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EFFECTIVENESS OF HOME EXERCISE PROGRAM WITH MODIFIED ROOD'S APPROACH ON MUSCLE STRENGTH IN POST CEREBRAL HAEMORRHAGIC INDIVIDUALS OF ASSAM: A RANDOMIZED TRIAL

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ABSTRACT

Background: Physical therapists are integral to the rehabilitation of patients of stroke, and home exercise program (HEP) prescription is a routine part of physical therapy care. Strength training is imperative in interventions for stroke patients. Various components of Rood's Approach are effective in stroke rehabilitation, an aspect that has not been thoroughly explored as yet.

Methods: A randomized controlled trial study was done at Gauhati Medical College & Hospital, Assam. The subjects were 236 hemorrhagic stroke patients who were randomly assigned into two groups. Both the groups were given a HEP consisting of routine physiotherapy exercises. Additionally, one group out of the two was also taught exercises based on the Rood's approach, consisting of facilitation and inhibition techniques with the help of sensory stimulation and repetitive task-specific activity. The output was evaluated in terms of muscle strength using Manual Muscle Testing (MMT) after three months of intervention.

Results: It was observed that HEP with Rood's approach significantly improved ($p<0.05$) the muscle strength in shoulder flexors ($p=0.038$), shoulder extensors ($p=0.003$), shoulder abductors ($p=0.033$), shoulder adductors ($p=0.018$), elbow flexors ($p=0.009$), wrist flexors ($p=0.044$), finger flexors ($p=0.011$), hip flexors ($p=0.007$), hip extensors ($p=0.015$), hip adductors ($p=0.00$), knee flexors ($p=0.00$), ankle plantar flexors ($p=0.00$) and dorsi flexors ($p=0.039$). However, no improvements were observed for elbow extensors, wrist extensors, finger extensors, hip abductors and knee extensors.

Conclusion: Although it was observed that both the Groups improving their muscle strength, but HEP with Rood's approach was found to be more effective in improving muscle strength.

Keywords: Rood's approach, home exercise program (HEP), physiotherapy, intracerebral haemorrhage, stroke, muscle strength

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INTRODUCTION

Stroke is a disease that affects the brain functions due to disturbance in the blood supply to the brain which leads to paralysis of the limb or one side of the body, sensory disturbance, difficulty in understanding or formulating speech, visual disturbance, swallowing difficulty, bowel, and bladder incontinence, etc. [1]. Assam has the highest prevalence of stroke (270 out of every 100,000) in India [2]. Post-stroke rehabilitation is key to motor and functional recovery [3-5]. This exercise program leads to more rapid improvement in the aspects of physical, social, and role functions than the usual care that a person with subacute stroke receives [6-12]. A home exercise program is mandatory for stroke patients reeling from the long-lasting effects of stroke, though most of the recovery occurs in the first three months after stroke [13-14], and this is generally not possible at an acute care hospital.

Many stroke patients are deprived of stroke rehabilitation programs due to the lack of awareness, the remoteness of their homes from the city and financial constraints. Various studies show the improvement and benefits of home exercise programs in post-stroke individuals [15-17]. According to Lang et al., the repetitions of exercises during physiotherapy and occupational therapy for individuals after stroke are comparatively lesser, except for walking steps; which can be compensated by a home exercise program [18]. Many researchers found that HEP significantly improves muscle strength, muscle power and functional activity in stroke patients [19-21]. Hence, HEP is mandatory for stroke patients reeling from the after-effects of stroke.

Physiotherapists over the world have been using various neurophysiology based techniques such as the Brunnstrom approach [22], proprioceptive neuromuscular facilitation (PNF) [23,24], neuro-developmental therapy (NDT/ Bobath) [25], Rood's approach [26], etc in order to treat stroke patients reeling from the after-effects of stroke [27]. Among them, Rood's approach is a neuro-physiological approach that was designed for patients with motor control problems [26-28], it was developed by Margeret Rood in 1940 [29-30], based on four fundamental concepts - tonic and phasic muscles, anterior horn cell excitability, ontogenetic developmental sequence, and autonomic nervous system manipulation [31]. According to Rood, sensory stimulation can activate or deactivate the receptor by facilitation or inhibition, which makes it possible to get the desired muscular response [32-33]. Rood explained four types of receptors that can be stimulated to get desired muscular response - proprioceptive receptors, exteroceptive receptors, vestibular receptors and special sense organs Rood categorized all flexors and adductors muscle Group as phasic, or mobility muscle and all extensors and abductors are categorized as tonic or stability muscle [34]. Facilitation or inhibition of proprioceptors, exteroceptors, vestibular, and special sense organs can excite the anterior horn cell of the spinal cord, which will help normalize the muscular tone and motor recovery [31,35]. Autonomic nervous system stimulation is also a part of Rood's approach which can stimulate the motor activity of vital organs as well as the skeletal muscles [36-42]. The developmental sequence of Rood's approach is generally accepted as outdated because developmental studies show that normal human development depends on perception, action, cognition, exploration, inherited tendencies, and experience-dependent learning [43-45]. These researches showed that the developmental motor sequence was neither followed invariably by developing children nor adhered to by adults when rising from supine to erect posture. Hence, in this research the ontogenic developmental sequence part has been excluded [46].

