Effects of Proprioceptive Neuromuscular Facilitation Technique on the Functional Ambulation of Stroke Survivors

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ABSTRACT
This study investigated the effect of an 8-week proprioceptive neuromuscular facilitation (PNF) treatment programme on the functional ambulation of post-stroke individuals measured with the Emory Functional Ambulation Profile (EFAP) - a timed-test instrument comprising 5 subtasks. Seventeen male and female post-stroke individuals (mean age 56.73 ± 8.79 years) were recruited into the study and treated with a PNF protocol twice weekly for 8 weeks. Performance on individual subtasks of the EFAP were measured and recorded for each participant before and at the end of the study. Only the data for 15 participants was available at the post-test for analysis. EFAP subtasks completion times were significantly reduced for all subtasks at the post-test and total EFAP score ($p < 0.05$). PNF technique led to improvement in the functional ambulation of post-stroke individuals. PNF is recommended as an effective treatment for functional ambulatory gains in stroke rehabilitation.

Key words: *Stroke, ambulation, movement, Proprioceptive neuromuscular facilitation (PNF)*

INTRODUCTION

Stroke, described as the sudden development of a neurologic deficit caused by abnormalities of blood supply[1] is one of the major causes of morbidity and mortality worldwide.[2] It is the commonest neurological disorder worldwide, the second commonest medical condition in the developed world and the leading cause of disability among adults.[3,4] A majority of individuals who have suffered stroke are later able to walk, though rarely with a normal pattern.[5] For this group of individuals, posture, tone and coordinate reciprocal movements, which are required for normal gait, are usually impaired[6] and gait reeducation is a major component of physical therapy intervention for these patients.[7]

Functional ambulation is defined as the ability of a person to walk with maximal independence and in the least time under various environmental circumstances.[8] Post-stroke individuals may have difficulty adapting to environmental demands such as rising from a chair, stepping over an obstacle, or ascending stairs[8] and walking along inclines and uneven surfaces[9] as they may have compromised the ability to regain balance, control movement, or adjust energy expenditure.[10] Turnbull et al.[11] had also suggested that gait deficiencies observed in post-stroke individuals are likely limitations for their ability to respond to environmental demands. It thus became necessary to test the ability of a treatment protocol to remedy this problem.

Proprioceptive neuromuscular facilitation (PNF) is one of the major therapeutic approaches aimed at improving the important features necessary for the functional ambulation of hemiplegic patients, such as muscular tone, strength and flexibility.[12] Various procedures of PNF are used depending on the target body part.[12,13,14] Wang[15] reported that studies on the effectiveness of PNF-based treatment have been both supportive and conflicting and that very few studies on pelvic facilitation for gait improvement existed. Most of the studies[14,15,25] on PNF have mostly tested only gait speed and cadence and hardly functional ambulation. The authors also observed a general decline in the use of the PNF technique among physiotherapy clinicians in their practice environment. This may be due to the heavy patient load in most clinics and the physically-tasking nature of administering the PNF technique. No study on the effectiveness of PNF from this environment was available for referencing and none of the available ones from the other environments evaluated its effect on functional ambulation. This work was aimed at investigating the effect of a PNF protocol on the functional ambulation profile of stroke survivors.

METHODS AND PROCEDURE

Ethical approval was given by the Joint Institutional Review Committee of the University of Ibadan/University College Hospital, Ibadan. All the participants in the study gave their informed consent after the research purpose and procedures had been explained to them.

Participants

Seventeen consecutively referred male and female volunteer post-stroke individuals (mean age 56.73$\pm$8.79 years) were recruited for the study. These individuals all met the inclusion criterion of ability to perform the five subtasks on the Emory Functional Ambulation Profile (EFAP) without any form of human assistance but with the use of an assistive device (if required). None of the participants in the study required an assistive device. The presence of musculoskeletal or other cardiovascular problems apart from known and controlled hypertension excluded an individual from the study.

