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A Comparative Study on the Effect of Proprioceptive based Training and Closed Kinematic Chain Exercise to Improve Upper Limb Function in Stroke Patients

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Abstract: ***Background: Patient with stroke frequently demonstrate problems with proprioception and hand function in their impaired limb and the recovery of these lost functions are the greatest challenge for the physical therapists. Hence alternate treatment regimens are needed to reduce the long term disability and functional impairment from UE hemiparesis. This study was to investigate the effect of proprioceptive based training and closed kinematic chain exercise to improve upper limb function in chronic stroke patients. Methods: 30 subjects satisfying the inclusion criteria were allocated to 3 groups of 10 members each. Group A received Proprioceptive based training along with conventional therapy, Group B received closed kinematic chain exercise along with Conventional physiotherapy and group C received Conventional Physiotherapy alone The participants were treated for 5 days in a week, for 3 weeks and each session lasted for approximately 50 minutes along with warm up and cool down phase before and after exercise respectively.. The subjects were assessed by Fuglmeyer scale for upper limb, Hand dynamometer and Goniometer. Results & Discussion: Statistical analysis was done using SPSS software. Significant improvement in all main outcome parameters was observed in response to the intervention. Between group analysis showed a statistical difference in favour of Closed Kinematic chain exercise, in the parameters of motor function, strength and Range of motion. Conclusion: Repetitive training using the Closed kinematic chain exercise will leads a significant improvement in upper limb function among stroke patients***

Keywords: Proprioception based training (PBT), Closed kinematic chain (CKC) exercise, Motor function, Strength, Range of motion

1. Introduction

Stroke is a global health problem and is a leading cause of adult disability. According to WHO stroke is defined as “rapidly developing clinical signs of focal (or global) disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin ”.[(1)]

Stroke is the fourth leading cause of death and long-term disability. Each year approximately 795,000 individual experiences a stroke. The incidence of stroke is about 1.25 times greater for males than females.[(2)] The Trivandrum Stroke Registry reveals that Stroke occurred at a median age of 67 years; only 3.8% of patients were aged 40 years.[(3)]

The ischemic stroke is the most common type and affecting about 80% of individuals with stroke and it is usually due to a clot blocks or impairs blood flow to the brain. Hemorrhagic stroke occurs when blood vessels rupture, causing leakage of blood in and around the brain.[(2)]

The significant risk factors for all strokes were history of hypertension, smoking, waist-to-hip ratio, diet, regular physical activity, diabetes mellitus, alcohol intake, psychosocial stress and depression, cardiac causes.[(4)] High blood pressure is the most important modifiable risk factor of stroke.[(5)]

The effects of a stroke depend on which part of the brain is injured and how severely it is affected. A very severe stroke can cause sudden death. More than 69% of cerebrovascular lesions provoke impairment of motor function to the upper limb. The functional impairment of the upper limb can impact negatively on quality of life and limit many activities of daily living.

The impairment of UE motor function following stroke is the most deliberating condition for the patients and the recovery of these lost functions are the greatest challenge for the physical therapists. UE may be more involved and demonstrate less complete recovery than the lower extremity in MCA stroke.[(2)]Patients with mild to moderate upper extremity paresis in acute phase have a good prognosis for functional recovery, as 71% of these patients achieve at least some dexterity at 6 months after stroke. Only 5% of patients who initially experienced complete paralysis achieve functional use of their arm. Upper extremity impairments chronically affect the functional independence and satisfaction in 50–70% of all stroke patients.[(6)]

Dysfunctions from UE paresis impairs performance of daily activities such as dressing, bathing, self-care and writing, thus reducing the functional independence. Hence alternate treatment regimens are needed to reduce the long term disability and functional impairment from UE hemiparesis. So rehabilitation of UE to restore the lost motor function within a maximum expected recovery is required

Patient with stroke frequently demonstrate problems with proprioception and hand function in their impaired limb. After stroke rehabilitation, many patients with MCA stroke can walk independently but there is a moderate to severe variation in the function of affected arm and hand. The stroke patient suffers from difficulties with fine motor coordination which consist of reaching, grasp, release and bilateral hand use.

