient with stroke after intervention remains unclear. Therefore, the goal of this study was to investigate and compare the responsiveness and relationship of the CAHAI, ARAT, and WMFT for motor recovery in patients after stroke rehabilitation

3. Method

Design:

Pre- and Post-intervention comparison of three different outcomes conducted to find out responsiveness and relationship among clinical tests.

Participants and recruitment:
Institutional Ethics Committee for Human Research (IECHR) MEDICAL COLLEGE & SSG HOSPITAL, BARODA approved this study. All participants gave written informed consent before data collection began. 45 participants were recruited in the study fulfilling inclusion and exclusion criteria from physiotherapy O.P.D-16, S.S.G Hospital, Vadodara. Participants were referred from the Neurology Outdoor Physiotherapy Department (O.P.D) to physiotherapy O.P.D-16, S.S.G. Hospital, Vadodara. Inclusion criteria were 1) Patient with diagnosis of stroke onset at least 6 months previously2) No excessive spasticity in the joints of the affected UE (Modified Ashworth Scale score equal or less than 2 in each joint) 3) Demonstration of Brunnstrom stage IV to VI for the proximal and distal UL 4) Ability to give follow up 5) No severe deficits in communication, memory and understanding (Mini Mental State Examination (MMSE) score > 23).

Intervention:
Participants received therapies in form of Conventional Therapy, Bilateral Arm Training (BAT) and TASK SPECIFIC TRAINING (TST). Conventional therapy like Stretching of the more affected muscle group, Strength training, Coordination and functional task practice, BAT included 1) lifting two glasses simultaneously 2) picking up two blocks simultaneously 3) reaching forward or upward to move block 4) reaching and grasping two towels and task specific training included 1) opening and closing the jar and 2) lift up and throw the ball. Duration for conventional therapy was 20 min; bilateral arm training was 20 min and task specific training for 15 min. So, treatment session consists of 1 hour per day 6 times a week for 3 weeks (18 sessions).

Outcome measures:
Post-stroke participants fulfilling the inclusion criteria were selected and assessed before start of intervention. The assessment tools used in study were functional outcome measures: CAHAI, WMFT and ARAT.

1) The CAHAI consists of 13 real-life functional tasks, which assess bilateral activities; non–gender-specific items; the full range of normative movements, pinches, and grasps; and the various stages of motor recovery post stroke on 7-level activity scale.[29]
2) The ARAT assesses the ability to handle objects, with 19 items divided into 4 subscales of grasp, grip, pinch, and gross movement by using a 4-level ordinal scale ranging from 0 (no movement) to 3 (normal movement).[30]
3) The Wolf Motor Function Test (WMFT) was originally developed to assess the impact of forced use on upper extremity function. The WMFT contains 17 tasks (15 function-based and 2 strength-based).[31]

To avoid deterioration of the function due to fatigue, tests will be evaluated on different consecutive days and then after intervention is given. Post-intervention outcomes are assessed in same sequence for consecutive days.

Data analysis:
All the tests and calculations were performed using SPSS 16.0 software. To determine how the three functional outcome measures are related to each other, "Spearman's correlation coefficient" was performed at baseline and end of 3 weeks. Correlations between 0 and 0.25 were considered low; those between 0.25 and 0.5 were considered fair; those between 0.5 and 0.75 were considered moderate to good; and those greater than 0.75 were considered good to excellent.[32]Paired t-test was used to determine responsiveness of the 3 outcome measures from pre- to post-treatment of 3 weeks. Higher the mean difference considered more responsive to change.

4. Results

Table 1 lists the demographic and clinical characteristics of the 45 participants recruited in this study. All patients were subjected to a standardized interview including details regarding. No excessive spasticity in the joints (shoulder and elbow) of the affected UE and demonstrated Brunnstrom stage IV to VI for the proximal and distal UL.

