

Original Research Article**STROKE SEVERITY VARIATIONS IN A 12 MONTH PROSPECTIVE STUDY
INVOLVING SUB-ACUTE STROKE SURVIVORS WITH AND WITHOUT
COGNITIVE IMPAIRMENT IN NNEWI, NIGERIA****Abstract**

Background: Stroke severity may intensify with cognitive impairments (CI), and impede functional recovery. Therefore proprioceptive neuromuscular facilitation (PNF) and task specific balance training (TSBT), were explored as an exercise intervention package for stroke survivors with and without cognitive impairment (CI).

Objective: To determine stroke severity variations in sub-acute ischemic stroke survivors with CI and without CI after 12 months prospective study

Methods: One hundred of 143 available sub-acute first ever ischemic stroke survivors recruited using convenience sampling technique in a quasi-experimental study. They were later assigned into the cognitive impaired group (CIG) and non-cognitive impaired group (NCIG). PNF and TSBT were applied to each group, 3 times a week, 60mins per session, for 12 months. Data were computed using independent t- test, and repeated measure ANOVA, at $p < 0.05$.

Results: There was statistical significant ($p < 0.05$) improvement across time points in the stroke severity of CIG and NCIG with large effect size of .773 and 0.641 respectively after 12 months of PNF and TSBT.

Conclusions: Within the groups, a 12-month PNF and TSBT intervention significantly improved stroke severity recovery, respectively, but with broader effects in the NCIG than CIG.

Key Words:- Stroke, cognitive impairment, stroke severity, Task specific Balance Training, proprioceptive neuromuscular facilitation

27 INTRODUCTION

28 Stroke severity is well-established predictor of outcome and it has
29 been significantly associated especially with short-term and not long-term survival. Although
30 stroke severity can fluctuate during the first week, assessments at day one and day seven
31 post stroke give day ninety post stroke and later long term disability estimates. [1] In the
32 Copenhagen Stroke Study which was a prospective community based study that evaluated the
33 outcome of stroke according to both initial stroke severity and initial level of disability, the
34 Scandinavian stroke Scale and Barthel Index were used as outcome measures. The study
35 showed that 78% of stroke survivors had no or only mild deficits on discharge and that even
36 the most severe cases regularly experience meaningful improvement during rehabilitation.[2]
37 Stroke severity at onset is important in predicting the outcome of rehabilitation. People who
38 had stroke presents varying forms of stroke severity depending on the degree of cortical
39 assault which evolve when stroke events occur. Stroke severity is determined hours or days
40 after stroke onset and this has helped in planning viable care for the patients. The NIHSS is a
41 systematic assessment tool that provides a quantitative measure of stroke-related neurological
42 deficit. [3] The NIHSS was originally designed as a research tool to measure baseline data
43 from patients in acute stroke clinical trials. The scale is widely used today as a clinical
44 assessment tool to check severity of stroke, to decide proper treatment, and to predict patient
45 outcome. [4] Stroke severity comprised three bands: Upper band – milder strokes; Middle
46 band – moderate strokes and Lower band – severe strokes. Garraway et al. [5, 6] first
47 proposed the concept of three bands of stroke patients based upon stroke severity. The upper
48 band was basically milder strokes that showed minimal deficits. These patients can generally
49 be managed at home if outpatient resources are available and there are no specific
50 issues to address on an inpatient stroke unit. Milder stroke patients do not need inpatient
51 rehabilitation, make limited rehabilitation gains (due to a ceiling effect) and can

52 be rehabilitated a community/outpatient setting without negative functional outcomes. The
53 middle band of patients suffered moderately severe strokes; they were conscious and had a
54 clinically significant hemiplegia/hemiparesis.[7] These patients often show marked
55 improvements in all areas although they are often partly dependent in most areas by
56 discharge. Over 85% discharged to the community.[7] These patients are best managed in a
57 comprehensive, well-staffed and intensive rehab unit. Moderately severe stroke patients make
58 the most benefit from stroke rehabilitation and are the most common admissions to a stroke
59 rehabilitation unit. The lower band of patients was the most severe strokes, unconscious at
60 onset with severe unilateral or bilateral paresis. Alternatively such patients may have serious
61 medical co-morbidity which adds to the stroke disability. There are two types of recovery:
62 neurological recovery and functional recovery. Neurological recovery of neurological
63 impairments and is often the result of brain recovery/reorganization; it has been increasingly
64 recognized as being influenced by rehabilitation. Functional recovery is improvement in
65 mobility and activities of daily living; it has long been known that it is influenced by
66 rehabilitation. However, functional recovery is influenced by neurological recovery but is not
67 dependent on it. As a general rule, the severity of the initial deficit is inversely proportional
68 to the prognosis for recovery. Most spontaneous recovery occurs during the first 3-6 months
69 after the stroke. The course of recovery negatively accelerates as a function of time and is a
70 predictable phenomenon. [8] Skilbeck et al. studied 92 stroke survivors with a mean age of
71 67.5 years (range= 36-89) at final assessment, either 2 or 3 years after stroke. The majority
72 of recoveries was reported within the first 6 months, with continued but non-statistically
73 significant recovery after 6 months. [8] This type of recovery has, until recently, been
74 regarded as largely inaccessible to medical intervention or manipulation. Neurological
75 deficits resulting from a stroke are often called impairments. Functional recovery refers to
76 improvement of independence in areas such as self-care and mobility. Recovery depends on