Any soft tissue or joint injury can lead to alter the proprioception, kinesthesia and alter neuromuscular control. Re-establishing the efficient use of sensory information to initiate and control movement is a high priority in neurorehabilitation. In closed kinetic chain (CKC) exercise, the distal segment of the extremity is fixed, and proximal motion takes place in multiple planes. Closed kinetic chain exercise is thought to establish early proximal stability of the joint, providing a stable base for the upper extremity to function. Furthermore, CKC exercise may train the shoulder girdle musculature to appreciate its own static and dynamic functions.[7] Also, in closed chain exercise, sensory receptors in more muscles and intra-articular and extra-articular structures are activated to control motion than during open-chain exercises. The weight-bearing element (axial loading) of closed-chain exercises, which causes joint approximation, is believed to stimulate mechanoreceptors in muscles and in and around joints to enhance sensory input for the control of movement.[8]

The proprioceptive based training enhances the voluntary contraction of the muscles and it is based on the principles of motor learning such as repetition of task with concurrent use of feedbacks. Now a days, compared to other modalities bilateral training has received outstanding attention. The bilateral training is a method of execution of repetitive tasks with both (affected and unaffected) upper extremity. The bilateral movement allows optimizing the activation-inhibition balance between the two hemispheres and this may cause the reduction of excitability of the healthy hemisphere and can help to improve motor function of the paretic limb after stroke.[9]

There are studies performed on closed kinematic chain exercise which resulted in significant functional improvement of lower limb in stroke patients but fewer literatures are available on its effect in upper limb. Moreover studies proved that PBT exercise enhances the proprioception in stroke patients. So in this study we are comparing the effect of proprioceptive based training and closed kinematic chain exercise to improve upper limb function in chronic stroke patients.

2. Methodology

Study Setting: Home based programe for patients in and around Ernakulam district and those who were referred from Rajagiri Hospital Aluva, L.F Hospital Angamaly and MOSC Medical Collage Kolencherry.

Research Design: Experimental study design

Sample Design: Purposive sampling

Sample Size: Total study group of 30 patients with MCA stroke (N=30).They were assigning into 3 groups of equal number (n =10).

Study Duration:3 weeks

Outcome Measures

- Fugl-Meyer upper extremity (F-M UE) scale for upper limb motor function.
- Dynamometer for measuring muscle force.
- Goniometry for assessing joint range of motion.

Study Procedure

The study was conducted as a home based programme for patients in and around Ernakulam district and those who were referred from Rajagiri Hospital Aluva, L.FHospital Angamaly and MOSC Medical Collage Kolencherry. The inclusion criteria was kept as: MCA stroke (ischemic or haemorrhagic, within 1-6 month), Both men and women of age in between 50-70 years, Upper limb paresis (minimum grade 2 according to the MRC scale for all upper extremity muscle.) and those who encountered first stroke. Those patients who had Global sensory aphasia, Unilateral Neglect, Cognitive impairment (MMSE <24 points), any presence of Pathological conditions that would severely limit a person's participation in the study (e.g.: shoulder subluxation, CRPS, RSD) were excluded. 30 consecutive subjects were randomly assigned into 3 groups A, B&C, with 10 subjects in each group. Group A received Proprioceptive Based Training along conventional neuromotor treatment. Group B received Close Kinetic Chain exercise and conventional neuromotor treatment. Group C is a control group and received conventional neuromotor treatment only. The outcome measures were assessed using Fugl Meyer score for upper extremity, goniometry and dynamometer.

The study duration was 5 days in a week, for 3 weeks and each session lasted for approximately 50 minutes along with warm up and cool down phase before and after exercise respectively. The exercise protocol included in conventional physiotherapy were active assisted range of motion exercise for upper and lower extremity, functional mobility exercises. The CKC group performed wrist push up, wobble board balance, towel slide exercises in addition to conventional exercise. The PBT group performed assisted symmetrical mobility exercise, rhythmic stabilisation, mirroring upper extremity and duplicating position exercises along with conventional exercises. Each exercises were done for 3 minutes with a 2 minute rest period before moving on to next exercise.

Pre-treatment score was taken a day before the commencement of the treatment session and post treatment score was taken the day after the completion of 3 weeks of treatment session.

3. Result

A total of 30 subjects participated in this study. They were conveniently assigned to either control group or experimental group. The data were analysed using SPSS software. Paired t test was used to analyse the intra group

significance. Independent t test was used to analyse the inter group significance.

