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Effect of Task-Based Bilateral Arm Training on Upper Extremity Motor Functions Among Rural and Urban Community-Dwelling Stroke Survivors in Nigeria

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Abstract

Introduction: One of the leading causes of disability in low- and middle-income countries like Nigeria is stroke. During rehabilitation, occupational therapists employ interventions like bilateral arm training (BAT) for motor recovery among stroke survivors (SSVs). However, evidence of BAT's effectiveness, especially in diverse settings like Nigeria, is inconclusive. This study evaluates task-based BAT intervention on upper extremity functions among rural and urban community-dwelling stroke survivors.

Methods: This quasi-experimental study recruited 10 rural and 11 urban community-dwelling SSVs from the OT unit of a Nigerian tertiary healthcare facility using purposive sampling. The task-based BAT intervention, consisting of four tasks, was delivered thrice weekly for 8 weeks. Motor functions were assessed using Fugl-Meyer upper extremity scale (FMA-UE), Upper Extremity Functional Index (UEFI), and Wolf Motor Function test (WFMT) at baseline, 4-weeks, and 8-weeks following intervention. Data was analyzed descriptively and inferentially.

Results: FMA-UE and WFMT scores showed significant improvement in both groups post-intervention reflecting enhanced motor function and performance. Specifically, there was a significant increase in WFMT scores at the 8-week mark among SSVs in rural communities (mean difference = 3.00, 95% CI [0.14, 6.14], $p = 0.031$), indicating the importance of longer rehabilitation periods. The changes in FMA-UE, UEFI, and WFMT between rural and urban community-dwelling SSVs were not statistically different.

Conclusion: The task-based BAT intervention was effective in improving upper extremity motor functions among SSVs in rural and urban settings. Tailored and individualized rehabilitation strategies, considering the unique characteristics of diverse community settings, are crucial for optimizing stroke recovery outcomes.

Keywords: Bilateral arm training; Nigeria; Rural dwelling; Stroke survivors; Task-based; Upper extremity function; Urban dwelling.

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Introduction

Stroke is one of the most common reasons for severe physical disability, and it has been established as one of the leading causes of disability and death worldwide, especially within the adult population (Adamson et al., 2004; Katan & Luft, 2018). The World Health Organization reports an estimate of about 15 million people experiencing stroke annually with about 5 million deaths and another 5 million living with resulting disability (World Health Organization – Regional Office for the Eastern Mediterranean, 2023). In Nigeria, the incidence of stroke is reported to be on the rise, a meta-analysis by Adeloye and colleagues (Adeloye et al., 2019) reported a crude rate from all studies analysed between the year 1995 and 2016 as 26.0 per 100,000 py. Danesi et al. (Danesi et al., 2007) also report a crude prevalence rate of 1.14 per 1000 population in urban Nigeria. On the other hand, Onwuchekwa and colleagues (Onwuchekwa et al., 2014) found a prevalence of 8.51 per 1000 in a rural context in the South-South region Nigeria. In another rural setting in South-East Nigeria, Enwereji et al. (Enwereji et al., 2014) estimated a prevalence of 1.63 per 1000 of the population. These findings are, however, higher than the incidence rates reported globally and within other low and middle-income countries (Ezejimofor et al., 2017; Owolabi et al., 2015). The prevalence is further observed to be higher in rural community settings compared to urban settings with increasing negative outcomes observed among stroke survivors (SSVs) dwelling in rural areas (Owolabi et al., 2015). The most common deficits observed in stroke survivors is the loss of motor function at the contralateral limb secondary to hemiparesis or hemiplegia (Raghavan, 2015). The severe physical deficits following a stroke invariably lead to the loss of functional independence due to limitations in the performance of activities of daily living (ADL) such as feeding, grooming; work and productivity: and leisure activities (Govender & Kalra, 2007). Evidence suggests a 50% reduction in the quality of life of SSVs due to loss of arm function that impacts ADL performance negatively (Kantak et al., 2017).