Results showed that the clinical tests were fairly to strongly correlate with each other on both measurements. At baseline, all correlations were significant at 95% C.I. shown in table 2. The highest correlation was found between CAHAI and WMFT which was 0.902 consider as excellent (or strong) correlation. The lowest correlation was found between ARAT and WMFT which was 0.345 consider as fair correlation. At 3-week point; all correlations were significant at 95% C.I. shown in table 3. The highest correlation was found again between CAHAI and WMFT which was 0.637 consider as moderate to good correlation. The lowest correlation was found between ARAT and CAHAI which was 0.335 consider as fair correlation. Overall, the correlation coefficients between pairs of clinical tests were generally similar at both time points, indicating that the relationships between tests remain stable over the period.

The responsiveness indices of the 3 outcome measures are shown in Table 4. Responsiveness of all three outcomes from pre-treatment to post-treatment was significant at 95% C.I. The responsiveness of CAHAI was significantly higher of mean difference 10.533 (10.06to10.99) compared to WMFT and ARAT. The sensitivity to change was lowest for WMFT of mean difference 5.000(4.72to5.27) compared to CAHAI and ARAT.

5. Discussion

Recovery of dexterous function is essential part of stroke rehabilitation as per Bobath's concept. But there is no significant study which has proved a standard tool for assessment of dexterous function of upper limb. Selection of outcome with good clinimetric properties is crucial part of assessment.

Correlations between Clinical Tests
Present study examined whether the clinical tests were correlated to each other. Results showed that the clinical tests were fairly to strongly correlate with each other on both time points. Based on interpretation at baseline it was found strong correlation found between CAHAI and WMFT and lowest correlation found between ARAT and WMFT. At end of three week also highest correlation exists between

CAHAI and WMFT and other correlation were also fair to moderate. The correlation coefficients between pairs of tests were generally similar at both time points, indicating that the relationships between tests remain stable over the period. Susan R. Barreca et al. showed high correlation exist between CAHAI and ARAT [33], present study also shows similar result fair to moderate correlation was found between CAHAI and ARAT. Correlation between ARAT and WMFT was found fair in this study. Correlation data of this study were different from Rinske Nijland et al.; they reported Spearman's rank correlation coefficients ranged from 0.70 to 0.86 which is strong correlation between ARAT and WMFT. [34]This discrepancy in result may be due to difference in recruitment and sequential assessment of patients. They included mild to moderate stroke patient and inclusion not reveal about stroke onset and present study was done with patients with chronic (more than six months) stroke.

Responsiveness of the Clinical Tests:

A responsive instrument used as an outcome measure in clinical trials should be able to detect change with improvement or deterioration and distinguish effective or ineffective treatments. [35] In this study responsiveness of all three outcomes with respect of pre- to post-intervention were highly significant at 95% confidence interval using Paired 't' test. The responsiveness of CAHAI was significantly higher of mean difference 10.533 ($p<0.000$) compared to WMFT and ARAT. The responsiveness WMFT was lowest of mean difference 5.000($p<0.000$) compared to CAHAI and ARAT.This study favors the result of previously published studies; Susan R. Barreca et al. tested whether the CAHAI was more sensitive to change in upper-limb function than the Impairment Inventory of the Chedoke-McMaster Stroke Assessment (CMSA) and the Action Research Arm Test (ARAT). They found that CAHAI is more sensitive to clinically important change than the ARAT. [36]Barreca SR, et al. compared 2 versions of the Chedoke Arm and Hand Activity Inventory with the Action Research Arm Test. They concluded that both versions demonstrated more sensitivity to change than that of ARAT .[37]This study also determines that CAHAI demonstrate higher responsiveness i.e. sensitive to change following treatment as compared to ARAT. The result can be thought as CAHAI evaluates actual performance of patient and take in consideration both arms in performing activities. Yu-wei Hsieh et al. studied Responsiveness and validity of FMA, ARAT, and WMFT and concluded that responsiveness of FMA and ARAT was significantly higher than WMFT index. [38] Present study also shows similar result, responsiveness of ARAT is higher as compared to WMFT.Many assessments for upper extremity (UE) function after stroke have been published in the literature. However, they vary considerably in their focus, and a golden standard is lacking. Therefore, the selection of a proper assessment tool is a complex process. CAHAI assess both aspect of hand function; one arm for stabilizing and other for manipulating activity. The CAHAI consists of 13 real-life functional tasks that reflect (1) the domains deemed important by survivors of stroke; (2) bilateral activities; (3) non–gender-specific items; (4) the full range of normative movements, pinches, and grasps; and (5) the various stages of motor recovery post stroke.[29] Therefore, CAHAI is a functional outcome measure that assesses overall function of upper limb and takes in consideration every aspect of assessment and so, it is sensitive to clinically important change, incorporates patient- preferences and provides an accurate and relevant measure of clinical change.The main advantage of the ARAT is its ability to evaluate multiple tasks of varying complexity for a more comprehensive assessment of UL movement abilities. Its main limitations are that it is time-consuming to administer and requires standardized equipment.The WMFT is preferable to the commonly used UE performance tests because it tests a wide range of functional tasks (i.e., from simple to complex) and explores both performance time and quality of movement. Because half of the items on the WMFT involved simple limb movements without assessing functional task and so it not reveals the actual functional capacity of ADL.