Analysis of Pre Test and Post Test of Fugl Meyer and Hand Dynamometry in Group A (PBT)

Table 1: Pre test- post test analysis of fuglmeyer and hand dynamometry in PBT group

Group A	*Test*	*Mean*	*S.D.*	*n*	*Mean difference*	*t*	*df*	*Significance (p-value)*
Fuglmeyer	Pre-test	36.6	3.09	10	7.0	11.7	9	*p <0.05*
	Post-test	43.6	3.09					
Hand held dynamometer	Pre-test	1.86	0.33	10	0.55	12.1	9	*p <0.05*
	Post-test	2.41	0.42					

Table 1 shows paired t test of fuglmeyer, hand held dynamometry of group A. From the result the Mean, S.D. And t value assists in assessing the effectiveness of proprioceptive based training in stroke patients in improving hand function

Since the significance (p-value) is less than 0.05, we can conclude that theaverage improvement in the Fugl-Meyer, 7.0 is significant and the calculated t value is greater than the table value for 9 degree of freedom. So there is a significant effect of PBT physiotherapy treatment to improve motor function instroke patients.

In case of hand held dynamometry the significance (p-value) is less than 0.05, we can conclude that the average improvement of 0.55, is significant and the calculated t value is greater than the table value for 9 degree of freedom. So there is a significant effect of PBT treatment to improve strength in stroke patients.

Analysis of Pre Test and Post Test of Goniometry in Group A (PBT)

Table 2: Pre test- post test analysis of goniometer in PBT group

Movement	Test	Mean	S.D.	N	Mean improvement	T	df	Significance (p-value)
Shoulder Flexion	Pre-test	136.6	3.6	10	7.9	8.4	9	P<0.05
	Post-test	144.5	3.5					
Shoulder Extension	Pre-test	13.0	2.9	10	6.2	18.9	9	P<0.05
	Post-test	19.2	3.6					
Shoulder Abduction	Pre-test	96.2	3.0	10	6.8	9.3	9	P<0.05
	Post-test	103.0	3.8					
Shoulder Internal rotation	Pre-test	26.0	2.6	10	5.3	17.6	9	P<0.05
	Post-test	31.3	2.4					
Shoulder External rotation	Pre-test	37.	2.5	10	5.6	21.0	9	P<0.05
	Post-test	42.6	2.4					
Elbow Flexion	Pre-test	126.1	3.9	10	5.7	5.4	9	P<0.05
	Post-test	131.8	2.3					
Forearm Supination	Pre-test	38.0	4.3	10	6.0	10.7	9	P<0.05
	Post-test	44.0	4.5					
Forearm Pronation	Pre-test	35.6	3.3	10	5.5	20.4	9	P<0.05
	Post-test	41.1	3.7					
Wrist Flexion	Pre-test	25.1	3.6	10	8.0	18.9	9	P<0.05
	Post-test	33.1	3.8					
Wrist Extension	Pre-test	36.5	3.4	10	6.7	11.5	9	P<0.05
	Post-test	43.2	2.2					
Radial Deviation	Pre-test	7.3	2.2	10	4.5	12.0	9	P<0.05
	Post-test	11.8	2.6					
UlnarDeviation	Pre-test	17.0	2.3	10	4.6	9.2	9	P<0.05
	Post-test	21.6	2.9					

Table 2 hows paired t test of goniometry of group A. From the result the Mean, S.D. And t value assists in assessing the effectiveness of proprioceptive based training in stroke patients in improving hand function

Since there is significant improvement in all the parameters in goniometry with thelevel of significant p<0.05 and the calculated t value is greater than the table value for 9 degree of freedom in all the parameters we can conclude that there is a significant effect of PBT physiotherapy treatment to improve range of motion instroke patients.