Research Instrument

The Emory functional ambulation profile (EFAP) is an instrument measuring the time it takes an individual with stroke to complete each of its five subtasks:

i. 5-metre walk on the hard surface floor marked out on the gymnasium floor.
ii. 5-metre walk on the carpeted (rug) floor
iii. Performance of 'up and go' task
iv. Negotiation of an obstacle course
v. Ascent and descent of 4 stairs

Subtasks were completed in the above sequence (a standardized protocol). The EFAP has a high intra-rater (ICC = .997) and test-retest (r = .99) reliability as reported by Wolf et al.[8] and Fasoyin[16] respectively. The EFAP has a concurrent validity of r = -.708 and r = -.783 (with and without assistance factor respectively) for stroke survivors when compared with the Timed 10-metre Walk Test (8) and r = -602 and r = -.592 (with and without assistance factor respectively) when compared with the Berg Balance Test.[8]

Each participant was allowed a rest period between performances long enough for one of the researchers (ACO) to explain and demonstrate the next component. This varied from participant to participant as opportunities were given to participants to seek clarification. It also varied from subtask to subtask. Two of the researchers (ACO and MFA) recorded the performance times for all five subtasks and calculated the total EFAP score on completion of the entire data collection session.

Treatment Protocol

The PNF was given in each hospital by a physical therapist skilled in the procedures. Both physical therapists had participated in a refresher course just before the commencement of the study. The course was facilitated by a PNF-certified instructor and emphasized the appropriate use of the different PNF components (such as commands, stretching, timing and manual resistance) in optimizing patients' output. The average of the measurements taken at the pretest and post-test for each participant was computed in the final data sheet by ACO.

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 patterns was completed, it was repeated twice in each treatment session making 3 sets per session. This usually lasted about 45 minutes for each patient. The PNF patterns in the set used in the study are as described by Knott and Voss[19] for the following:

Lower extremity:

- Flexion-abduction-external rotation (knee flexed and knee extended)
- Extension-adduction-internal rotation (knee flexed and knee extended)
- Flexion-adduction-internal rotation (knee flexed and knee extended)
- Extension-abduction-external rotation (knee flexed and knee extended)

Upper extremity:

- Flexion-abduction-external rotation (elbow flexed and elbow extended)
- Extension-adduction-internal rotation (elbow flexed and elbow extended)
- Flexion-adduction-internal rotation (elbow flexed and elbow extended)
- Extension-abduction-external rotation (elbow flexed and elbow extended)

A pamphlet containing the described patterns also serves as treatment guide for the attending physical therapists. Each participant received treatment twice a week for 8 weeks making 16 sessions in all.

Data Analysis

The Statistical Package for the Social Sciences (SPSS) version 11 was used for data analysis in this study. The mean, standard deviation, minimum and maximum values for each test score, age and for time since onset of stroke (post-stroke period) was determined. Gender of post-stroke individuals and side of lesion were summarized as frequency occurrence. Paired t-test was used to compare differences between pre-test and post-test EFAP scores. Alpha level was set at .05 for all tests.

Table 1. Paired t-test for comparison of participants' scores pre- and post-test

	Pre-test $x + SD$ (seconds)	Post-test $x \pm SD$ (seconds) N = 15	t	p
Floor	11.75±7.64	10.88±4.74	3.23	0.01*
Carpet	15.87±7.84	11.49±6.30	2.99	0.01*
Up and Go	25.93±11.44	20.26±7.77	4.14	0.00*
Obstacle	38.77±17.82	32.16±15.10	3.79	0.00*
Stairs	19.79±7.55	13.88±5.11	6.13	0.00*
Total	115.1±50.75	88.67±37.30	4.48	0.00*

*Significant at $p < 0.05$ alpha level

RESULTS

The mean age of participants was 56.73±8.79 years and mean post-stroke period was 19.53±22.72 months. Seven (46.7%) of the participants were males while 8 (56.3%) were females. Eight (53.3%) of the participants suffered right-sided hemiplegia while 7 (46.7%) had left-sided affectation. The mean total EFAP was also significantly lowered ($p < 0.05$) from 115.10±50.75 seconds pretest to 88.67±38.30 seconds at the post-test measurement.

DISCUSSION

The mean age of the participants in this study was similar to that of the population used in establishing the validity of EFAP.[8] They were however younger than the populations studied by other authors.[20,9,21] The average ages of post-stroke individuals in studies evaluating effectiveness of different physical therapy protocols range between 50 and 65 years. The average participants in this study had suffered the stroke for just slightly over 19 months. This was longer than that of the population in the validation study by Wolf et al.[8] and some other studies,[9,22] but shorter than that of the population in Francisco and Boake.[23]

The participants made appreciable improvement in each of the EFAP sub tasks – floor, carpet, 'up and go', obstacle and stairs – and total EFAP scores. The subtasks in the EFAP were all walk tests that evaluate walking time across different terrains. Reduction in walk time for a fixed distance (or task) of the EFAP translates to an improvement in walking speed. Trueblood et al.[14] were unable to show gait speed improvement after one session of treatment consisting of four sets of five repetitions of resisted PNF pelvic motions in 20 patients but stance stability and limb advancement of the involved lower extremity improved. Our finding is in line with that of Wang[15] who demonstrated improvements in gait speed and cadence with twelve sessions of PNF pelvic facilitation in patients with hemiplegia of short duration and long duration. He however concluded that the cumulative effect of PNF was more beneficial than the immediate effects.