77 the patient's motivation, ability to learn and family supports as well as the quality and
 78 intensity of therapy. This type of recovery is modifiable by interventions and is
 79 influenced by, but may occur independently of neurological recovery. Functional deficits are
 80 often referred to as disabilities and measured in terms of functions such as activities of daily
 81 living. The mechanisms which account for neurological recovery after a stroke include: post-
 82 stroke edema were: reperfusion of the ischemic penumbra; diaschisis CNS Reorganization
 83 (Later Recovery) and reorganization of the brain after a stroke are dependent not only on the
 84 lesion site, but also on the surrounding brain tissue and on remote locations that have
 85 structural connections with the injured area. While a number of processes have been
 86 identified as playing a role in neurological recovery following stroke, the role each play is not
 87 completely understood. Recovery from stroke is often attributed to resolution of edema and
 88 return of circulation within the ischemic penumbra. [9]

89 Current evidence shows that a higher level of physical activity is associated with a decreased
 90 risk of stroke, has beneficial effects on stroke risk factors, and results in lesser stroke severity
 91 and a better long-term outcome following stroke. The human brain changes with response to
 92 various types of activities and experience through the reorganization of its neural
 93 connections. This phenomenon is called as neural plasticity. Studies over the past decade
 94 have indicated that the adult brain is structurally dynamic. Indeed, dendritic spines
 95 dynamically turn over in the adult brain, and learning of novel tasks is associated with further
 96 increases in spine turnover. Exercise training is an effective therapy for CNS dysfunctions
 97 like stroke, traumatic brain injuries etc. which has been applied to clinic. Traditionally, the
 98 exercise training has been considered to improve brain function only through enhancement,
 99 compensation, and replacement of the remaining function of nerve and muscle. [10, 11, 12]

100 Neural plasticity is the “ability of neurons to change their function, chemical profile (amount
 101 and types of neurotransmitters produced) or structure”. [13] It is essential for recovery from

damage to the central nervous system. Injuries that damage or severe axons cause degeneration, but may not result in cell death. Injuries that destroy the cell body of a neuron invariably lead to death of the cell. When neuron dies, the nervous system promotes recovery by altering specific synapses, functionally reorganizing the central nervous system (CNS) and changing neurotransmitter release in response to neural activity.

Recently, accumulating evidences indicated that exercise training can improve the function in different levels from end- effector organ such as skeletal muscle to cerebral cortex.[14] Although stroke is the most common life threatening neurological disorder globally, attempts to describe each trajectory of recovery following stroke, and identify variables associated with functional decline and recovery over twelve months are limited. Identifying influences that optimize functional recovery following stroke should continue as priority for researchers and clinicians alike. [14]

A lot of multidisciplinary approaches are known to impact resolution of stroke severity both in the acute and chronic situations, but the influence of PNF and TSBT on stroke severity recovery of sub-acute stroke survivors with CI and without CI have not been previously studied to the best of authors' knowledge. This is the gap the present study wants to fill. The current study thus aims to find if there will be comparable stroke severity variations between CI and NCI sub-acute stroke survivors after 12 months PNF and TSBT interventions. We therefore hypothesize that there will be no significant difference between the CI and NCI sub-acute stroke survivors after 12 months PNF and TSBT interventions.

Material and Methods

A multi-centre quasi-experimental study of 143 stroke survivors, who were selected using convenience sampling, conducted at four hospitals: Nnamdi Azikwe University Teaching Hospital, Myles Specialist Hospital, Hope Specialist Hospital and Mercy Specialist Hospital.