As key actors within the multidisciplinary stroke rehabilitation team, occupational therapists (OTs) design interventions using meaningful and purposeful activities to facilitate the recovery of lost abilities or teach compensatory approaches for occupational performance when it is impossible to restore lost functions (Govender & Kalra, 2007). Rehabilitation of the paretic side entails relearning real-life tasks and activities using motor relearning approaches. To achieve remediation following a stroke, OTs use functional retraining methods that may be unilateral i.e., involving only the affected upper extremity or bilateral arm training (BAT) which involves both extremities (Chen et al., 2022; Kantak et al., 2017; Sainburg et al., 2013). Much attention has been paid to interventions targeted at strengthening the affected upper extremity following a stroke without involving the non-paretic arm; this is based on the assumption that strengthening the affected arm will lead to the functional performance of tasks (Kantak et al., 2017). However, there is growing evidence that the strengthening of a paretic arm does not translate into bilateral coordination for task performance (Kantak et al., 2016; Kantak et al., 2017). For instance, Sainburg and colleagues (Sainburg et al., 2013) indicated that stroke rehabilitation that involves only the paretic arm causes poor bilateral coordination and avoidance behaviours in ADL performance.

BAT on the other hand has emerged as a viable intervention technique to improve bimanual coordination and improve the paretic arm following a unilateral stroke (Fan et al., 2015; Fan et al., 2016; Whitall et al., 2011). BAT involves the repetitive movement training of both upper extremities in both symmetric and asymmetric movement patterns. It emphasizes the influence of inter-hemispheric coupling and neural cross-talk for motor relearning in stroke rehabilitation (Hatem et al., 2016). Since most daily task performance requires the use of both upper extremities, BAT has been incorporated as one of the routine interventions employed by OTs for enhancing motor recovery and occupational performance of tasks involving the upper extremities during stroke rehabilitation within Nigerian healthcare settings. The OAU-THC which serves as the study setting is the only public tertiary health facility that currently renders occupational therapy services to stroke survivors within her environs.

Despite the neurological evidence for BAT, there is still little evidence for its efficacy for functional outcomes and contradictory evidence has been reported in the literature (Chen et al., 2022; Kim, 2022). A need for more studies to evaluate the efficacy of BAT intervention in stroke rehabilitation has been suggested (Sleimen-Malkoun et al., 2011). In Nigeria, considering that stroke patients served by OTs come from different community settings, activities and tasks utilized in BAT intervention must be individualized to achieve optimal recovery in the patients. It is expected that tasks within BAT should be in line with the daily activities and roles that are meaningful and relevant to SSVs. More often, the predominant occupations, lifestyles, and cultural norms of rural and urban communities differ. Thus, to guarantee that tasks utilized in BAT are engaging and relevant, it must take into consideration the unique context and preferences of the SSVs. Although commonly employed as a routine intervention for SSVs within the study setting based on available literature evidence, the effectiveness of BAT intervention among this population residing in different community settings is yet to be explored. This study, therefore, seeks to evaluate the effectiveness of BAT on the upper extremity functions of community-dwelling stroke survivors across indices of sensorimotor functions and functional performance.

Materials and Methods

The Research and Ethics Committee of the Obafemi Awolowo University Teaching Hospital, Ile-Ife, Osun state (OAUTHC) approved this quasi-experimental study with the reference number – ERC No ERC/2023/02/18. The study was conducted at the Occupational Therapy unit of the OAUTHC from February 2023 to November 2023. Written informed consent was provided by all participants. Participants also retained their right to discontinue participation at any phase of the study.

Participants

Individuals who had a previous clinical diagnosis of stroke, were 18 years and older, and resided in rural and urban communities within Ile-Ife where hospital units of the OAUTHC are sited in Osun state of southwest Nigeria, were invited to participate in this study through purposive sampling technique. 23 stroke survivors who met the inclusion criteria of a score of 23 on the Mini-Mental State Examination, a score of 2 or lower on the Modified Rankin scale, and a minimum post-stroke duration of 6 months were recruited into the study. Exclusion criteria involved having severe spasticity indicated by a score of 3 or more on the Modified Ashworth scale. The presence of marked visual perception as well as uncontrolled hypertension. Among the 23 stroke survivors initially recruited, two dropped out as they were unable to participate regularly in the study, thereby leaving a final inclusion of 21 patients.

