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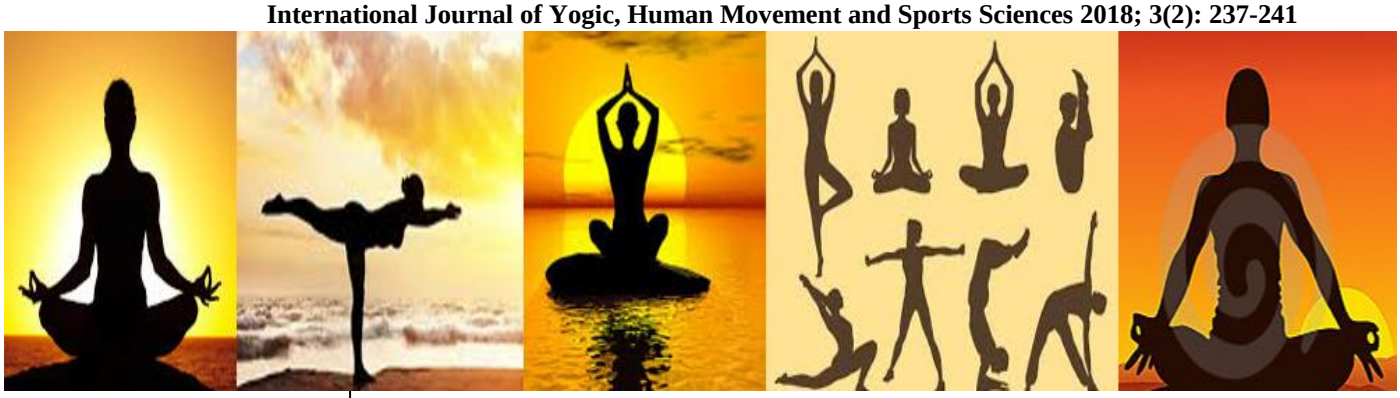

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Effect of robotic tilt table on rehabilitation outcome in right side versus left side hemiplegia

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Abstract
Stroke is highly debilitating and leaving the individuals depend on some kind of assistance for months or years, or even for their entire life. Injury location and size have a strong influence on its clinical evolution, and the differences in the functional consequences of right and left hemispheric strokes are of particular interest. The objective of the study is to find out the difference between rehabilitation outcomes depending upon the side affected. Total 80 hemiplegic patients (age 50.61±7.46 years, 8.65±5.82 days after stroke) were assigned randomly into two groups for 30 days of Conventional physiotherapy or Robotic tilt-table rehabilitation. Both groups were further stratified into subgroups of right and left hemiplegia. The National Institutes of Health Stroke Scale (NIHSS), Mini Mental Scale Examination (MMSE), Modified Ashworth Scale, Quality of Life and Muscle strength of affected upper and lower limb outcomes were assessed either before (day 0) or after (day 30) the rehabilitative protocols. After statistical analysis using paired and unpaired t test results shows that there was no statistical difference found in the outcome variables of right and left hemiplegic patients after the intervention either conventional or robotic tilt table. This study concludes that the rehabilitation outcome either of right hemiplegia or left hemiplegia are found to be same after rehabilitation.

Keywords: right side hemiplegia; neurological outcome; rehabilitation; robotic tilt table

Introduction
Stroke can result in a large variety of symptoms and signs but the most common and widely recognized impairment caused by stroke is motor impairment [1], which typically affects the control of movement of the face, arm and leg of one side of the body and affects ~80% of patients to varying degrees. However, with a high incidence of residual disability among stroke survivors; neuro-rehabilitation remains one of the cornerstones of post-stroke treatment. It plays a central role in successfully reducing the long-term effects of stroke and achieving optimal functional recovery for community re-integration.

The focus of stroke rehabilitation is largely on the recovery of impaired movement and function in an effort to reduce disability and encourage participation in everyday activities. Many non-motor impairments can also result in significant disability post-stroke. These impairments influence, to varying degrees, the rate and extent of stroke recovery. Frequently encountered examples include cognitive decline [2] (including memory, executive functioning, attention, concentration and alertness), low mood [3] and impaired communication abilities [4], which can impact upon motivation, interaction with rehabilitation staff and carry-over of learned activities. The presence of sensory impairments [5], as well as visual [6] and perceptual disorders [7] (including agnosia, apraxia and neglect) may also affect participation in rehabilitation.