127 The patients recruited were treated at facilities with the required equipment: Landmark
128 Physiotherapy Services, Nnewi and Department of Physiotherapy, Nnamdi Azikiwe
129 University Teaching Hospital, Nnewi. The study conformed to STROBE guidelines
130 (Strengthening the Reporting of Observational Studies in Epidemiology)

131 **Sample size calculation:**

132 The sample size was determined using a mathematical relationship recommended
133 by Macfarlane. [15]

$$134 \quad N = 2 \frac{(Z_1 + Z_2)^2}{(ES)^2}$$

$$135 \quad (ES)^2$$

136 ES= standardized difference of variable with the least possible change = mean difference

137 · Standard deviation= 1.8/3.0= 0.60. [16]

138 · N= sample size for a group

139 · Z_1 = percentage point of normal distribution for statistical significance level at
140 95% confidence Interval = 1.96

141 · Z_2 = percentage point of normal distribution for statistical power at 80% = 0.8416;

$$142 \quad N = 2 (1.96 + 0.84)^2 / (0.60)^2 = 15.68 / 0.36 = 43.56 = 44$$

$$143 \quad N = 2 \times 44 = 88.$$

144 About 70% of the population was expected to be compliant, and therefore an attrition rate of
145 30% of the calculated sample size amounting to $30/100 \times 88 = 26$), was added to the sample
146 size. Therefore, N (total sample size) = $88 + 26 = 114$. Initially 143 participants were
147 recruited comprising 85 and 58 participants with and without cognitive impairments..
148 However, only 100 participants comprising 50 stroke survivors each were allotted into

cognitive impaired group (CIG) and non-cognitive impaired (NCIG) group, who eventually completed the study. We included participants with a diagnosis of ischemic stroke between the ages of 30 - 65 from 3 - 6 months since stroke onset; adjudged either cognitively or non-cognitively impaired by a neurologist using mini mental state examination; no history of other neurological (Parkinson, cognitive impairment or dementia), metabolic (severe or uncontrolled diabetes) or orthopedic conditions (severe arthritis or multiple fracture leading to significant bone loss; no recurrent or multiple cerebral infarctions; participants must be resident within Nnewi North or South LGAs and; participants must be able to read, write and understand English language.

Ethical Approval: Ethical Consideration. Ethical approval from the Nnamdi Azikiwe University Teaching Hospital Ethical Committee (NAUTHEC), Nnewi, was obtained along a supervision approval from a Consultant neurologist. All the participants gave their informed consent and the principle of principles of the declaration of Helsinki was adhered to before participation. They were also assured of the confidentiality of the information they provide. It was made clear to the participants that they have the right to refuse to participate or to withdraw at any stage of the project, and these rights were respected all through the research procedure.

Interventions

Proprioceptive Neuromuscular Facilitation (PNF)

The PNF technique/ strengthening program that was applied comprised rhythmic initiation, repeated contraction, slow reversal and rhythmic stabilization. Ten repetitions of each pattern were done before proceeding to the next pattern, in line with what obtains in previous PNF studies. [17, 18] After the set of pattern were completed, it was repeated twice in each treatment session making 3 sets per session. This usually lasted about

173 30 minutes per participant per session. However, the PNF training was applied equally in
 174 terms of frequency and duration irrespective of the side affected, and the set used in the study
 175 were as described by Knott and Voss. [19] A pamphlet containing the described patterns also
 176 served as treatment guide during training. [20].

177 The participants in the two groups (CIG and NCIG) were treated using same task specific
 178 activities parameters targeted at optimizing balance, such as:

179 (a) a repetitive task oriented practice of sit to stand transfer – 10 repetitions

180 (b) aerobic training using bicycle ergometer

181 (c) Obstacle crossing- stepping over obstacle using 5 wooden obstacles placed at 5
 182 meters apart- 10 repetitions

183 (d) standing balance with eyes open using a balance board for 1 minute for 10 repetitions

184 (e) forward and backward and forward progression- 5 repetitions, and

185 (f) turning task- a cylinder of 20 cm diameter and 20cm height was placed on the ground with
 186 participant walking with feet spread apart, the participants performed a pivot turn for 10
 187 times. [21] These tasks were made flexible according to the needs of each participant, and
 188 lasted for 60 minutes to avoid getting them fatigued. However, the duration of tasks was
 189 same irrespective of laterality. An interval of 10 minutes rest was allowed for the participants
 190 between sets of exercises. Deep breathing exercises were performed during rest period to
 191 improve fatigue and shortness of breath. Patients were closely monitored to prevent any
 192 adverse cardiovascular or respiratory reactions as a result of the intervention. The
 193 intervention was timed with a stop watch and scheduled between 8 am -12noon on the

194 appointment days. TSBT was applied one hour per session, three times a week, for 12
195 months. Four research assistants were trained to assist in each treatment session. [21]