Hemiplegia is one of the most common impairments after stroke, which is the leading cause of major disability [47,6]. In the present study, hemiplegic patients following stroke were categorized into two intervention groups, i.e., Group A and Group B. Patients in Group A have prescribed the conventional home exercise program (HEP), whereas the patients in Group B were prescribed HEP with Rood's approach. The ultimate aim and objective of this study were to evaluate the effectiveness of HEP with and without Rood's approach in improving the muscle strength in cases of post intracerebral hemorrhage.

Thus, this study was conducted to answer the question – What is the extent of effectiveness of HEP with and without Rood's approach in improving the muscle strength in cases of post intracerebral hemorrhage?

METHODOLOGY

Design

A randomized controlled trial prospective study was done with a three months follow-up period at Gauhati Medical College & Hospital (GMCH) involving the Department of Neurology. This schedule of follow up period was chosen because a change in outcomes was expected after three months in stroke patients.

Participants

The patients were selected from GMCH depending upon the inclusion and exclusion criteria. Specific inclusion criteria for participation in this study consisted of patients suffering a haemorrhagic stroke with supratentorial hematoma with hemiplegia; the muscle power being in the range of grades 0 to 3 (found by manual muscle testing) and age in between 20-65 years. The exclusion criteria were unrestrained hypertension; severe dysphagia or cognitive deficiency; patients previously demonstrating disability during self-care; and patients had been staying in a nursing home before stroke.

The patients were randomly divided into two groups (A and B) using block randomization (blocks of four) to achieve the predetermined sample size. The consultant physiotherapist (first author), with the help of second author, generated the random allocation sequence and enrolled participants based on the inclusion and exclusion criteria.

Intervention

All the patients and caretakers were instructed with a common HEP by the consultant physiotherapist (first author), which included a range of motion exercises, strengthening, stretching, weight-bearing, balance and coordination exercises. Additionally, Group B was taught exercises based on Rood's approach which included facilitation and inhibition with the help of exteroceptive and proprioceptive stimulation. The Group A (control) patients and caregivers were blinded from the Rood's approach techniques. The patients reported to the Department of Neurology at GMCH after every 15 days for three months, for modifications in the exercises as per change in their condition.

Range of motion exercises: 30 repetitions for each muscle group once in a day.

- Passive Range of Motion - if a muscle has no contraction.
- Active Assistive Range of Motion - A slight movement will be present.
- Active Range of Motion - if the movement can be done against gravity.

Strengthening exercises: 30 repetitions once in a day – 6 days a week.

Once the muscle power reached to grade 3, the caregiver starts helping the patients perform resistive exercises.

Stretching exercises: 10 repetitions once in a day.

The muscle Groups emphasized - shoulder flexors, shoulder abductors, wrist-forearm extensors, quadriceps, hip adductors, hamstring, and calf.

Weight-bearing exercises: 10 repetitions once in a day

- Upper limbs weight-bearing exercise - sit on the bed with hands placed on a bed. The patients had to press the bed with the palm to raise the body upward.
- Lower limbs weight-bearing exercise - the patients were made to stand with support.

Balance and coordination training

- Balance and coordination exercise - sitting balance training and then standing.