Analysis of Pre Test and Post Test of Fugl meyer and Hand Dynamometryin GroupB (CKC)

Table 3: Pre test- post test analysis of fuglmeyer and hand dynamometry in CKC group

Group A	*Test*	*Mean*	*S.D.*	*n*	*Mean difference*	*t*	*df*	*Significance (p-value)*
Fuglmeyer	Pre-test	35.5	2.7	10	9.1	17.3	9	*p <0.05**
	Post-test	44.6	3.5					
Hand held dynamometer	Pre-test	1.7	0.23	10	1.17	20.2	9	*p <0.05**
	Post-test	2.9	0.30					

Table 3 shows paired t test of fuglmeyer, hand held dynamometry of group B. From the result the Mean, S.D. And t value assists in assessing the effectiveness of closed kinematic chain exercise in stroke patients in improving hand function

Since the significance (p-value) is less than 0.05, we can conclude that theaverage improvement in the Fugl-Meyer, 9.1 is significant and the calculated t value is greater than the table value for 9 degree of freedom. So there is a significant effect of CKC physiotherapy treatment to improve motor function instroke patients.

In case of hand held dynamometry the significance (p-value) is less than 0.05, we can conclude that the average improvement of 1.17, is significant and the calculated t value is greater than the table value for 9 degree of freedom. So there is a significant effect of CKC treatment to improve strength in stroke patients.

Analysis of Pre Test and Post Test of Goniometry in Group B (CKC)

Table 4: Pre test- post test analysis of goniometer in CKC group

Movement	Test	Mean	S.D.	n	Mean improvement	T	df	Significance (p-value)
Shoulder Flexion	Pre-test	136.3	3.3	10	11.2	12.9	9	P<0.05
	Post-test	147.5	2.6					
Shoulder extension	Pre-test	15.6	1.8	10	7.4	16.3	9	P<0.05
	Post-test	23.0	2.7					
Shoulder abduction	Pre-test	96.1	3.1	10	7.4	16.3	9	P<0.05
	Post-test	107.0	3.3					
Shoulder internal rotation	Pre-test	27.0	3.0	10	7.4	16.3	9	P<0.05
	Post-test	33.4	2.4					
Shoulder external rotation	Pre-test	36.0	2.8	10	7.8	12.4	9	P<0.05
	Post-test	43.8	2.7					
Elbow flexion	Pre-test	127.3	3.4	10	5.2	6.6	9	P<0.05
	Post-test	132.	2.6					
Supination	Pre-test	37.5	2.9	10	10.1	13.4	9	P<0.05
	Post-test	47.6	3.6					
Pronation	Pre-test	36.7	3.4	10	9.0	18.2	9	P<0.05
	Post-test	45.7	4.2					
Wrist flexion	Pre-test	27.3	4.0	10	8.6	15.3	9	P<0.05
	Post-test	35.9	4.3					
Wrist extension	Pre-test	37.9	3.8	10	10.0	21.2	9	P<0.05
	Post-test	47.9	4.5					
Radial deviation	Pre-test	6.8	1.9	10	5.4	33.0	9	P<0.05
	Post-test	12.2	2.0					
Ulnar deviation	Pre-test	17.3	2.6	10	4.9	12.04	9	P<0.05
	Post-test	22.2	2.6					

Table 4 shows paired t test of goniometry of group B. From the result the Mean, S.D. And t value assists in assessing the effectiveness of closed kinematic chain exercise in stroke patients in improving hand function

Since there is significant improvement in all the parameters in goniometry with thelevel of significant p<0.05 and the calculated t value is greater than the table value for 9 degree of freedom in all the parameters, we can conclude that there is a significant effect of CKC physiotherapy treatment to improve range of motion in stroke patients.

Analysis of Pre Test and Post Test of Fugl meyer and Hand Dynamometry in Group C (conventional group)

Table 5: Pre test- post test analysis of fuglmeyer and hand dynamometry in conventional group

Group A	*Test*	*Mean*	*S.D.*	*n*	*Mean difference*	*t*	*df*	*Significance (p-value)*
Fuglmeyer	Pre-test	36.6	3.09	10	4.2	12.8	9	*p <0.05*
	Post-test	40.8	3.25					
Hand held dynamometer	Pre-test	1.86	0.33	10	0.38	15.23	9	*p <0.05*
	Post-test	2.24	0.38					

Table 5 shows paired t test of fuglmeyer, hand held dynamometry of group B. From the result the Mean, S.D. And t value assists in assessing the effectiveness of conventional physiotherapy exercise in stroke patients in improving hand function

Since the significance (p-value) is less than 0.05, we can conclude that theaverage improvement in the Fugl-Meyer, 4.2 is significant and the calculated t value is greater than the table value for 9 degree of freedom. So there is a significant effectofconventional physiotherapy exercise toimprovemotor function instrokepatients.

