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Original Article

Handgrip and Quadriceps Strength as Independent Predictors of Post-Stroke Depression and Anxiety

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ABSTRACT

Background: The objective of this study was to whether handgrip and quadriceps strength can predict post-stroke depression (PSD) and post-stroke anxiety (PSA).

Methods: This cross-sectional study involved sixty-six consenting stroke patients whose symptoms of depression and anxiety and affected handgrip and quadriceps strength were assessed by the Hospital Anxiety and Depression Scale (HADS) and handheld dynamometers. Data was analyzed using descriptive and inferential statistics. Alpha level was set at $P<0.05$.

Results: The participants' mean handgrip and quadriceps strength were 19.03 kg and 20.70 kg, respectively, while the prevalence of PSD and PSA were 33.4% and 42.4%, respectively. PSD was significantly correlated with PSA ($r=0.61$; $P<0.001$), handgrip strength ($r=-0.24$; $P=0.049$), functional independence ($r=-0.26$; $P=0.036$), and stroke severity ($r=0.26$; $P=0.039$), while PSA was significantly correlated with stroke severity ($r=0.25$; $P=0.046$) and age ($r=-0.25$; $P=0.048$). Multiple linear regression results indicate that handgrip and quadriceps strength were not independent predictors of PSD and PSA ($P>0.05$); however, the presence of PSA was an independent predictor of PSD ($B=0.590$; $P<0.001$), while the presence of PSD ($B=0.621$; $P=0.001$) and younger age ($B=-0.307$; $P<0.001$) were independent predictors of PSA.

Conclusion: Handgrip and quadriceps strength are not significant predictors of PSD and PSA in stroke survivors; however, PSD and PSA can predict each other, indicating a bi-directional relationship, while age is a negative predictor of PSA.

Introduction

Stroke is one of the main public health issues in both developed and developing countries [1], and it is said to be responsible for one third of all deaths globally, accounting for 11.13% total deaths after ischemic heart disease and cancer [2]. Stroke is the main cause of disability worldwide often resulting in residual impairment of physical, social, and psychological health [3]. The most common psychological disorders following stroke are post-stroke depression (PSD) and post-stroke anxiety (PSA) [4]. PSD is reported to be present in about 33% in patients with stroke [5], and it adversely affects their functional activities, quality of life, and rehabilitation outcome [6]. PSD increases muscle tension, reduces muscle strength, and influences cortical function in the brain of stroke survivors [7].

Furthermore, the prevalence of PSA is high, occurring in about one-quarter of stroke survivors [8]. PSA negatively impacts the quality of life and rehabilitation

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outcome of survivors [8]. Despite its high prevalence among stroke survivors, PSA is understudied compared to other psychological disorders affecting stroke survivors [9]. Considering that PSD and PSA are significant psychological challenges, understanding their predictors is relevant to screening and effective management. Towfighi et al. [5] identified dependence in functional activities, severity of stroke, history of depression, and cognitive impairment as common predictors of PSD. Other authors have implicated depression, cognitive impairment, fatigue, sleep disturbance, and lesion location as important factors for developing PSA [8, 10].

While measures of these predictors are varied and sometimes tedious for clinicians other than mental health physicians, many patients with psychological impairments may remain undiagnosed and undertreated. Therefore, an objective measure for identifying PSD and PSA that is easy and quick to use is needed. Muscle strength assessment, especially handgrip and quadriceps strength, has been found to be a valid predictor of psychological disorders in various health conditions and populations [11-13]. However, there is an apparent dearth of evidence regarding handgrip and quadriceps strength being objective predictors of PSD and PSA. Therefore, the objective of the current study was to explore whether handgrip and quadriceps strength can predict PSD and PSA.

Material and Methods

Participants

Participants in this cross-sectional study were consenting stroke survivors undergoing treatment at the outpatient physiotherapy clinic of the Osun State University Teaching Hospital, Osogbo, Nigeria. The Research Ethics Committee of the institution gave approval for this study (LTH/EC/2021/01/496), and a written informed consent form was obtained from each participating subject. Eligible participants were stroke survivors who had hemorrhagic or ischemic stroke, who were without communication problems (e.g., aphasia, confusion, or dementia), and who had stable cardiovascular status. Stroke survivors with other neurological problems, more than one incidence of stroke, a Mini-Mental State Examination (MMSE) score ≤ 16, and who were younger than 18 years of age were excluded from the study. Sample size calculation based on Eng's [14] sample size formula indicated that approximately 62 participants were required for this study; however, a total of 66 participants were recruited.

Procedure

A proforma was used to obtain socio-demographic data (age, gender, marital status, occupation, employment status, educational status, and income level), and clinical characteristics (stroke duration, side of affectation, type of stroke, severity of stroke, and dominant handedness) were also assessed.