ROOD'S APPROACH

Various researches have put forward the use of Rood's approach towards a variety of neurogenic applications [26,29-34]. Details on the facilitation and inhibition based on Rood's approach provided in this study are as follows:

For Facilitation:

Quick stretch: 10 repetitions each stretch.
Resistance: 20 repetitions of each movement.
Tapping: 5 repetitions during the time of voluntary contraction.
Quick icing: 3 quick strokes for each muscle belly
Fast brushing: apply 5 seconds and repeat after 30 seconds. Ten repetitions for each muscle.
Light touch: apply five strokes with a light brush and give rest for 30 seconds. Ten repetitions
Traction: 20 repetitions each joint.
Approximation: 20 repetitions
Heavy joint compression: 10 repetitions each joint

For Inhibition: Inhibitory stimulus for desired muscle Group and facilitatory for opposite muscle.

Prolonged stretch: 10 mins
Inhibitory tendon pressure: 10 repetitions
Prolonged ice: 10 mins
Slow rolling: 10 repetitions

Along with the stimulation, patients were advised to do some repetitive, purposeful activity; such as

(1) For the upper limb - wipe the table 5 minutes, grasp a glass and try to open it, touch a wall at the shoulder level and touch his/her cheek, touch hair, and slide a ball with the help of the extensor aspect of forearm.

(2) For lower limb - sitting to standing with support, kick a ball, standing to half-sitting, walk with support.

Outcome measures

The muscle strength of the patients was assessed in the first session and then reassessed by Manual Muscle Testing (MMT) [48] at the end of 3 months. The effectiveness of the home exercise program upon incorporation of exercises based on Rood's approach in enhancing the muscle strength of the patients was determined. Moreover, comparative studies were made for the two Groups on their ability to increase the muscle strength of the patients.

STATISTICAL ANALYSIS

The sample size was calculated using the data from The Glasgow Augmented Physiotherapy Study (GAPS) Group [49]. We used an expected mean improvement of the Rivermead Mobility Index (RMI) score was 9.7(+/-3.3) for the intervention Group (augmented physiotherapy) and 8.1 (+/-3.1) for the control Group (standard physiotherapy). Setting alpha=0.05 (2-tailed) for the two-sample t-test, with 80% statistical power to detect the accurate sample size. The calculated n value is 106 (per arm), making the total sample size to be 212. Hence, the total sample size for this study is taken as 236, i.e. 212 + 24, where the additional 24 more samples are added to overcome the possibility of non-responds/ missing subjects. So the sample size for the study is 236.

The data were analyzed by the statistical software SPSS 20.0. The intergroup data of manual muscle testing was analyzed using the paired t-test, and the intragroup analysis was done by an independent t-test. The level of significance set for this study was 95% ($p < 0.05$).

RESULTS

From 12 May 2014 to 10 December 2017, 1200 patients were assessed for eligibility, and, of those, 964 were excluded based on the exclusion criteria (Figure 1); while the remaining 236 participants were recruited for the study and their baseline characteristics were recorded (Table 1). Subsequently, they were randomized into Group A (control) and Group B (intervention), whereby they have prescribed their quota of HEP (with and without Rood's approach) for three months. The follow upended on 10 March 2018 (after three months). The follow up of a total of 33 numbers of patients were missed during the study (Table 1).

Figure 1: Design and flow of participants through the trial, HEP=Home exercise program