196 **Aerobic Exercise Protocol**

197 Initial aerobic exercise intensity was based on 60% of maximum heart rate achieved on a
198 stress test. Each subject was progressed to 85% of the value over 12 months. All
199 subjects were engaged in an aerobic warm-up of at least 5minutes with perceived rating in the
200 light range of Borg's rating of perceived exercise scale, following the warm up, the
201 subjects were instructed to start with a ten minutes exercise which was increased until the
202 exercise intensity gets to the range of target heart rate and rate of perceived exertion (RPE) to
203 commensurate with "somewhat hard", heart rate and RPE were monitored to ensure subjects
204 were exercising at their prescribed intensity throughout the study. Subjects were encouraged
205 to increase their exercise time by 5minute each two months until they reach 50minute at the
206 ninth month, which was maintained until the end of the 12 months program.

207 **Outcome Measures**

208 Mini-mental state examination was used to assess global cognition level, which comprised
209 items concerning attention, language, following commands and figure copying, orientation,
210 registration and recall for all participants with a stroke history ≤ 3 months minimum duration.
211 The cutoff score was 23/24. [22] Participants that fell below the cut off were
212 assigned to CIG group while those that scale above the cut off were assigned to NCIG group.

213 **National Institute for Health Stroke Scale (NIHSS)**

214 NIHSS is a tool used by healthcare providers to objectively quantify the impairment caused
215 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. The cut off values are 1-6 mild impairment, 7-12 moderate impairment, 13-42 severe impairment. [22]

Statistical Analysis

Statistical Analysis was performed by using SPSS version 20: Descriptive statistic of Mean $\pm$ SD was used in the analysis of demographic and baseline characteristics. The raw data was tested for normality using Shapiro-wilks while Log Transformation was utilized to normalize the data. Repeated Analysis of Variance (ANOVA) was adopted to compare variations within each group; independent t-test was applied to compare variations between the two treatment groups. Probability value less than 0.05 was considered statistically significant.