Right hemisphere function is to control not only the movement of the left side of the body, but also analyze spatial orientation (distance, depth, position, size, and stereotaxis) and perceptual abilities. Stroke patients with right hemisphere lesion often demonstrate lack of safety awareness and impulsive behaviours. With these complex impairments, they have difficulties in re-learning ADL (activities of daily living). Major functions of the left hemisphere are to control the movements of the right side of the body and to maintain speech-language function. Patients with left hemispheric strokes sustain right hemiplegia and aphasia. They behave cautiously and need more time to complete the same task compared with right hemispheric

stroke patients [8].

It has been shown that robot-based rehabilitation improves motor performances by boosting brain plasticity, which plays a crucial role for motor control recovery, especially in stroke patients [9, 10, 11]. The Erigo device (Hocoma AG, Volketswil, Switzerland) combines progressive verticalization, cyclic leg movement and body weight loading to ensure the safe stabilization of the patient in the upright position.

No other similarly comprehensive studies were found in the literature in regards to functional and neurological outcome variables in relation to the characterizations of the side of the injury. Thus this study hypothesize the similarities and difference in rehabilitation outcome of right and left hemiplegia after rehabilitation.

Methodology

Participants and study design

This study has been designed as a randomized, controlled trial. Total 80 patients were recruited from in-patient and out-patient department of Neurology, for rehabilitation of sequelae of their first stroke. These 80 patients were then randomized equally by lottery method [12] to treat either with Conventional Physiotherapy or Robotic Tilt-table treatments. Inclusion criteria were hemiplegia after stroke both ischemic and haemorrhagic, within 7 to 28 days of onset, either male or female of age group 30-60 years having independent sitting balance and dependent standing and walking, with National Institutes of Health Stroke Scale (NIHSS) between 11- 22 were included.

Subjects were excluded from the study if they are with metal implant, recurrent stroke, hemiplegia due to non-vascular causes (malignancy, infections, tumours, brain injury etc.), cognitive and speech problem, chronic renal failure, sensation loss in the lower extremity and poor sitting balance. Experimental protocols of the present study has the approval of institutional local ethical committee and informed consent were obtained from all the participants.

The subjects were randomized into two groups by lottery method, Group A for Conventional physiotherapy and Group B for Robotic tilt-table rehabilitation. Both the groups were further stratified into sub-groups of right side and left side hemiplegia. The diagnosis of site of lesion of stroke was diagnosed by CT scan or MRI by the Neurologist. After stratification, in Conventional physiotherapy group there were 22 patients of right side and 18 patients of left side hemiplegia. Whereas, in robotic tilt-table group there were 18 patients of right side and 22 patients of left side hemiplegia. The clinical demographic characteristics are reported (age, height, weight, systolic and diastolic blood pressure). Both treatments were given as individual treatment by same physiotherapist with same intensity and capacity on 30 regular days (except Sunday) and reassessment was done after 30 days. The subjects were also informed about the experimental risks, if any. The duration of each individual treatment session was about 50 to 60 minutes per day. All subjects were allowed to take treatment for their comorbid condition like hypertension, dyslipidemia, hypothyroidism, cardiac problem in both the conditions under supervision of Neurologist. No other treatment will be allowed other than mention above.

Training protocol

Conventional physiotherapy (Group A)

Range of motion exercises, muscles stretching, bed mobility exercises, according to the standard procedure in physiotherapy setting [13]. All the exercises were done for 10 repetition, 2 sets with 10 seconds hold ones in a day under the supervision of physiotherapist.

Robotic tilt-table therapy (Group B)

Robotic tilt-table therapy was administered according to the standard protocol [13]. Patient received treatment session of 40 minutes, 6 times per week for about 4 weeks.

Outcome measures

The assessment of QOL was done according to SF-36 assessment tool [14] and also used earlier in acute stroke patients [15].

It is a multipurpose, self-administered, short form (SF) health survey with 36 questions which measures generic health status in the general population. These questions consist of physical functioning, role functioning, body pain, general health, vitality, social functioning and mental health. Response choices are numbered from left to right, starting with 1. The maximum scores obtained from 36 questions where 149 which represents best QOL whereas minimum score 36 represents the worst.

Muscle strength was measured by MRC classification of Manual Muscle Testing (MMT) [16].

The National Institutes of Health Stroke Scale, or NIH Stroke Scale (NIHSS) is a tool used by healthcare providers to objectively quantify the impairment caused by a stroke. The NIHSS is composed of 11 items, each of which scores a specific ability between a 0 and 4. For each item, a score of 0 typically indicates normal function in that specific ability, while a higher score is indicative of some level of impairment. The individual scores from each item are summed in order to calculate a patient's total NIHSS score. The maximum possible score is 42, with the minimum score being a 0 [17].