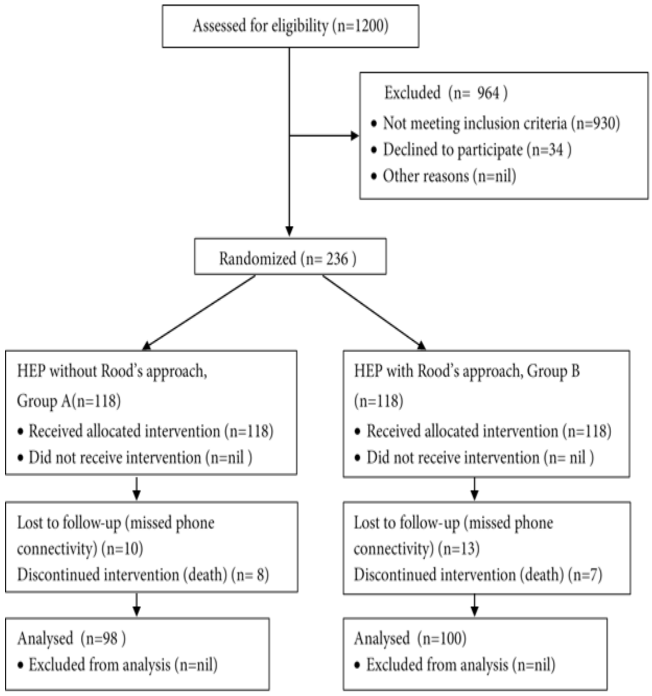

Table 1: Baseline Characteristics

		Randomized n(%)		Lost of follow up n(%)	
		236(100)		38(16.1)	
		Group A	Group B	Group A	Group B
		118(50)	118(50)	20(8.5)	18(7.6)
Age mean(SD)		50.65(9.8)	51.91(9.1)	52.70(9.5)	53.06(8.4)
Sex(%)	Female	76(64)	72(61)	15(75)	11(61)
	Male	42(35)	46(39)	5(25)	7(38)
Work(%)	Service	20(16)	25(21)	5(25)	5(27)
	Bussiness	18(15)	39(33)	2(10)	5(27)
	Farming	40(33)	27(22)	8(40)	6(33)
	House wife	39(33)	27(22)	5(25)	2(11)
	Retired	1(0.8)	0(0)	0(0)	0(0)
Education(%)	No school	22(18)	27(22)	3(15)	5(27)
	Primary	27(22)	31(26)	2(10)	5(27)
	Secondary	35(29)	25(21)	4(20)	4(22)
	High school	29(24)	23(19)	10(50)	3(16)
	College	5(4.2)	12(10)	1(5.0)	1(5.6)

Table 2: Comparison of Upper Limb Muscle Strength between the two groups on the day of randomization.

Muscle Group	**Evaluation Day of randomization**	**Mean N%**	**SD (N%)**	**t value**	**p-value**
Shoulder Flexors	Group A	0.81	0.915	0.569	0.570
	Group B	0.88	0.917		
Shoulder Extensors	Group A	0.43	0.768	0.254	0.800
	Group B	0.46	0.770		
Shoulder Abduction	Group A	0.47	0.770	0.084	0.933
	Group B	0.46	0.781		
Shoulder Adduction	Group A	1.17	0.955	0.482	0.631
	Group B	1.23	0.937		
Elbow Flexor	Group A	0.54	0.823	0.000	1.000
	Group B	0.54	0.813		
Elbow Extensors	Group A	0.31	0.647	0.200	0.841
	Group B	0.32	0.652		
Wrist Flexors	Group A	0.39	0.717	0.091	0.928
	Group B	0.40	0.718		
Wrist Extensors	Group A	0.40	0.764	172	0.864
	Group B	0.38	0.750		
Finger Flexors	Group A	0.33	0.600	0.000	1.000
	Group B	0.33	0.600		
Finger Extensors	Group A	0.31	0.595	0.439	0.661
	Group B	0.35	0.590		

On the day of randomization, the mean of upper limb muscles strength in Group A ranged from 1.17±0.955 to 0.31±0.595, and in group B, it ranged from 1.23±0.937 to 0.32±0.652 (table 2). There was no significant difference in the pre-treatment strength of upper limb muscles in both groups (p>0.05).

Table 3: Comparison of lower Limb Muscle Strength between two groups on the day of randomization.

Muscle Group	Evaluation on the day of randomization	Mean N%	SD (N%)	t value	p-value
Hip Flexors	Group A	0.86	0.942	0.612	0.541
	Group B	0.94	0.972		
Hip Extensors	Group A	0.64	0.781	0.497	0.62
	Group B	0.69	0.792		
Hip Abduction	Group A	0.53	0.781	0.166	0.869
	Group B	0.54	0.791		
Hip Adduction	Group A	0.88	1.039	0.062	0.95
	Group B	0.89	1.044		
Knee Flexor	Group A	0.49	0.689	0.830	0.407
	Group B	0.57	0.722		
Knee Extensors	Group A	0.49	0.689	0.000	1.000
	Group B	0.49	0.676		
Ankle Flexors	Group A	0.20	0.404	0.000	1.000
	Group B	0.20	0.404		
Ankle Extensors	Group A	0.23	0.442	1.439	0.151
	Group B	0.33	0.628		
Toes Flexors	Group A	0.17	0.420	0.000	1.000
	Group B	0.17	0.420		
Toes Extensors	Group A	0.32	0.597	1.181	0.239
	Group B	0.24	0.501		

On the day of randomization, the mean of lower limb muscles strength in Group A ranged from 0.88±1.039 to 0.17±0.420, and in Group B, it ranged from 0.94±0.972 to 0.17±0.420 (table 3). There was no significant difference in the pre-treatment strength of upper limb muscles in both Groups (p>0.05).