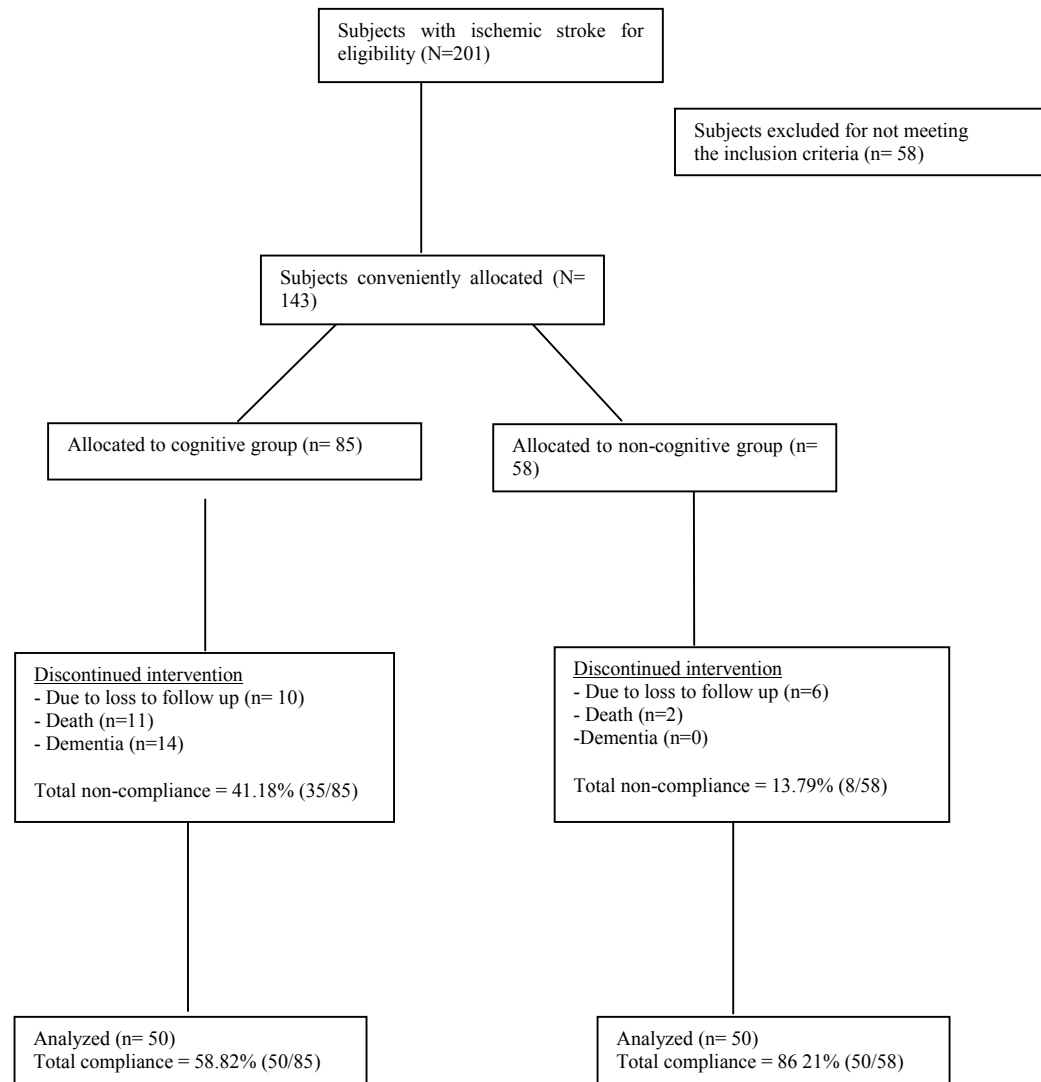


Figure 1: Subject Selection Flow Chart [22]

Results

Summary of figure 1

Out of 143 participants that commenced the treatment, 43 dropped out before the 6th month of the study for different reasons. Thus, in the cognitive group, 10 participants missed their follow-up appointments, 11 deaths were recorded as serious adverse events; while 14 others

tended towards dementia. The non-cognitive group had 6 participants who missed their follow up appointments, 2 deaths were reported as serious adverse event. Thus, only 100 participants completed the study. In the cognitive group, 58.82% completed the study; 41.18% did not complete the study. This contrasts with 86.21% who completed the study and the 13.79% who did not complete the study in the noncognitive group.

Summary of table 1

The baseline characteristics in table 1 showed the number of male and female participants were 23(46%) and 27(54%), respectively, for the cognitive group, while the non-cognitive had 22(34%) and 28(56%) for the males and females, respectively. Their mean age differed significantly ($p < 0.05$) and was recorded as 53.94 ± 9.316 years and 49.30 ± 12.214 years for the cognitive and non-cognitive groups, respectively. However, the duration of stroke and body mass index were not significantly different ($p > 0.05$) for the groups. The both types of stroke were common among the traders (business men) and civil servants with professional workers having least incidence of stroke. The other physical characteristics of the participants are presented in Table 1.

Summary of table 2

The Mauchly's test indicated that assumption of sphericity had been violated by the NIHSS scores for cognitive group, therefore degrees of freedom was corrected using Greenhouse Geisser estimates of sphericity. The mean scores for NIHSS scores were statistically significantly different: $F(1.589, 77.837) = 166.840$, $p < 0.001$. The result shows there was statistical significant decrease in NIHSS scores of cognitive impaired stroke survivors after 12 months PNF and Task specific Balance Training. The partial eta squared (effect size) was large = .773

278 The Mauchly's test indicated that assumption of sphericity had been violated by the NIHSS
 279 scores for non-cognitive group, therefore degrees of freedom was corrected using Greenhouse
 280 Geisser estimates of sphericity. The mean scores for NIHSS scores were statistically
 281 significantly different: ($F(1.800, 87.205) = 87.677, p < 0.001$). The result shows there was
 282 statistical significant decrease in NIHSS scores across time points in non-cognitive group.
 283 The partial eta squared (effect size) was large = .641.

284 **Summary of table 3**

285 There was a significant difference in NIHSS scores for cognitive group: 17.816 ± 6.030 and
 286 non-cognitive group: 8.080 ± 3.213 ; $t(97) = 10.054, p = .001$ at baseline. There was also
 287 significance difference in NIHSS mean scores for Cognitive: 6.306 ± 3.362 and non-
 288 cognitive: 3.680 ± 1.596 ; $t(97) = 4.981, p = .001$ across time points after 12 months
 289 intervention.

290 **Table 1: Baseline Characteristics of Participants**

Characteristic	Cognitive	Non-cognitive	p- value
Number(n)	50	50	
Age	53.94 ± 9.316	49.30 ± 12.214	.041*
Male	23 (46%)	22 (34%)	
Female	27 (54%)	28 (56%)	
Duration (months)	3.96 ± 1.029	4.04 ± 1.106	.928
Height	$1.706 \pm .0699$	$1.711 \pm .0453$	
Weight	78.760 ± 5.635	79.760 ± 6.1397	
BMI(kgm ²)	27.20 ± 2.80	27.196 ± 2.80	.863

Ischemic

Left (%) 30 (60%) 18(36%)

Right (%) 20 (40%) 32 (64%)