From present study, we concluded that all the three clinical tests found to be having significant responsiveness; out of all CAHAI possess highest responsiveness. Strongest correlation was found between CAHAI and WMFT at both time points. So, CAHAI can be included in regular part of assessment which is having good clinimetric properties and assesses bilateral arm activities and actual performance of patient.This information will be useful to carry out evidence-based practice for clinicians and research purpose.

6. Conclusion

All the clinical tests were fairly to strongly correlate with each other at both time of assessment. Strongest correlation found between CAHAI and WMFT. Overall, the correlation coefficients between pairs of tests were generally similar at both time points, indicating that the relationships between tests remain stable over the period of time.

All three clinical tests are suitable to detect changes over the course of interventions. CAHAI showed highest responsiveness as compared to ARAT and WMFT. This information helps the clinicians and researchers in making decisions to choose appropriate tests for measuring hand dexterity in people receiving stroke interventions.

7. Future Scope

- Study should be conducted with appropriate calculated sample size.
- Study should include specific intervention to rule out the limitation favouring of one assessment tool over other
- 3-week intervention might limit the recovery of dexterous function. A longer time to detect improvements in dexterity may be needed.

References

[1] Kwakkel G , Kollen BJ, Van der Grond J, Prevo AJ. Probability of regaining dexterity in the flaccid upper limb: Impact of severity of paresis and time since onset in acute stroke. Stroke. 2003;34(9):2181–86. [PMID: 12907818]

[2] Kibler, W.B. (1998) the role of the scapula in athletic shoulder function. *The American Journal of Sports Medicine*, **26** (2), 325–337.