Table 4: Comparative data of muscle strength between Groups A and B before and after treatment in upper limb

Muscle Group	Group	Evaluation	Mean N%	SD (N%)	t value	p-value
Shoulder Flexors	Group A	Day of randomization	0.73	0.88	6.545	0.000
		After treatment	1.57	0.908		
	Group B	Day of randomization	0.86	0.899	9.081	0.000
		After treatment	1.9	1.267		
Shoulder Extensors	Group A	Day of randomization	0.46	0.802	8.983	0.000
		After treatment	1.36	0.853		
	Group B	Day of randomization	0.47	0.797	15.00	0.000
		After treatment	1.72	0.817		
Shoulder Abductors	Group A	Day of randomization	0.51	0.803	6.577	0.000
		After treatment	0.97	0.813		
	Group B	Day of randomization	0.46	0.797	9.023	0.000
		After treatment	1.22	0.824		
Shoulder Adductors	Group A	Day of randomization	1.18	0.967	4.247	0.000
		After treatment	1.71	0.908		
	Group B	Day of randomization	1.25	0.947	6.318	0.000
		After treatment	2.07	1.174		
Elbow Flexor	Group A	Day of randomization	0.58	0.861	9.473	0.000
		After treatment	1.5	0.777		
	Group B	Day of randomization	0.55	0.845	11.549	0.000
		After treatment	1.82	0.925		
Elbow Extensors	Group A	Day of randomization	0.32	0.667	2.686	0.009
		After treatment	0.53	0.596		
	Group B	Day of randomization	0.33	0.682	4.198	0.000
		After treatment	0.56	0.715		
Wrist Flexors	Group A	Day of randomization	0.42	0.745	2.497	0.014
		After treatment	0.61	0.62		
	Group B	Day of randomization	0.41	0.74	4.627	0.000
		After treatment	0.81	0.748		
Wrist Extensors	Group A	Day of randomization	0.43	0.799	0.352	0.726
		After treatment	0.45	0.66		
	Group B	Day of randomization	0.4	0.791	0.467	0.642
		After treatment	0.37	0.646		
Finger Flexors	Group A	Day of randomization	0.35	0.611	2.632	0.01
		After treatment	0.49	0.662		
	Group B	Day of randomization	0.34	0.623	6.93	0.000
		After treatment	0.76	0.806		
Finger Extensors	Group A	Day of randomization	0.36	0.613	1.518	0.132
		After treatment	0.41	0.623		
	Group B	Day of randomization	0.38	0.616	1.714	0.09
		After treatment	0.45	0.626		

At the end of the study, both groups demonstrated significant improvement ($p<0.05$) in strength in all upper limb muscles except in wrist extensors and finger extensors. Mean post-treatment strength of upper limb muscles in Group A ranged from 1.71±0.90 to 0.41±0.623 and in Group B it ranged from 2.07±1.174 to 0.37±0.646 (Table 4).

Table 5: Comparative data of muscle strength between Groups A and B before and after treatment in lower limb

Muscle Group	Group	Evaluation	Mean N%	SD (N%)	t value	p-value
Hip Flexors	Group A	Day of randomization	0.92	0.949	9.794	0.000
		After treatment	2.21	1.416		
	Group B	Day of randomization	0.96	0.984	12.085	0.000
		After treatment	2.7	1.096		
Hip extensors	Group A	Day of randomization	0.69	0.805	6.474	0 .000
		After treatment	1.23	0.797		
	Group B	Day of randomization	0.7	0.81	13.659	0.000
		After treatment	1.54	0.947		
Hip Abductors	Group A	Day of randomization	0.55	0.814	3.55	0.001
		After treatment	0.82	0.866		
	Group B	Day of randomization	0.55	0.809	8.37	0.000
		After treatment	1.1	1.049		