Procedure and Intervention

A BAT programme that is culturally and context-specific for community-dwelling stroke survivors was developed by the researchers and neuro-occupational therapists in the study setting. The face and content validity of the BAT programme was assessed by an expert panel that included rehabilitation specialists that were not involved in its development. The programme was developed following the protocol of Jung and colleagues (Jung et al., 2013). The BAT intervention comprised 4 daily tasks that are routinely performed within the communities of the patients. These tasks include: lifting cups from the table to the mouth using both upper extremities; Tying/wearing headgear/traditional cap with both hands; picking utensils with both upper extremities from the top of a cupboard and placing them on a table; as well as buttoning and folding of clothes with both upper extremities which are performed over a 50 minutes duration. All participants received BAT which was delivered by occupational therapists three times a week for 8 weeks. Each intervention session involved 5 minutes of warm-up activities followed by repetitive practice of bilateral symmetrical activities performed over 50 minutes duration with a rest period of five minutes. Before recruitment into the study, most of the participants were receiving usual rehabilitative services that comprised occupational therapy and physiotherapy.

Outcome Measurement

Three outcome measures that included the Fugl-Meyer upper extremity scale (FMA-UE) (Fugl-Meyer et al., 1975), the Upper Extremity Functional Index (UEFI) (Gabel et al., 2006), and the Wolf Motor Function test (WFMT) (Wolf et al., 1989) were used to assess upper extremity motor function at baseline, fourth and eight week. FMA-UE is a 33-item tool that is rated on a three-point ordinal scale of 0–2 which represents the extent of performance of motor functions along different subgroups of the UE to identify underlying impairments. The FMA-UE has been extensively used in stroke research (Ahmed et al., 2023; Okamura et al., 2024; Rozevink et al., 2023) and it is documented with remarkable test-retest reliability (total range 0.98–0.99), inter-rater reliability, and construct validity (Chiam et al., 2023). On the other hand, the UEFI is a 20-item patient-reported outcome measure that assesses the level of difficulty in performing activities of daily living with the UE on a 5-point Likert scale of 0 (extreme difficulty) to 4 (no difficulty with a total maximum obtainable score of 80. Excellent test-retest reliability values (ICC 0.73–0.95) and internal consistency (0.94) have been reported for UEFI (Arumugam & MacDermid, 2018). Additionally, the WFMT uses 17 items to assess the upper extremity motor ability of the patient in carrying out timed functional tasks with the affected extremity on a six-point ordinal scale of 0–5 with a maximum achievable score of 75. Lower scores on the WFMT are indicative of lower functioning levels. Extensive psychometric evaluation of its use in stroke research has been carried out with reports of high test-retest and inter-rater reliability (Turtle et al., 2020).

Data Analysis

Descriptive statistics of mean, standard deviation, frequency, and percentages were used to present the demographic and clinical features of participants. Also, inferential statistics of independent t-test, Mann-Whitney U, and Fisher's exact test were used to compare the characteristics of participants who were rural community dwellers and urban community dwellers. Repeated measure ANOVA was used to compare upper extremity functions as measured by FMA-UE, UEFI, and WFMT at the baseline, 4th week, and the 8-week of intervention. The data analysis was managed using SPSS version 27. The alpha value was set at $p \leq 0.05$.

Results

The mean age of the participants was 61.7 ± 12.0 years with a range of 42 to 78 years. The majority of them were male (66.7%), and had ischaemic stroke as well as a slight disability on the modified Rankin scale. The demographic and clinical features of both rural and urban participants were comparable as presented in Table 1. Similarly, the baseline upper extremity functions (FMA-UE: $t=-0.09$, $p=0.925$; UEFI: $t=-0.25$, $p=0.803$; WFMT: $t=-0.37$, $p=0.713$) were comparable between the participants who dwell in rural and urban communities (Table 2). A repeated measure ANOVA with a Greenhouse-Geisser correction revealed that the mean FMA-UE ($F[1.648, 13.185] = 5.28$, $p = 0.025$) and WFMT ($F[1.430, 11.439] = 6.73$, $p = 0.017$) for participants residing in rural community differ significantly between treatment points (Table 3). For this group, post-hoc analysis with a Bonferroni adjustment showed that the WFMT score was significantly increased from baseline to 8 weeks post BAT only (3.00 (95% CI, 0.14 to 6.14), $p = 0.031$). Among participants who were urban community dwellers, mean FMA-UE ($F[1.858, 14.864] = 8.73$, $p = 0.004$), UEFI ($F[1.439, 11.513] = 7.42$, $p = 0.013$) and WFMT ($F[1.183, 9.465] = 7.37$, $p = 0.020$) statistically differ across the treatment points. FMA-UE score (4.22 (95% CI, 0.82 to 7.62), $p = 0.017$), and UEFI score (3.89 (95% CI, 0.18 to 7.60), $p = 0.040$), significantly increased from baseline to 8th-week post-BAT intervention while WFMT significantly increased from 4th week to 8th week (1.44 [95% CI, 0.31 to 2.58], $p = 0.015$) (Table 3). There was no significant differences ($p>0.05$) in the changes in FMA-UE, UEFI, and WFMT between rural and urban community-dwelling participants (Table 4).