The participants' symptoms of depression and anxiety were evaluated with the Hospital Anxiety and Depression Scale (HADS). This instrument comprises subscales for depression and anxiety which consist of 7 items each relating to symptoms, and each item is scored 0 to 3 for a total score of 21 for each subscale. A score of 0 to 7 indicates no case (no anxiety or depression), 8 to 10 indicates a mild case, 11-15 indicates a moderate case, and 16-21 indicates a severe case [15]. HADS is well validated among stroke survivors for the assessment of depression and anxiety [15], and it is significantly related to major depressive episodes of patients seen in general practice [16].

The Orpington Prognostic Scale (OPS) was used to assess the severity of stroke. This scale assesses patients' motor function of the arm, upper-limb proprioception, balance, and cognition with a score<3.2 considered as a minor stroke, ≥3.2 and ≤5.2 as a moderate stroke; and >5.2 as a major stroke. The psychometric property of OPS has been tested among stroke survivors, and it is well correlated with the National Institute of Health Stroke Scale (NIHSS) in assessing stroke severity [17].

The Modified Barthel Index (MBI) questionnaire was used to assess the level of functional independence of the participants. It measures how well a stroke survivor can function independently in activities of daily living (ADL). Developed by Shan et al., the MBI has a five-step scoring system and is more sensitive and reliable than the original version [18]. It has a 100-point rating scale on the ability of a patient to undertake 10 types of ADL, comprising bowel and bladder control, grooming, toileting, feeding, transfers, walking, dressing, climbing stairs, and bathing. The higher the score is, the greater the level of independence will be, with 100 being the maximum score and 0 the lowest score.

Handgrip and Quadriceps Strength Assessment

Handgrip strength was assessed using a Jamar® Hydraulic Hand Dynamometer (Patterson Medical, Warrenville, IL, USA). It has excellent test-retest reliability and has been used previously to assess grip strength in stroke survivors [19]. Participants were asked to sit on a straight-backed armless chair with their feet flat on the floor, and their handgrip strength was measured according to the American Society of Hand Therapists' recommendations. Three measurements were made, and the maximum strength was used for analysis with a 60-second rest period between each trial [20]. Handgrip strength was expressed in kilograms.

Quadriceps strength was measured using the Microfet2®, a handheld dynamometer (Hoggan Health Industries Inc., Salt Lake City, UT, USA). Its validity and reliability have been established previously among stroke survivors [21]. To assess quadriceps strength, participants were asked to sit at the edge of the treatment table and positioned near their maximal knee extension (0°), consistent with clinical muscle testing with the knee in 90° of flexion. The dynamometer was placed just above the ankle against the shins, and participants placed their arms across their chests to isolate the quadriceps muscle. They were then asked to push against the dynamometer to measure quadriceps isometric strength. Three measurements were made with a 60-second rest period between each trial, and the maximum strength

was used for analysis. The measurement was expressed in kilograms. Only the affected handgrip and quadriceps strength of the participants were evaluated. Handgrip and quadriceps strength were evaluated before other assessments to avoid the effect of fatigue.

Data Analysis

The normality of the data was examined by the Shapiro-Wilk test, and the data was summarized in means, standard deviations, proportions, and percentages. Pearson's or Spearman's correlation coefficient was used to examine the relationship among depression, anxiety, handgrip strength, quadriceps strength, and survivors' clinical characteristics such as functional independency, stroke duration, and stroke severity. Correlations were classified as strong (r±0.70–1.00), moderate (r±0.30–0.69), or weak (r±0.00–0.29). Multiple linear regression was used to determine the predictors of each of PSD and PSA. Alpha level was set at $P<0.05$. Statistical analysis was performed using IBM SPSS (Ver. 21).

Results

The general characteristics of the participants are presented in Table 1. The means and standard deviations of age, weight, height, and body mass index of the participants were 59.61±9.91 years, 69.65±10.72kg, 1.63±0.80m and 26.25±3.92 kgm^{-2}, respectively. Most of the participants in this study were male (54.5%), married (83.3%), self-employed (39.4%), and had a high income level (65.2%). The participants were mostly right-handed (92.4%), with right hemiparesis (54.5%), and 42.4% of them had a stroke more than 12 months prior to assessment (mean stroke duration was 16 months). The mean values of OPS and MBI were 2.92 and 88.18, respectively, and the mean values for handgrip and quadriceps strength were 19.03 kg and 20.70 kg, respectively.

Table 2 shows the prevalence and level of PSD and PSA of the participants. The prevalence rates of PSD and PSA was 33.4% and 42.4%, respectively. Positive caseness of mild PSD accounted for 18.2%, and there were no severe cases of PSD. Likewise, the rate of mild PSA (28.8%) was higher, but there were no reported cases of severe PSA.