The Mini–Mental State Examination (MMSE) or Folstein test is a 30-point questionnaire that is used extensively in clinical and research settings to measure cognitive impairment. Administration of the test takes between 5 and 10 minutes and examines functions including registration (repeating named prompts), attention and calculation, recall, language, ability to follow simple commands and orientation. Any score greater than or equal to 24 points (out of 30) indicates a normal cognition. Below this, scores can indicate severe (≤9 points), moderate (10–18 points) or mild (19–23 points) cognitive impairment [18].

The Modified Ashworth Scale is a 6-point rating scale that is used to measure muscle tone with ratings from 0 indicating no increase in tone to 5 indicating limb rigid in flexion or extension [19].

Statistical Analyses

A two tailed ($\alpha = 2$) probability (P) values less than 0.05 ($P < 0.05$) was considered to be statistically significant. . Data was summarized using descriptive statistics of mean and standard deviation. Microsoft EXCEL was used for the analysis.

Scores of the dependent variables NIHSS, MMSE, Ashworth, QOL, muscle strength of lower limb and upper limb was compared for the two instances in each group at baseline and after 30 days using paired t-test and the comparisons between both the groups were evaluated using un-paired t-test.

Results

In this study, total 80 subjects are recruited on the basis of inclusion and exclusion criteria and randomized equally into two groups, conventional exercise group and Robotic tilt table

group (40 in each). Mean age of the 80 patients was age 50.61±7.46 years, and training was started on average 8.65±5.82 days after the stroke. Patient's demographic parameters and baseline scores of outcome variable shows that there was no significant difference (Table 1).

Table 2 shows that after 30 day of rehabilitation all the outcome variables were improved significantly either right or left hemiplegia of both the conventional and robotic tilt table group.

On comparison between the right and left hemiplegia of conventional physiotherapy group after 30 days of rehabilitation, all the outcome variables were statistically non-significant i.e QOL (p=0.900), muscle strength of lower limb (p=0.1237), NIHSS (p=0.1260), Ashworth (p= 0.8426) and MMSE (p= 0.1515) except muscle strength of upper limb (p=0.0449). This shows that both the right and left hemiplegic patients improves equally after rehabilitation (Graph 1)

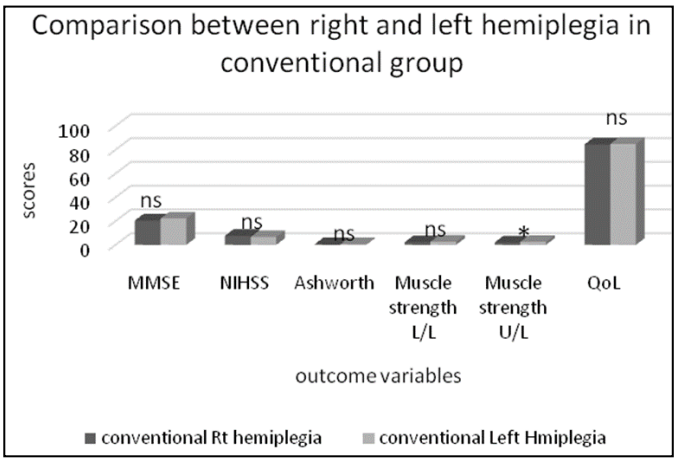
Whereas after robotic tilt table rehabilitation, both the right and left hemiplegia shows that there was no significant difference in outcome variables i.e. QOL (p=0.3520), muscle strength of lower limb (p=0.6944), muscle strength of upper limb (p=0.5843), NIHSS (p=0.9104), Ashworth (p= 0.0956) and MMSE (p= 0.4164), which indicate equal improvement on 30th day (Graph 2).