291 * Indicates significant difference at $\alpha = 0.05$, BMI=Body Mass Index

292 **Table 2:** Repeated Analysis of Variance (ANOVA) was adopted to compare variations
293 within each group after 12 months PNF and TSBT

294

Period	Type	Mean $\pm$ SD	Mean $\pm$ SD	Mean	%	P-	Conf.
		Raw	Transformed	Diff.	Change	value	Inter.
Baseline-	CIG	17.700 $\pm$ 6.025	1.222 $\pm$.157	5.600	31.638	.001	3.928-
4Months		12.100 $\pm$ 4.464	1.052 $\pm$.1684				-7.272
Baseline	NCIG	8.080 $\pm$ 3.212	.8701 $\pm$.1913	1.500	18.564	.001	.770-
4 Months		6.580 $\pm$ 3.289					-2.230
B/	CIG	17.700 $\pm$ 6.025	1.222 $\pm$.158	11.440	64.633	.991	.9.396-
12 months		6.260 $\pm$ 3.343	.742 $\pm$.217				-13.484
B/	NCIG	8.080 $\pm$ 3.212	.8701 $\pm$.1913	4.400	54.455	.001	3.428 -
12 months		3.680 $\pm$ 1.596	.5369 $\pm$.1539				-5.372
4/ months	CIG	12.100 $\pm$ 4.464	1.052 $\pm$.1684	4.940	40.826	.001	3.790 -
8months		7.160 $\pm$ 3.792	.790 $\pm$.229				-6.090
4 months/	NCIG	6.580 $\pm$ 3.289	.767 $\pm$.215	2.600	39.313	.001	1.606 -
8 months		3.980 $\pm$ 1.571	.570 $\pm$.161				-3.594
8 months/	CIG	7.160 $\pm$ 3.792	.796 $\pm$.229	.900	12.569	.001	.251-
12 months		6.260 $\pm$ 3.34	.742 $\pm$.217				-1.549

8 months/	NCIG	3.980± 1.571	.570 ± .161	.300	7.537	.001	-.087 –
12 months		3.680 ± 1.596	.537 ± .154				-687

* Values are presented as the mean standard Deviation. Significant difference at $\alpha = 0.05$, CIG= cognitive impaired group, NCIG= Non cognitive impaired group.

Table 3: independent t-test for comparison of means at baseline to 12th month for Cognitive impaired and Non-cognitive impaired groups

Type	NIHSS0	NIHSS4	NIHSS8	NIHSS12
CIG	17.816 ± 6.030	12.163±4.488	7.204±3.819	6.306±3.362
NCIG.	8.080±3.213	6.580±3.289	3.980±1.571	3.680±1.596
t-value	10.054	7.070	5.513	4.981
p.value	.001	.050	.001	.001
Confidence Interval	7.814 – 11.658	4.016 – 7.151	2.063 – 4.385	1.579 – 3.673

* Indicates significant difference at $\alpha = 0.05$, NIHSS0= National Health Institute Scale at baseline, NIHSS4= National Health Institute Scale at 4 months, National Health Institute Scale at 8th month, NIHSS12= National Health Institute Scale at 12th month, CIG= cognitive impaired group, NCIG= Non cognitive impaired group.

Discussions

This study was undertaken to explore the effect of PNF and TSBT on the stroke severity of CI and NCI stroke survivors after 12 months of intervention. The findings of this study show that there was clinical significant improvement in the stroke severity of cognitive impaired stroke survivors after four months of exercise intervention and other time points. Similarly there was statistical significant improvement in the stroke severity of non-cognitive impaired stroke survivors after four months of exercise intervention and other time points. The effect

size of the two groups was large making the interventions clinically significant. This reduction in stroke severity as shown in the NIHSS scores in table 2 might be linked to influence of exercises in bringing about cortical reorganization and neural plasticity which helped to relieve stroke severity after spontaneous recovery window (3-6 months). A key aspect of neuroplasticity that has important implications for rehabilitation is change in neuronal networks that are use-dependent. Animal experimental studies and clinical trials in humans have shown that forced use and functional lead to improved function. [23] On the other hand, techniques that promote nonuse may inhibit recovery. This believe collaborated the finding that prolonged lack of active movement following cortical injury may lead to subsequent loss of function in adjacent, undamaged regions of the brain (Animal study).[24] In the past, the conventional wisdom was that benefits from rehabilitation were achieved primarily through training patients in new techniques that compensate for impairments (for example, using the uninvolved hand to achieve self-care independence). This approach avoided intense therapy on the weak upper limb. Currently, it is recognized that repeated participation by patients in active physical therapeutic programs probably provides direct influence on the process of functional reorganization in the brain and enhances neurologic recovery. [23] Furthermore a comparative analysis of the two groups revealed a significant difference between the two groups at baseline, four months and other time points. This may be attributed to the effect of cognitive impairment on stroke severity- cognitive impairment is known to have inverse relationship with stroke severity. Cognitive impairment is known to worsen the clinical sequelae of stroke.