[3] Zackowski KM, Dromerick AW, Sahrmann SA, Thach WT, Bastian AJ. How do strength, sensation, spasticity and joint individuation relate to the reaching deficits of
[4] people with chronic hemiaresis? *Brain.* 2004;127:1035–1046.
[5] Gowland C, deBruin H, Basmajian JV, Plews N, Burcea I. Agonist and antagonist activity during voluntary upper-limb movement in patients with stroke. *Phys Ther.* 1992;72(9):624–633.
[6] Wagner JM, Lang CE, Sahrmann SA, Hu Q, Bastian AJ, Edwards DF, Dromerick AW. Relationships between sensorimotor impairments and reaching deficits in acute hemiparesis. *Neurorehabil Neural Repair.* 2006;20(3):406–416.
[7] McCrea PH, Eng JJ, Hodgson AJ. Saturated muscle activation contributes to compensatory reaching strategies after stroke. *J Neurophysiol.* 2005;94(5):2999–3008.
[8] Canning CG, Ada L, Adams R, O'Dwyer NJ. Loss of strength contributes more to physical disability after stroke than loss of dexterity. *Clin Rehabil.* 2004;18(3):300–308.
[9] Mercier C, Bourbonnais D. Relative shoulder flexor and handgrip strength is related to upper limb function after stroke. *Clin Rehabil.* 2004;18(2): 215–221.
[10] Canning CG, Ada L, O'Dwyer N. Slowness to develop force contributes to weakness after stroke. *Arch Phys Med Rehabil.* 1999;80(1):66–70.
[11] Bohannon RW, Warren ME, Cogman KA. Motor variables correlated with the hand-to-mouth maneuver in stroke patients. *Arch Phys Med Rehabil.*1991;72(9):682–684.
[12] Harris JE, Eng JJ. Paretic upper-limb strength best explains arm activity in people with stroke. *Phys Ther.* 2007;87(1):88–97.
[13] Lum PS, Burgar CG, Shor PC. Evidence for strength imbalances as a significant contributor to abnormal synergies in hemiparetic subjects. *Muscle Nerve*. 2003;27(2):211–221.
[14] Sukal TM, Ellis MD, Dewald JP. Shoulder abduction induced reductions in reaching work area following hemiparetic stroke: neuroscientific implications. *Exp Brain Res.* 2007;183(2):215–223.
[15] Dewald JP, Beer RF. Abnormal joint torque patterns in the paretic upper limb of subjects with hemiparesis. *Muscle Nerve.* 2001;24(2):273–283.
[16] Sangani SG, Starsky AJ, McGuire JR, Schmit BD. Multijoint reflexes of the stroke arm: neural coupling of the elbow and shoulder. *Muscle Nerve.* 2007;36(5):694–703.
[17] Cirstea MC, Mitnitski AB, Feldman AG, Levin MF. Interjoint coordination dynamics during reaching in stroke. *Exp Brain Res.* 2003;151(3):289–300.
[18] Reisman DS, Scholz JP. Workspace location influences joint coordination during reaching in post-stroke hemiparesis. *Exp Brain Res.* 2006;170(2): 265–276.
[19] Zackowski KM, Dromerick AW, Sahrmann SA, Thach WT, Bastian AJ. How do strength, sensation, spasticity and joint individuation relate to the reaching deficits of people with chronic hemiparesis? *Brain.* 2004;127(5):1035–1046.
[20] Beer RF, Dewald JP, Rymer WZ. Deficits in the coordination of multijoint arm movements in patients with hemiparesis: evidence for disturbed control of limb dynamics. *Exp Brain Res.* 2000;131(3):305–319.
[21] Rohrer B, Fasoli S, Krebs HI, et al. Movement smoothness changes during stroke recovery. *J Neurosci.* 2002;22(18):8297–8304.
[22] Krebs HI, Aisen ML, Volpe BT, Hogan N. Quantization of continuous arm movements in humans with brain injury. *Proc Natl Acad Sci USA.* 1999;96(8): 4645–4649.
[23] Fang Y, Yue GH, Hrovat K, Sahgal V, Daly JJ. Abnormal cognitive planning and movement smoothness control for a complex shoulder/elbow motor task in stroke survivors. *J Neurol Sci.* 2007;256 (1-2):21–29.
[24] Granger CV. Foreword. In: Dittmar SS, Gresham GE, editors. Functional assessment and outcome measures for the rehabilitation professional. Gaithersburg (MD): Aspen; 1997. p ix x.
[25] KunjiShirahama, Masatoshi Gocyou, Tomomi Morita, Taeko Kitahashi. Development of a task-specific occupational therapy training menu for the improvementof upper limb function in stroke patients. Asian J OccupTher. 2016;12: 43-51.
[26] Sneha S. Khandare, R.M. Singarvelan, Subhash M. Khatri. Comparison of task specific exercises and mirror therapy to improve upper limb function in subacute stroke patient. Journal of Dental and Medical sciences. 2013;7: 2279-0861
[27] Cauraugh JH, Kim SB, Duley A. Coupled bilateral movements and active neuromuscular stimulation: intralimb transfer evidence during bimanual aiming. *Neurosci Lett*. 2005;382:39–44.
[28] Husted JA, Cook RJ, Farewell VT, Gladman DD. Methods for assessing responsiveness: a critical review and recommendations. *J Clin Epidemiol*. 2000;53:459–468.
[29] McCombe Waller S, Whitall J. Fine motor control in adults with and without chronic hemiparesis: baseline comparison to nondisabled adults and effects of bilateral arm training. *Arch Phys Med Rehabil*. 2004;85:1076–1083
[30] Barreca S, Gowland C, Stratford P, et al. (2004). Development of the Chedoke Arm and Hand Activity Inventory: Theoretical constructs, item generation, and selection. *Top Stroke Rehabil*; 11(4): 31-42.
[31] Lyle RC. A performance test for assessment of upper limb function in physical rehabilitation treatment and research. *Int J Rehabil Res*. 1981;4:483-492.
[32] Wolf Motor Function Test (WMFT) Manual UAB CI Therapy Research Group written by: Edward Taub, David M. Morris and Jean Cragowith contributions by:Danna Kay King, Mary Bowman, Camille Bryson, Staci Bishop, Sonya Pearson, Sharon E. Shaw
[33] Portney LG, Watkins MP. *Foundations of Clinical Research: Applications to Clinical Practice.* 1st ed. Norwalk, CT: Appleton & Lange; 1993.
[34] Susan R. Barreca, Paul W. Stratford et al. Test-Retest Reliability, Validity, and Sensitivity of the Chedoke Arm and Hand Activity Inventory: A New Measure of Upper- Limb Function for Survivors of Stroke. Arch Phys Med Rehabil Vol 86, August 2005