Hip Abductors	Group A	Day of randomization	0.92	1.062	8.433	0.000
		After treatment	2.09	1.348		
	Group B	Day of randomization	0.89	1.063	14.457	0.000
		After treatment	2.79	0.88		
Knee Flexor	Group A	Day of randomization	0.52	0.721	3.465	0.001
		After treatment	0.76	0.747		
	Group B	Day of randomization	0.59	0.753	7.129	0.000
		After treatment	1.01	1		
Knee Extensors	Group A	Day of randomization	0.52	0.721	11.812	0.000
		After treatment	1.82	0.829		
	Group B	Day of randomization	0.5	0.704	17.02	0.000
		After treatment	2.02	0.899		
Ankle Flexors	Group A	Day of randomization	0.2	0.405	4.948	0.000
		After treatment	0.6	0.714		
	Group B	Day of randomization	0.2	0.402	9.232	0.000
		After treatment	1.11	0.875		
Ankle Extensors	Group A	Day of randomization	0.22	0.443	1.538	0.127
		After treatment	0.3	0.502		
	Group B	Day of randomization	0.35	0.657	1.787	0.077
		After treatment	0.45	0.539		
Toes Flexors	Group A	Day of randomization	0.15	0.415	7.432	0.000
		After treatment	0.69	0.738		
	Group B	Day of randomization	0.16	0.42	10.841	0.000
		After treatment	1	0.739		
Toes Extensors	Group A	Day of randomization	0.34	0.625	2.898	0.000
		After treatment	0.51	0.677		
	Group B	Day of randomization	0.23	0.51	8.533	0.000
		After treatment	0.79	0.891		

At the end of the study, both groups demonstrated significant improvement ($p<0.05$) in strength in all upper limb muscles except in ankle extensors. Mean post-treatment strength of lower limb muscles in group A ranged from 2.21±1.416 to 0.30±0.502, and in group B it ranged from 2.79±0.880 to 0.45±0.539 (Table 5).

Table 6: Comparison of Upper Limb Muscle Strength in Two Groups after three months of treatment.

Muscle Group	Evaluation after 3 months	Mean N%	SD (N%)	t value	p- value
Shoulder Flexors	Group A	1.57	0.908	2.093	.038
	Group B	1.90	1.267		
Shoulder Extensors	Group A	1.36	0.853	3.057	.003
	Group B	1.72	0.817		
Shoulder Abduction	Group A	0.97	0.818	2.148	0.033
	Group B	1.22	0.824		
Shoulder Adduction	Group A	1.71	0.908	2.381	0.018
	Group B	2.07	1.174		
Elbow Flexor	Group A	1.50	0.777	2.633	0.009
	Group B	1.82	0.925		
Elbow Extensors	Group A	0.53	0.596	0.314	0.754
	Group B	0.56	0.715		
Wrist Flexors	Group A	0.61	0.620	2.023	0.044
	Group B	0.81	0.748		
Wrist Extensors	Group A	0.45	0.660	0.851	0.396
	Group B	0.37	0.646		
Finger Flexors	Group A	0.49	0.662	2.576	0.011
	Group B	0.76	0.806		
Finger Extensors	Group A	0.41	0.623	0.471	0.638
	Group B	0.45	0.626		

When compared between groups, group B demonstrated a significantly better effect than group A on the strengths of shoulder extensors, shoulder flexors, shoulder abduction, shoulder adduction, elbow flexors, wrist flexors, and finger flexors. There was no significant difference in the strength of elbow extensors, wrist extensors, and finger extensor muscles. After three months of treatment, the mean of upper limb muscles strength in Group A ranged from 1.57±0.908 to 0.41±0.623 and in Group B, it ranged from 2.07±1.174 to 0.37±0.646 (Table 6).

Table 7: Comparison of Lower Limb Muscle Strength in Two Groups after three months of treatment.

Muscle Group	Evaluation after 3 months	Mean N%	SD (N%)	t value	p- value
Hip Flexors	Group A	2.21	1.416	2.702	0.007
	Group B	2.70	1.096		
Hip Extensors	Group A	1.23	0.797	2.452	0.015
	Group B	1.54	0.947		
Hip Abduction	Group A	0.82	0.866	2.073	0.390
	Group B	1.10	1.049		
Hip Adduction	Group A	2.09	1.348	4.325	0.000
	Group B	2.79	0.880		
Knee Flexor	Group A	0.76	0.747	2.029	0.000
	Group B	1.01	1.000		

Knee Extensors	Group A	1.82	0.829	1.657	0.099
	Group B	2.02	0.899		
Ankle Flexors	Group A	0.60	0.714	4.47	0.000
	Group B	1.11	0.875		
Ankle Extensors	Group A	0.30	0.502	2.081	0.039
	Group B	0.45	0.539		
Toes Flexors	Group A	0.69	0.738	2.917	0.004
	Group B	1.00	0.739		
Toes Extensors	Group A	0.51	0.662	2.504	0.013
	Group B	0.79	0.891		

When compared between groups in the lower limb, group B demonstrated a significantly better effect than group A on the muscle strengths of hip flexors, hip extensors, hip adduction, knee flexors, ankle plantar flexors, ankle dorsi flexors, toes flexors and extensors except hip abductor and knee extensors. After three months of treatment, the Mean post-treatment strength of lower limb muscles in Group A ranged from 2.21±1.416 to 0.30±0.502, and in group B it ranged from 2.79±0.880 to 0.45±0.539 (table 7).