The relationships among PSD, PSA, handgrip strength, quadriceps strength, and clinical characteristics are shown in Table 3. The Spearman correlation coefficients showed a significant moderate correlation between PSD and PSA ($r=0.61$; $P<0.001$) and PSD and stroke severity ($r=0.26$; $P=0.039$). Meanwhile, there was a significant weak correlation between PSD and handgrip strength ($r=-0.24$; $P=0.049$) and PSD and the level of functional independency ($r=-0.26$; $P=0.036$). However, there was no significant correlation between PSD and quadriceps strength ($r=-0.10$; $P=0.425$), PSD or stroke duration ($r=0.15$; $P=0.219$) or between PSD and age ($r=0.17$; $P=0.181$).

The correlation coefficients showed a weak correlation

Table 1: General characteristics of participants (N=66)

Variable	n (%)	Mean±SD
Sex (M)	36 (54.5)	
Age (years)		59.61±9.91
Height (meters)		1.63±0.80
Weight (Kg)		69.65±10.72
BMI (Kgm^{-2})		26.25±3.92
Marital Status		
Married	55 (83.3)	
Divorced	1 (1.5)	
Widowed	9 (13.7)	
Separated	1 (1.5)	
Occupation		
Unemployed	2 (3.0)	
Self-employed	26 (39.4)	
Government	17 (25.8)	
Retiree	21 (31.8)	
Income level[a]		
Low	17 (25.8)	
Average	6 (9.1)	
High	43 (65.2)	
Type of stroke		
Ischemic	36 (54.5)	
Hemorrhagic	30 (45.5)	
Duration of stroke[b]		16.02±13.79
Paretic side (R)	36 (54.5)	
Handedness (R)	61 (92.4)	
OPS		2.92±0.88
MBI		88.18±11.92
Handgrip Strength (Kg)		19.03±14.23
Quadriceps Strength (Kg)		20.70±9.13

n-number; %-percentage; SD-standard deviation; M-male; [a]-based on Nigerian minimum wage; [b]-calculated in months; R-right; OPS-Orpington prognostic score; MBI-Modified Barthel Index; Kg-kilograms

Table 2: Prevalence and level of post-stroke depression (PSD) and post-stroke anxiety (PSA) among participants (N=66)

Variable	Caseness n (%)	Normal n (%)	Total n (%)
PSD			
Mild	12 (18.2)		
Moderate	10 (15.2)		
Severe	0 (0)		
Total	22 (33.4)	44 (66.7)	66 (100)
PSA			
Mild	19 (28.8)		
Moderate	9 (13.6)		
Severe	0 (0)		
Total	28 (42.4)	38 (57.6)	66 (100)

PSD-post-stroke depression; PSA-post-stroke anxiety; n-number; %-percentage

Table 3: Relationship among post-stroke depression (PSD), post-stroke anxiety (PSA), handgrip strength, quadriceps strength, and clinical characteristics of the participants (N=66)

	PSD			PSA	
	Correlation (r)	P value		Correlation (r)	P value
PSA	0.61	<0.001*	PSD	0.61	<0.001*
Handgrip strength	-0.24	0.049*	Handgrip strength	-0.21	0.079
Quadriceps strength	-0.10	0.425	Quadriceps	-0.22	0.863
MBI	-0.26	0.036*	MBI	-0.19	0.119
Stroke duration	0.15	0.219	Stroke duration	0.10	0.417
Orpington score	0.26	0.039*	Orpington score	0.25	0.046*
Age	0.17	0.181	Age	-0.25	0.048*

*-significant; MBI-Modified Barthel Index; PSD-post-stroke depression; PSA-post-stroke anxiety

Table 4: Multiple regression analysis showing predictors of post-stroke depression among participants

PSD	Beta	Test statistic	P value	95% CI	
				Lower	Upper
Constant		1.793	0.078	-0.944	17.326
MBI	-0.150	-1.101	0.275	-0.121	0.035
Handgrip strength	-0.096	-0.716	0.477	-0.088	0.041
OPS	-0.100	-0.652	0.517	-1.580	0.804
PSA	0.590	5.611	<0.001*	0.352	0.742

%-percentage; CI-confidence interval; MBI-Modified Barthel Index; OPS-Orpington prognostic score; *-significant; PSD-post-stroke depression; PSA-post-stroke anxiety

Table 5: Multiple regression analysis showing predictors of post-stroke anxiety among participants

PSD	Beta	Test statistic	P value	95% CI	
				Lower	Upper
Constant		3.052	0.003*	2.436	11.690
PSD	0.621	6.533	<0.001*	0.465	0.875
OPS	0.165	1.758	0.084	-0.095	1.475
Age	-0.307	-3.339	<0.001*	-0.183	-0.046

%-percentage; CI-confidence interval; OPS-Orpington prognostic score; *-significant; PSD-post-stroke depression; PSA-post-stroke anxiety

between PSA and stroke severity (r=0.25; P=0.046) and PSA and age (r=-0.25; P=0.048). However, PSA had no significant correlation with handgrip strength (r=- 0.21; P=0.079), quadriceps strength (r=-0.22; P=0.863), level of functional independency (r=-0.19; P=0.119), or stroke duration (r=0.10; P=0.417) as shown in Table 3.