Participants in this study had about 45 minutes of PNF treatment thrice weekly for 8 weeks; a duration that is long enough to produce the cumulative effects suggested by Wang. Kwakkel and Wagenaar[24] have shown that the duration devoted to training of the upper and lower extremities during rehabilitation does not affect walking speed and gait symmetry. The duration devoted to the upper and lower limbs in this study was largely dependent on patients' tolerance and the judgment of the attending clinician. It is assumed that it did not affect the results in any way. Just as observed in this study, Kawahira et al.[25] were able to show that a rehabilitation programme comprising mainly the PNF technique led to improvement in voluntary movement of the hemiplegic lower limb.

The participants in this study received PNF treatment which included upper and lower limbs and pelvic and trunk facilitations and subjectively reported improvements in arm functions and activities of daily living (ADL). PNF and PNF-inclusive protocols had been shown to lead to significant improvements in the upper limb functions of post-stroke individuals.[26,27] A greater level of improvement in upper limb functions was reported for participants with post-stroke periods greater than 11 months in the Krawczyk and Sidaway[25] study, than for those with a shorter post-stroke period. The average post-stroke period for participants in this study was greater than 11 months, and participants with longer post-stroke periods may have contributed more to the obtained significant result of this study.

Improvement in walking speed has been found to be positively correlated to different spatiotemporal parameters not evaluated in this study. Perry et al.[28] and Roth et al.[29] have established positive relationships between gait speed and temporal gait parameters like gait cadence, stride length, hemiplegic and non hemiplegic limbs' stance phases and double support phase duration and percent. De Quervain et al.[30] reported that there were abnormal movements of the upper extremity, the trunk, the pelvis and the lower extremity on the affected side in an effort to compensate for the decreased velocity on the hemiplegic side and that these abnormal movements reduced with improvement in gait velocity. The improvement in the functional ambulation (reduced task completion time) or increased speed observed among the participants is expected to translate to improved coordination of walking as Wade et al.,[31] Olney et al.,[32] Lennon,[7] and Kwakkel and Wagenaar[22] had variously established a positive relationship between walking speed and coordination of post-stroke individuals.

Increased walking speed has also been linked to an improvement in the stage of synergistic patterned movement in the paretic leg,[33, 34] and improvement in maximal ankle power.[32] The improvement in walking speed observed as reduced task completion time on all the EFAP subtasks might have occurred along with improvements in the stated parameters. These improvements in walking naturally lead to an improvement in the individual's ability to negotiate real-world overground environments (steps, obstacle and uneven surfaces) and to walk independently and confidently.[9] Guimares and Isaacs[35] had identified walking speed improvement as an indicator for reduced risk of falls and subsequent injury.

Kwakkel and Wagenaar[24] had shown that the increased stability and asymmetry of walking resulting from improved walking speed are better observed when post-stroke individuals move at a comfortable walking speed. All EFAP subtasks involve movement at comfortable walking speeds. David et al.[9] opined that this ability to walk safely at a functional speed would enhance the quality of life of post-stroke individuals by promoting increased involvement with family and community.

The PNF protocol used in this study led to improvements in all the EFAP subtasks and consequently overall functional ambulation. Clinicians will likely prefer a treatment protocol found effective in improving patients' ability to undertake daily ambulatory challenges. Inclusion of PNF in any treatment plan for post-stroke individuals may be of benefit, especially when improved functional ambulation is a key part of treatment goals. Since the improvement in gait speed (reduced task-completion time) – obtained with the PNF treatment – has been found to be positively-related to many spatiotemporal gait parameters and improvements in other muscular characteristics and functional activities, clinicians are likely to include PNF in treatment plans to obtain these added values. They may thus be able to contribute better to improved quality of life in patients with hemiparesis.

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