In case of hand held dynamometry the significance (p-value) is less than 0.05, we can conclude that the average improvement of 0.38, is significant and the calculated t value is greater than the table value for 9 degree of freedom. So there is a significant effect of conventional physiotherapy exercise to improve strength in stroke patients.

Analysis of Pre Test and Post Test of Goniometry in Group C (conventional group)

Table 6: Pre test- post test analysis of goniometer in conventional group

Movement	Test	Mean	S.D.	n	Mean improvement	T	df	Significance (p-value)
Shoulder Flexion	Pre-test	136	3.33	10	5.3	13.39	9	P<0.05
	Post-test	141.3	3.74					
Shoulder extension	Pre-test	16	2.49	10	5	16.77	9	P<0.05
	Post-test	21	2.44					
Shoulder abduction	Pre-test	96.5	2.63	10	8.6	8.39	9	P<0.05
	Post-test	105.1	4.72					
Shoulder internal rotation	Pre-test	26.1	3.72	10	5.3	14.45	9	P<0.05
	Post-test	31.4	4.08					
Shoulder external rotation	Pre-test	36	3.19	10	5.5	13.7	9	P<0.05
	Post-test	41.5	3.8					
Elbow flexion	Pre-test	125.6	2.79	10	6.2	7.26	9	P<0.05
	Post-test	131.8	2.39					
Supination	Pre-test	37.1	4.17	10	5.8	13.93	9	P<0.05
	Post-test	42.9	3.54					
Pronation	Pre-test	36.6	2.75	10	5.6	9.33	9	P<0.05
	Post-test	42.2	2.39					
Wrist flexion	Pre-test	28.8	4.58	10	5.1	7.06	9	P<0.05
	Post-test	33.9	3.81					
Wrist extension	Pre-test	37.8	3.35	10	5.3	14.45	9	P<0.05
	Post-test	43.1	3.63					
Radial deviation	Pre-test	6.9	2.02	10	4.4	19.9	9	P<0.05
	Post-test	11.3	2.16					
Ulnar deviation	Pre-test	16.7	2.58	10	4.1	6.78	9	P<0.05
	Post-test	20.8	3.04					

Table 6 shows paired t test of goniometry of group C. From the result the Mean, S.D. And t value assists in assessing the effectiveness of conventional physiotherapy exercise in stroke patients in improving hand function

Since there is significant improvement in all the parameters in goniometry with thelevel of significant p<0.05 and the calculated t value is greater than the table value for 9 degree of freedom in all the parameters, we can conclude that there is a significant effect of conventional physiotherapy treatment to improve range of motion instroke patients. ANOVA test was used to compare the difference of each outcome measures in all the three groups.

Comparison of difference in Fugl Meyer and hand held dynamometry among The Three Groups

ANOVA showed a significant difference in changes in fugl Meyer and hand held dynamometry among the threegroups, F = 24.537with p<0.05 and F=86.13 with p<0.05 respectively. The maximum change in Fugl-Meyer and hand dynamometer was seen in theCKC intervention group which is statistically significant when compared with other groups using post-HocAnalysis Tukey.

Comparison of difference in Goniometry among the Three Groups

ANOVA showed a significant difference in changes in shoulder flexion among the three groups, F=14.69 with p<0.05, shoulder extension: F=10.80 with p<0.05, shoulder abduction: F=7.26 with p<0.05, shoulder external rotation: F= 8.076 with p<0.05, supination :F=16.82withp<0.05, pronation: F=17.60 with p<0.05, wrist flexion: F= 10.36 with p<0.05, wrist extension: F=25.27withp<0.05, radial deviation: F= 4.24 with p<0.05.

When Comparing of changes in shoulder internal rotation, elbow flexion and ulnar deviation using ANOVA, no significant difference in changes were found.

4. Discussion

This study was an experimental approach to compare the effectiveness of proprioceptive based training, closed kinematic chain exercises and conventional physiotherapy treatment on improving hand function in stroke patients. The age of the subjects was almost identical in all the groups with a mean age of 56.8, 56.6 and 56.1 in group A, group B and group C respectively. The duration of the condition was 1- 6 months post diagnosis of stroke. The mean BMI in group A, group B and group C was 23.56, 23.5 and 24.15 respectively.