The baseline characteristics revealed that a total of 100 stroke survivors (50 cognitive and 50 non-cognitive) completed this research study. The ratio of the male to female was almost the same in the two groups; therefore, the differences in sex were consistent and indicate the

similarity of the samples in this context. It was further revealed that the duration of stroke and the body mass index were not significantly different ($p>0.05$) between the two groups.

The stroke severity as measured by NIHSS showed a steady improvement (decline in NIHSS scores) in within group analysis from baseline to 12 months in CIG stroke survivors after 12 months PNF and TSBT showed a significant improvement at 4 months, 8 months and other time points. The p-value was statistically significant throughout the duration of the study accounting for 64.633% improvement in stroke severity with large effect size (.773) for CIG stroke survivors after the 12 months of intervention. Also for the NCIG, there was significant decline in stroke severity between baseline, 4 months and other time points after 12 months PNF and TSBT intervention. The mean percentage change was 54.455% with effect size of .541. This has made the outcome to be clinically significant in both groups after 12 months of PNF and TSBT interventions. The implication to the study is that both the neurological recovery engendered by spontaneous recovery, and the functional recovery engendered by cortical reorganization and neuroplasticity are important for determining the final stroke severity outcomes. It is pertinent to infer that the recovery of stroke severity recorded between baseline and 4th month in the two groups may be attributed to spontaneous recovery more than the intervention given. A reduction in the extent of neurologic impairment can result from spontaneous, natural neurologic recovery (via the effects of treatments that limit the extent of the stroke) or from other interventions that enhance neurologic functioning. A patient demonstrating neurologic recovery presents with improvements in motor control, language ability, or other primary neurologic functions. [23] The initial recovery from stroke is often attributed to resolution of edema and return of circulation within the ischemic penumbra [9]. Between 4th month and 8th month there was a significant improvement (NIHSS decline) in the stroke severity in the two groups. The course of this recovery may be attributed to the effects of both the neurological recovery

360 and functional recovery. This finding is supported by Skilbeck et al, who opined that most
 361 spontaneous recovery occurs during the first 3-6 months after the stroke. [8] The implications
 362 being that spontaneous recovery, the effect of PNF and TSBT that elicit cortical
 363 reorganization and neural plasticity hold sway at this level of recovery of stroke severity.
 364 Also in the two groups there was statistically significant difference between 8th month and
 365 12th month PNF and TSBT intervention. This recovery may be entirely attributed to the effect
 366 of cortical reorganization and neural plasticity simulated by the exercise intervention. This is
 367 the point functional recovery which is mostly influenced by exercises shows dominance. The
 368 course of recovery negatively accelerates as a function of time and is a predictable
 369 phenomenon. [8] Functional recovery is influenced by neurological recovery but is not
 370 dependent on it. The implication being that the prevalence of functional recovery at this level
 371 is elicited by the fact that the influence of neurological recovery is almost nonexistent.
 372 Functional recovery which is a manifestation of degree of stroke severity recovery relies on
 373 the effectiveness and efficiency of exercise intervention applied. As a general rule, the
 374 severity of the initial deficit is inversely proportional to the prognosis for recovery. It is
 375 pertinent to assert that the resolution of the severity of stroke is critical to level of functional
 376 recovery and independence being anticipated in a patient. [25] The level of stroke survivor's
 377 reintegration back to the society may invariably lean on the quantum of functional recovery
 378 and degree of independence attained post rehabilitation. This assertion is collaborated by
 379 the finding that initial severity of the stroke is inversely proportional to the final functional
 380 outcome, with the majority of patients who suffer mild strokes demonstrating no or only mild
 381 disabilities, while the majority of patients suffering very severe strokes still experience severe
 382 or very severe deficits even after the completion of rehabilitation. A number of studies have
 383 shown that recovery may continue at a slower pace for at least 6 months; with up to 5% of
 384 patients continuing to recover for up to one-year. This is especially true with patients who are