Table 1: Socio-Demographics and Clinical Characteristics of Participants (N=21)

Variable	**Total (21)** $\bar{x}$±**SD/n(%)**	**Rural (11)** $\bar{x}$±**SD/n(%)**	**Urban (10)** $\bar{x}$±**SD/n(%)**	**t/U/χ^2**	***p***
Age	61.7±12.0	61.4±13.8	62.0±10.3	0.12	0.900
Sex					
Male	14 (66.7)	8 (72.7)	6 (60.0)	0.38	0.659
Female	7 (33.3)	3 (27.3)	4 (40.0)		
Lesion type					
Haemorrhagic	7 (33.3)	2 (18.2)	5 (50.0)	2.39	0.132
Ischaemic	14 (66.7)	9 (81.8)	5 (50.0)		
PSD (Months)	13.0±6.4	13.1±6.1*	13.0±7.0	0.03	0.975
≤12	13 (61.9)	6 (54.5)	7 (70.0)		
13–24	6 (28.6)	4 (36.4)	2 (20.0)		
>24	2 (9.5)	1 (9.1)	1 (10.0)		
Side affected					
Right	14 (66.7)	5 (45.5)	9 (90.0)	4.68	0.630
Left	7 (33.3)	7 (54.5)	1 (10.0)		
Hand dominance					
Right	18 (85.7)	9 (81.8)	9 (90.1)	0.29	1.000
Left	3 (14.3)	2 (18.2)	1 (10.0)		
Level of disability (MRS)					
No significant disability	7 (33.3)	4 (36.4)	3 (30.0)	5.50	0.763
Slight disability	14 (66.7)	7 (63.6)	7 (70.0)		

Key: PSD = Post-Stroke Duration; MRS = Modified Rankin Scale. *As supplied in the source manuscript, the rural PSD mean was given as "3.1±6.1," which is numerically inconsistent with the reported total (13.0±6.4) and urban (13.0±7.0) values for the same row – most plausibly a dropped leading digit (i.e., "13.1"). Displayed here as "13.1±6.1" for internal consistency; worth confirming the original value with the authors.

Table 2: Comparison of Baseline Upper Extremity Motor Function Between Rural and Urban Community-Dwelling Stroke Survivors

Variable	**All**	**Rural dwelling**	**Urban dwelling**	**t-value**	**p-value**
		Mean ± SD			
FMA-UE Score	89.52±16.9	89.18±15.6	89.90±19.0	–0.09	0.925
UEFI Score	33.24±14.50	32.45±15.2	34.10±14.5	–0.25	0.803
WMFT	29.48±8.30	28.81±5.8	30.20±10.7	–0.37	0.713

Key: FMA-UE = Fugl-Meyer Assessment for Upper Extremity; UEFI = Upper Extremity Functional Index; WFMT = Wolf Motor Function Test.

Table 3: Comparison of Upper Extremity Motor Function at Baseline, 4th and 8 Weeks

	Rural dwelling (mean ± SD)					**Urban dwelling (mean ± SD)**				
Variable	**Baseline**	**4th wk**	**8th wk**	**F**	***p***	**Baseline**	**4th wk**	**8th wk**	**F**	***p*-value**
FMA-UE Score	91.0±16.4	92.6±16.9	95.0±18.7	5.28	0.025*	88.3±19.5	90.9±20.2	92.6±21.2	8.73	0.004*
UEFI Score	33.9±16.5	37.3±15.6	38.0±15.4	5.16	0.050	33.4±15.2	35.8±15.4	37.3±14.3	7.42	0.013*
WMFT Score	30.7±4.6	32.1±4.8	33.7±6.1	6.73	0.017*	30.9±11.1	31.0±12.2	33.3±12.8	7.37	0.020*

Key: FMA-UE = Fugl-Meyer Assessment for Upper Extremity; UEFI = Upper Extremity Functional Index; WFMT = Wolf Motor Function Test; * = p-value is statistically significant. FMA-UE Rural: F(1.648, 13.185) = 5.28, p = 0.025. FMA-UE Urban: F(1.858, 14.864) = 8.73, p = 0.004. UEFI Rural: F(1.049, 8.389) = 5.16, p = 0.050. UEFI Urban: F(1.439, 11.513) = 7.42, p = 0.013. WFMT Rural: F(1.430, 11.439) = 6.73, p = 0.017. WFMT Urban: F(1.183, 9.465) = 7.37, p = 0.020.