DISCUSSION

It was observed from the results that a significant difference exists between the two groups ($p<0.05$). HEP with Rood's approach significantly improves muscle strength in shoulder flexors, shoulder extensors, shoulder abductors, shoulder abductors, elbow flexors, wrist flexors, finger flexors, hip flexors, hip extensors, hip adductors, knee flexors, ankle plantar flexors, ankle dorsi flexors, toe flexors, and toe extensors. Literature discussing the direct effects of Rood's approach in enhancing the muscle strength is very limited; though many other factors may also be the cause for which it to show significant result. However, it is paramount to state that the use of certain specific aspects of Rood's treatment might be the cause of improvement in the muscle strength *viz.* Proprioceptor stimulation, exteroceptive stimulation, purposeful activity and repetition of movement. Facilitation or inhibition of proprioceptors, exteroceptors, vestibular and special sense organs can excite the anterior horn cell of spinal cord, which will help normalize the muscular tone and motor recovery [31-35]. Autonomic nervous system stimulation is also a part of Rood's approach which can stimulate the motor activity of vital organs as well as the skeletal muscles [36-42]. The proprioceptor's stimulation significantly improves muscle strength in post-stroke patients; this fact was also reinforced by the research of Ambrose et al.(2003), and Moitra and Kumar(2016) who found that proprioceptive stimulation helps to improve muscle strength, functional ability, and joint position sense [50-51].

Additionally, Hunter et al. (2008), Gibb et al.(2010), and Kolb et al.(2010) also found that exteroceptive stimulation is effective in improving muscle strength and motor recovery in stroke rehabilitation [52-54]. Purposeful movement or task-specific activity also may be a factor of improving strength in this research; a fact supported via the studies of Da Silva et al.(2015), Lang et al.(2007) and Deekshita et al.(2014) who also found that purposeful activity is effective in improving the muscle strength, balance and motor recovery [18, 55-56]. Furthermore, it may also be stated that repetition of exercise regime is also significant in enhancing the muscle strength of post-stroke patients as also reported by other researches *viz.* Lang et al.(2007), Butefisch et al.(1995) and de Sousa et al.(2018) who stated the benefits of intensive practice in stroke rehabilitation [18,57,58].

However, the possible factors for insignificance shown in case of certain muscle groups may be due to poor performance of the techniques, shorter duration of follow up and exercise given by unskilled and inexperienced hands (attendants of patients at home).

LIMITATIONS OF THE STUDY

- All the muscle groups were not evaluated.
- Small sample size.
- Follow-ups after long time intervals.
- Shorter evaluation duration of 3 months only.

CONCLUSION

A comparative study on the effectiveness of HEP with and without Rood's approach is done to determine the efficacy of Rood's approach towards post-stroke rehabilitation. It is observed that when compared with HEP alone, HEP, along with Rood's approach is significant in improving the strength of a variety of muscle groups than usual care in post-stroke individuals. After 3 months of randomization, it was observed that HEP with Rood's approach significantly improved the muscle strength in shoulder flexors, shoulder extensors, shoulder abductors, elbow flexors, elbow extensors, wrist extensors, finger flexors, finger extensors, hip flexors, hip extensors, hip adductors, knee flexors, and ankle dorsi flexors. Rood's treatment might be the cause of improvement in the muscle strength *viz.* Proprioceptors stimulation, exteroceptive stimulation, purposeful activity and repetition of movement. Facilitation or inhibition of proprioceptors, exteroceptors, vestibular and special sense organs excited the anterior horn cell of spinal cord, which will help normalize the muscular tone and motor recovery. Autonomic nervous system stimulation is also a part of Rood's approach which can stimulate the motor activity of vital organs as well as the skeletal muscles. This suggests that adherence to Rood's approach, along with the HEP, is instrumental in increasing muscle strength when compared with HEP alone. The effective increase in muscle strength also leads to a decrease in the disability of the patients.

Abbreviations:

HEP: Home Exercise Program
MMT: Manual Muscle Testing

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