385 severely disabled at the time of initial examination. [26,27,28,29,30,31] Significantly,
 386 progress towards recovery may plateau at any stage of recovery with only a very small
 387 percentage of those with moderate to severe strokes (about 10%) achieving ‘full recovery’.
 388 The progress of recovery may however be dependent on the initial severity of stroke, how
 389 early the exercise intervention commenced, type of exercise program, age of participants and
 390 the frequency of exercise intervention program. Brain plasticity is the ability of the nervous
 391 system to modify its structural and functional organization. The 2 most plausible forms of
 392 plasticity are collateral sprouting of new synaptic connections and unmasking
 393 of previously latent functional pathways. Other mechanisms of plasticity include
 394 assumption of function by undamaged, redundant neural pathways, reversibility
 395 from diaschisis, denervation super sensitivity, and regenerative proximal sprouting
 396 of transected neuronal axons. Experimental evidence indicates that plasticity can be altered
 397 by several external factors, including pharmacologic agents, electrical stimulation, and
 398 environmental stimulation. [24]

399 A comparison of the two groups using independent t-test revealed a significant difference in
 400 the recovery of stroke severity at 4th month, 8th month and 12th month after exercise
 401 interventions. The outcome of this study rejected the hypothesis that there will be no
 402 significant difference in the stroke severity recovery in the CIG and NCIG after 12 months
 403 exercise intervention. It is important to see that at baseline the patients presented with
 404 moderately severe stroke symptoms on admission for CIG, while the NCIG presented with
 405 moderate stroke severity. This could have contributed to the significant difference between
 406 the two groups at baseline in table 3. The implication of finding to the study is that the
 407 significant difference in severity of stroke in the two groups across time points might have
 408 been influenced not only by the cognitive status of the study participants in the control group
 409 but also by the severity of stroke at baseline and the differences in age between the two

groups. This is consistent with the findings of America Heart Association in a prospective pilot study, that baseline NIHSS score was essential for prediction of acute ischemic stroke outcomes, followed by age; whereas traditional comorbidity index contributed little to the overall model. Future studies of stroke outcomes between different care systems will benefit from including a baseline NIHSS score. [32]

A preliminary data in humans and evidence from animal studies suggest that improving brain function would require 3-6 Months of moderate to high intensity training. In contrast, preservation of function can be best demonstrated with prolonged regimes where mild to moderate levels are more practical. [33] This agrees with the finding that the cumulative effects of the length, the intensity and the frequency of exercise training via PNF and TSBT over 1 year could trigger production of the brain-derived neurotrophic factor (BDNF) which possesses the extraordinary capacity to enhance neuronal excitability and synaptic plasticity by interacting with energy metabolism, thereby supporting cognitive abilities. Brain-derived neurotrophic factor is a member of the neurotrophin family; a group of proteins involved in neuroprotection, neurogenesis, and neuroplasticity, and has been identified as a key mediator of motor learning and rehabilitation after stroke. [22]

Conclusions

The variation in stroke severity recovery between the two groups in this study was influenced by differences in stroke severity, age and cognitive impairment at baseline. However, the recovery processes still aligned with neurological and functional recoveries triggered by both spontaneous and cortical reorganization/neuroplasticity. The degree of eventual outcome as per functional recovery ought to be influenced by the stroke severity at baseline. These cofounders lead to rejection of the hypothesis when the two groups were

434 compared. However, there might be some other cofounders which were not factored in this
435 study that might have influenced the stroke severity recovery in this current study. The
436 implication for rehabilitation is that stroke severity recovery may not translate to direct
437 functional performance if cognitive impairment, stroke severity and age of the sub-acute
438 stroke survivors are significant different ($p<0.05$) at baseline. Of interest is the fact that the
439 two groups benefitted from the intervention given but the recovery was better in the non-
440 cognitive group than the cognitive group.

441 The current work was limited by high level of drop out from the cognitive group and by the
442 limited number of participants. However, there were significant age differences between the
443 two groups which were not unexpected considering that the subjects were not randomly
444 selected. This might be a weakness for the study design, as age might be an important
445 confounding variable for stroke severity recovery. Perhaps, these differences between the
446 groups may add to the explanations that in between group comparison of the intervention
447 study, there were significant differences in the outcome measures across both groups. This
448 could be indication that age-related differences and cognitive dysfunction may have
449 suppressed gains in stroke severity recovery when PNF /TSBT were given to the cognitive
450 impaired stroke survivors. Other limiting factors include the significant difference between
451 the NHISS scores at baseline. This in addition to age differences at baseline was important
452 cofounding variables in the current research that might have created the variations in stroke
453 severity between CI and NCI.

454 More studies that will control the effects of stroke severity and age related differences at
455 baseline are advocated. PNF and TSBT is recommended in management of sub-acute
456 ischemic stroke survivors as their influence in eliciting cortical reorganization

and neuroplasticity in reducing stroke severity especially when the effect of spontaneous recovery stopped or diminished between 3 and 6 months.

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