[35] RinskeNijland, Erwin van Wegen, et al. A comparison of two validated tests for upper limb function after stroke: the wolf motor function test and the action research arm test. J Rehabil Med 2010; 42: 694–696
[36] Guyatt GH, Deyo RA, Charlson M, Levine MN, Mitchell A. Responsiveness and validity in health status measure-ment: A clarification. J Clin Epidemiol. 1989;42(5):403–8.[PMID: 2659745] DOI:10.1016/0895-4356(89)90128-5
[37] Susan R. Barreca, Paul W. Stratford et al. Test-Retest Reliability, Validity, and Sensitivity of the Chedoke Arm and Hand Activity Inventory: A New Measure of Upper- Limb Function for Survivors of Stroke. Arch Phys Med Rehabil Vol 86, August 2005
[38] Barreca SR, et al. Phys Ther. 2006 studied "Comparing 2 versions of the Chedoke Arm and Hand Activity Inventory with the Action Research Arm Test" *Phys Ther*. 2006;86:245-253
[39] Yu-wei Hsieh, MS; Ching-yi Wu, ScD, OTR; Keh-chung Lin, ScD, OTR; Ya-fen Chang, MS "Responsiveness and Validity of Three Outcome Measures of Motor Function After Stroke Rehabilitation" *Stroke.* 2009;40:1386-1391

Table 1: Participants Characteristics

Characteristics	*Value*
AGE (yrs Mean ± SD)	51.86 (10.48)
GENDER	
Male	31 (69 %)
Female	14 (31 %)
BRUNNSTROM (MEDIAN)	5
MMSE (Mean ± SD)	26.33 (1.31)
At pre-treatment (Mean ± SD)	
CAHAI	40.93 (2.01)
WMFT	46.78 (2.62)
ARAT	38.91 (2.29)

SD- standard deviation, CAHAI- Chedoke Arm and Hand Activity Inventory test, ARAT-Action Research Arm Test and WMFT-Wolf Motor Function Test

Table 2: Correlation of Outcome Measures at Baseline

	CAHAI	WMFT	ARAT
CAHAI	1	0.902**	0.429**
p-value		0	0.003
WMFT	0.902**	1	0.345*
p-value	0		0.02
ARAT	0.429**	0.345*	1
p-value	0	0.02	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 3: Correlation of Outcome Measures at 3-Weeks Time Point

	CAHAI	WMFT	ARAT
CAHAI	1	0.637**	0.335*
p-value		0	0.024
WMFT	0.637**	1	0.407**
p-value	0		0.005
ARAT	0.335*	0.407**	1
p-value	0.024	0.005	

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table 4: Responsiveness of three Outcome Measures

Scales	Mean Difference	p-Value (95% C.I)
CAHAI	10.553	<0.001(10.06 to10.99)
WMFT	5.000	<0.001 (4.72 to 5.27)
ARAT	6.667	<0.001 (6.12 to 7.21)

CAHAI- Chedoke Arm and Hand Activity Inventory test, ARAT-Action Research Arm Test and WMFT-Wolf Motor Function Test

Figure 1: CAHAI (Cleaning pair of glasses)

Figure 2: WMFT (flipping the cards)

Figure 3: ARAT (grasping the block)

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