Table 4: Comparison of Mean Difference Post-Eight-Week Intervention Between the Two Groups

Variable	**Rural dwelling (mean ± SD)**	**Urban dwelling (mean ± SD)**	**t-value**	**p-value**
FMA-UE Score	4.0±4.5	4.2±3.3	0.12	0.907
UEFI Score	4.1±5.2	3.9±3.7	0.10	0.918
WFMT Score	3.0±3.1	2.4±2.5	0.41	0.685

Key: FMA-UE = Fugl-Meyer Assessment for Upper Extremity; UEFI = Upper Extremity Functional Index; WFMT = Wolf Motor Function Test.

Discussion

This study quantified the effects of an eight-week of occupation-based BAT intervention on upper extremity functions between rural community-dwelling stroke survivors within Ile-Ife, and their counterparts residing in urban communities. The study participants, with a mean age of 61.7±12.0 years, predominantly comprised males who had experienced ischemic stroke and exhibited slight disability on the modified Rankin scale. Importantly, the demographic and clinical characteristics at baseline were comparable between SSVs residing in rural and urban residences. Even though SSVs residing in rural areas have been reported to have worse clinical profiles compared to their urban counterparts due to limited access to acute stroke care and rehabilitation services (Dwyer et al., 2019), the findings from this study showed that there was no corresponding difference in their clinical profiles. Since all of the SSVs were recruited from the outpatient clinic of OT in the study center, they were able to access needed healthcare services. The comparable baseline characteristics suggest that any observed differences in intervention outcomes are less likely to be confounded by these variables.

In addition, the findings from this study suggest that there were significant improvements in upper extremity motor function, as assessed by FMA-UE and WFMT among SSVs residing in rural areas and those in urban areas across different treatment points. This finding aligns with reports from the literature that indicated an increase in sensorimotor function and a decrease in motor impairment following BAT interventions (Dhakate & Bhattad, 2020; Kang et al., 2021; Lin et al., 2010). The bilateral use of the upper extremities to perform functional tasks facilitated inter-hemispheric coupling and neural cross-talk thus enabling motor recovery. Among SSVs dwelling in rural areas, a remarkable increase in the WFMT score specifically at the 8-week post-BAT intervention aligns with literature that emphasizes the importance of intensive and longer rehabilitation periods in stroke recovery (Clark et al., 2021). Similarly, the significant changes observed in FMA-UE and UEFI scores post-BAT intervention among SSVs in urban areas further lay credence to this. The differential response in the motor functions between SSVs residing in rural and urban areas prompts consideration of other factors that influence rehabilitation outcomes. Previous research suggests that social support networks and environmental factors such as access and distance to rehabilitation facilities contribute to these variations (Assefa et al., 2023).

In our study, familiarity with the various activities used for arm retraining during treatment by SSVs as well as the applicability of the activities within their settings may have influenced motor relearning. This further emphasizes the need for tailored and individualized rehabilitation strategies that consider the unique characteristics of the different settings of the SSVs during treatment implementation. However, the findings from our study did not show any significant difference in the changes between participants from the two settings, highlighting the potential effectiveness of the BAT intervention among SSVs residing in both rural and urban settings.

Conclusion

BAT administered to these individuals has a measurable impact on their upper extremity motor function. However, these changes in motor function were found to be comparable between SSVs dwelling in urban and rural areas. The absence of significant differences between SSVs living in urban and rural areas suggests that the BAT intervention could be applied effectively across diverse stroke survivor populations.

Declarations

Authors' Contribution

OAO, MOO and TMT conceptualized the study, collected and analyzed the data; OAO, MOO, TMT and ASA developed the study design, protocols, and operational procedures; OAO, MOO, ASA and MAA ensured accuracy and rigor of methods and findings. OAO, TMT and MAA were responsible for data visualization and graphical presentation of findings, while all authors were involved in drafting and critical revision of the manuscript for intellectual content. The final draft was read and approved by all authors.

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Conflicts of Interest

The authors reported no conflict of interest.

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