Each subjects in all the group received the conventional treatment and Group A received an extra Proprioceptive

based training program and group B received Closed kinematic chain exercise, for 5 days in a week, for 3 weeks and each session lasted for approximately 50 minutes along with warm up and cool down phase before and after exercise respectively. Just before the first day and on completion of 3 weeks treatment session, a pre-treatment score and a post treatment score was taken.

The Fugl Meyer scale for upper limb was used to assess motor function recovery of upper limb, hand held dynamometer was used to assess strength, and goniometer were used to estimate range of motion of each joints in upper limb. Standardized instruments that are often used in stroke patients were used in all of the measurements for this study.

Even though all the groups showed improvement, a significant improvement was shown by the CKC group where closed kinematic chain exercise along with conventional physiotherapy significantly improved motor function, Strength and range of motion among stroke patients.

Proprioceptive information is essential for the proper function of the upper limb. So altered proprioceptive information may directly affect the upper limb function. In MCA territory stroke upper limb is more involved than the lower limb.

The proprioceptive based training is a type of bilateral exercise programand it stimulates the voluntary contraction of muscle. It is exactly based on motorlearning principles, such as the repetition of task with concurrent use of feedbacks.The bilateral training is a method based on the execution of repetitive tasks with both (affected and non–affected) upper extremities, with the aim of regaining a better motor function. This approach is based on the rationale that bilateral movements allow to optimize the activation-inhibition balance between the two hemispheres. Thefinding states that the bilateral training will help to reduce the excitability of the healthy hemisphere and can help to improve motor function of the paretic limb afterstroke.[9]

From the studies conducted by WuCY et al, fMRI along with bilateral movement showed increased activation in both side of the cerebellum and some plastic changes in both hemispheres. On the other hand, decreased activation has beennoted in cerebellum when unilateral movement was provided. Furthermore, the fMRI studies showed that the cerebellum could be a critical site involved in bilateral movement.[10]

In upper extremity, closed –chain exercise in weight bearing positions are also thought to cause co-activation of the scapular and gleno humeral stabilizers and therefore, to improve dynamic stability of the shoulder complex. Studies reported thatclosed –chain exercise provide greater proprioceptive and kinesthetic feedback thanopen-chain exercise. It is due to multiple muscle groups that cross multiple joints areactivated during closed-chain exercise, more sensory receptors in more muscles andintra-articular and extra-articular structures are activated to control motion than duringopen-chain exercises. Close kinematic chain exercise will help to improve the proprioceptive feedback coming from Pacinian corpuscles, Ruffini endings, and Golgitendonorgan, through the functional use of multi joint and multiplaner movements.[8]

In a study conducted by Blackburn (2000), he said that closed kinetic chainactivities cause adaptations in the central nervous system that alter motor controlpatterns and allow the development of new patterns based on the stress and strain oftheactivities.[11]

5. Conclusion

In stroke, especially the MCA type of stroke, patients encounter a lot of difficulties in performing activities with their upper limb and the recovery of its lost function is one of the greatest challenge. It causes difficulties in performing almost all the activities of daily living as well as make the patient a slow withdrawal from society.

The aim of this study was to investigate the effect of PBT and CKC exercise to improve the upper limb function in stroke patients. The overall findings of thisresearch study revealed that there is a significant improvement showed in PBT, CKCand conventional intervention group.

The statistical intra group analysis ofGroup A (PBT), Group B(CKC) andGroup C (conventional) was done using the paired t test with thelevel of significant$p<0.05$. The inter group analysis was conducted using ANOVA, and came to a conclusion that even though all the groups showed significant improvements in all the parameters, the CKC group had a better performance when compared to other 2 group.

6. Future Scope

Limitations

- Sample size taken for the study is small and bigger sample might have led to some differences in the result.
- Only short term effects were being evaluated
- Influence of drug, nutritional factors and climate could not be controlled
- Study only conducted in MCA stroke patients
- As the measurement were taken manually, this may introduce human error, which could treat the study's reliability

Suggestion

- To examine whether these benefits are maintained for a longer duration.
- A large sample size should be taken to improve the consistency of results
- More parameters of outcome measurement will make the study more valuable.
- To make the result more generalized, the study can be done in acute and chronic stroke patients
- Blinding of procedure could improve the reliability of the outcome

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