Table 1: Shows demographic and baseline parameters of the participants

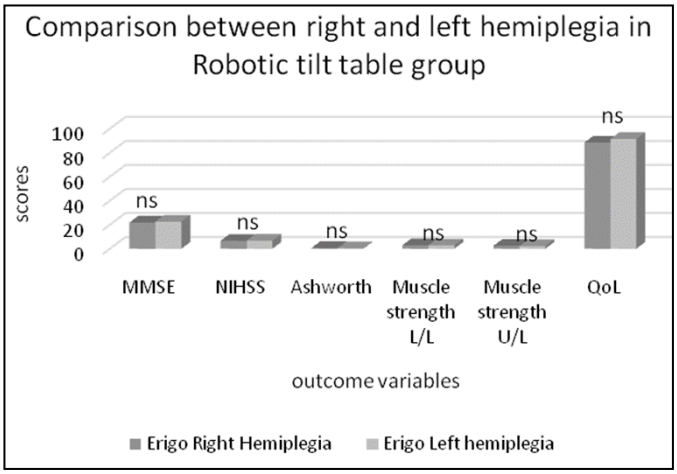
Demographic variables	Conventional group (n=40)		Level of significance (P value)	Robotic tilt table group (n=40)		Level of significance (P value)
	Right hemiplegia (n=22)	Left hemiplegia (n=18)		Right hemiplegia (n=18)	Left hemiplegia (n=22)	
Age (years)	50.50±7.65	52.28±8.66	0.4951	48.39±7.25	51.18±6.39	0.2033^{ns}
Gender (Number of females)	10	11	0.3365	5	10	0.2620^{ns}
Weight (in kg)	61.91±8.91	65.00±11.71	0.3490	62.44±6.66	63.86±8.25	0.5594^{ns}
Height (in m)	1.61±0.08	1.59±0.08	0.4081	1.62±0.09	1.60±0.10	0.3620^{ns}
BP systolic	130.91±17.16	136.67±12.83	0.2460	140.00±16.80	128.45±15.34	0.0291*
BP diastolic	85.00±10.58	87.22±10.74	0.5155	87.22±8.95	81.82±9.07	0.0669^{ns}
QOL	76.64±8.03	75.72±6.11	0.7270	77.44±11.33	80.59±8.13	0.3134^{ns}
Muscle strength lower limb	1.09±0.98	1.25±1.03	0.5961	1.33±1.35	1.62±0.81	0.4117^{ns}
Muscle strength upper limb	0.80±0.98	0.89±0.81	0.7631	0.93±0.92	1.17±0.90	0.4147^{ns}
NIHSS	12.86±1.78	12.28±1.45	0.2681	12.44±1.62	11.59±1.10	0.0547^{ns}
Ashworth	0.05±0.21	0.17±0.38	0.2136	0.28±0.46	0.09±0.29	0.1281^{ns}
MMSE	14.14±4.76	16.67±3.68	0.7270	15.06±4.30	16.95±4.37	0.1767^{ns}

Table 2: Shows comparison (0 versus 30th day) of outcome variables with time

		0 day	30 day	Level of difference P value
QOL	Conventional Right Hemiplegia	76.64±8.03	84.50±11.06	0.0001*
	Conventional Left Hemiplegia	75.72±6.11	84.89±7.61	0.0001*
	Robotic Tilt-table Right Hemiplegia	77.44±11.33	88.39±11.96	0.0001*
	Robotic tilt-table Left Hemiplegia	80.59±8.13	91.41±8.26	0.0001*
Muscle Strength Absolute Lower Limb	Conventional Right Hemiplegia	1.09±0.98	2.12 ± 1.10	0.0001*
	Conventional Left Hemiplegia	1.25±1.03	2.61 ± 0.81	0.0001*
	Robotic Tilt-table Right Hemiplegia	1.33±1.35	2.89 ± 1.07	0.0001*
	Robotic tilt-table Left Hemiplegia	1.62±0.81	2.77 ± 0.90	0.0001*
Muscle Strength Absolute Upperr Limb	Conventional Right Hemiplegia	0.80 ± 0.98	1.97 ± 0.88	0.0001*
	Conventional Left Hemiplegia	0.89 ± 0.81	2.56 ± 0.90	0.0001*
	Robotic Tilt-table Right Hemiplegia	0.93 ± 0.92	2.38 ± 0.81	0.0001*
	Robotic tilt-table Left Hemiplegia	1.17 ± 0.90	2.21 ± 1.08	0.0001*
NIHSS	Conventional Right Hemiplegia	12.86 ± 1.78	7.59 ± 2.09	0.0001*
	Conventional Left Hemiplegia	12.28 ± 1.45	6.61 ± 1.82	0.0001*
	Robotic Tilt-table Right Hemiplegia	12.44 ± 1.62	6.56 ± 2.53	0.0001*
	Robotic tilt-table Left Hemiplegia	11.59 ± 1.10	6.64 ± 1.99	0.0001*
Ashworth	Conventional Right Hemiplegia	0.05 ± 0.21	0.59 ± 0.50	0.0001*
	Conventional Left Hemiplegia	0.17 ± 0.38	0.56 ± 0.62	0.0147*
	Robotic Tilt-table Right Hemiplegia	0.28 ± 0.46	0.61 ± 0.61	0.0293*
	Robotic tilt-table Left Hemiplegia	0.09 ± 0.29	0.33 ± 0.48	0.0215*
MMSE	Conventional Right Hemiplegia	14.14 ± 4.76	20.50 ± 4.09	0.0001*
	Conventional Left Hemiplegia	16.67 ± 3.68	22.22 ± 3.15	0.0001*
	Robotic Tilt-table Right Hemiplegia	15.06 ± 4.30	21.78 ± 3.25	0.0001*
	Robotic tilt-table Left Hemiplegia	16.95 ± 4.37	22.59 ± 3.00	0.0001*



Graph 1: shows comparison between right and left hemiplegic subgroups of conventional group



Graph 2: shows comparison between right and left hemiplegic subgroups of Robotic tilt table group

Discussion

In fact the right side stroke affects the left side of the body and left side stroke affects the right side of the body but both the right and left hemiplegia improved equally in the outcome variables after rehabilitation. Thus, both the right and left hemiplegic patients are benefited equally after rehabilitation either by conventional physiotherapy or robotic tilt table therapy in improving all the functional i.e. quality of life, muscle strength of upper and lower limb and neurological parameters i.e. MMSE, NIHSS and Ashworth. Whereas in conventional group patient with left hemiplegia are found to be improved more in muscle strength of upper limb than the right hemiplegia.

The previous study suggest that difficulties in activities of daily living would be additionally aggravated in right-handed patients with left injuries as they would not be able to count on their dominant extremity, especially during the beginning of the recovery period, when the strength deficit is more pronounced. In healthy individuals, the dominant upper extremity is superior to the non-dominant extremity in tasks that that demand velocity, precision, coordination, muscle resistance and prehensile strength [20]. Therefore, it is possible to suppose that impairments of the dominant upper extremity would be most detrimental for activities of daily living compared to impairments on the non-dominant side, with the result of greater performance losses in right-handed individuals with left hemispheric injuries and right-side hemiparesis.

It is controversial whether rehabilitation outcomes differ depending on which hemisphere the lesion is occurs [21, 22, 23]. Possible reasons for the controversy are different outcome scales, measurement domain, presence of hemi-neglect, and evaluation timing. In one of the study, the outcome compared is vocational rehabilitation, patients with right hemisphere lesion show better outcome [24]. Whereas another study concluded that, the higher percentage of patients returning to work with a right hemispheric lesion largely can be explained by preserved speech-language function. However patients with right hemispheric lesions more frequently develop social defects than those with left hemispheric lesions [25]. In contrast, a study found that if regaining arm function is measured as a rehabilitation outcome, poorer outcome is reported in right hemispheric lesions [26]. And some found that among patients with right hemispheric lesions, patients with hemi-neglect are more disabled and stay longer at rehabilitation facilities than those without hemi-neglect.

Some studies have reported that patients with left side stroke demonstrate inferior performance on daily living activities during the first month of recovery, as measured by functional independence scales (Functional Independence Measure and the Barthel Index) [27]. Other studies that investigated this issue, however, did not find such performance differences.

Clinical practioners frequently have the impression that the functional recovery of patients with left-side stroke is worse than the recovery of patients with right-side stroke, however, no experimental confirmation of this idea has been found. Some authors describe poorer recovery of symmetry and velocity in sit-to-stand movements in these types of patients [28], however, results are difficult to interpret because patients with sensory deficits and hemineglect were excluded from the studied samples.

It has been suggested that verticalization may play a role in stimulating cortical areas involved in trunk and lower limb control, so that deafferentation and learned non-use can be contrasted [29]. VT may actively contribute to enhance cognitive performances through an increase in cerebral blood flow with a consequent induction of cortical plasticity, especially in frontal lobes [30]. Robotic verticalization include increased ventilation, increased arousal, improved weight bearing of the lower limbs, and facilitation of antigravity exercise of the limbs [31].

The possible mechanisms by which recovery after brain damage occurred could be Synaptogenesis (Creation of new synapses), Neurogenesis (the creation of new neurons), and Synaptic inhibition (Overcoming the diaschisis). The improved functional as well as neurological variables was related to the reversal of edema and biochemical alterations in the interstitial area of the injury [32], as well as to the neural reorganization resulting from the demands of daily life and rehabilitation training [33].

Practical application

The study concluded that after rehabilitation of right hemiplegia and left hemiplegia both are improved equally in there outcomes. Thus the practitioners should focus on better rehabilitation protocol rather than the side of the lesion for best rehabilitation outcomes.

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Conflict of Interest: Nil

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