The results of multiple linear regression to identify predictors of PSD and PSA are presented in Tables 4 and 5. Variables that significantly correlated with PSD in univariate analysis (PSA, handgrip strength, functional independence, and stroke severity) were used as independent variables to predict PSD. As shown in Table 4, the combinations of these variables account for 39.6% of the variability in PSD scores but did not significantly predict PSD when used together (Nagelkerke's R^2=0.396; P=0.078). PSA was the only variable that significantly and independently predicted PSD among the participants (B=0.590; P<0.001), while handgrip strength (B=-0.096; P=0.477), functional independence (B=-0.150; P=0.275), and stroke severity (B=-0.100; P=0.517) were not significant independent predictors of PSD.

The results of regression analysis combining variables that significantly correlated with PSA (PSD, stroke severity, and age) showed that 49.2% of the variance in PSA scores can be predicted from these three variables (Nagelkerke's R^2=0.492; P=0.003) (Table 5). However, only PSD (B=0.621; P<0.001) and age (B=-0.307; P<0.001) were independent predictors of PSA. Stroke

severity did not significantly predict PSA among the participants (B=0.165; P=0.084), as shown in Table 5.

Discussion

The current study explored whether handgrip and quadriceps strength can predict PSD and PSA among stroke survivors. The prevalence of PSD and PSA in this cohort was found to be 33.4% and 42.4%, respectively. The findings of this study indicated that handgrip and quadriceps strength were not independent predictors of PSD and PSA; however, presence of anxiety was revealed to independently predict PSD, while PSA was predicted by the presence of depression and being a younger stroke survivor. Furthermore, PSD had a significant correlation with handgrip strength, functional independence, and stroke severity of survivors. PSA was also associated with stroke severity of survivors.

The prevalence of PSD observed in this study was similar to the cumulative prevalence of PSD reported by Towfighi et al. [5] (33.3%) and comparable with the PSD prevalence reported by a study conducted in Uganda (31.5%) [22] and Nigeria (25.5%) [23], in which the prevalence of PSA was reported to vary between 6.06% to 56.4% with a mean prevalence of 33.5% [8], which is similar to the prevalence of PSA obtained in this study. The higher prevalence of PSA compared to PSD among the survivors in this study was previously observed by White et al. [24]. This is not surprising, as anxiety disorder is the most prevalent mental health disorder globally [25]. Unfortunately, despite the reported high prevalence of PSA and its deleterious effects on clinical outcomes of stroke, clinicians are said to often pay little or no attention to this particular psychological disorder in stroke rehabilitation [8, 24].

Similar to previous studies [26, 27], an association was observed between lower handgrip strength of the survivors and PSD in this study. Reports have shown that performance of daily activities is more affected in stroke survivors with lower handgrip strength and thereby worsens their mental health status [27]. Handgrip strength is essential in executing daily activities, as it is needed to grasp, manipulate, and grip or hold objects and surfaces in ADL execution. However, the results of multivariate analysis indicated that handgrip and quadriceps strength were not independent predictors of PSD and PSA. There is a dearth of data with which to compare the current findings, as this study, to the best of our knowledge, is the first to attempt to predict PSD and PSA with handgrip and quadriceps strength.

Handgrip and quadriceps strength are known predictors of various health outcomes. Fukumori et al. [12] reported lower handgrip strength as a predictor of depressive symptoms, but their study was carried out among community dwelling healthy adults [12] and not among stroke survivors. Lower handgrip strength has also been reported to predict persistence of depressive symptoms among patients with depression and anxiety disorders [28]. Furthermore, Gerrits et al. [29] reported that quadriceps muscle strength is a very important factor in the functional recovery of stroke patients and that lower quadriceps strength is a prognostic indicator for chronic diseases.

There seems to be a bi-directional relationship between PSD and PSA, as the presence of anxiety independently predicted PSD and vice versa in this study, which has also been reported in earlier studies [5, 8, 9]. Therefore, clinicians should screen for PSD in patients with PSA and vice versa. The results showed that age was a negative predictor of PSA, indicating that younger stroke survivors are at risk of developing PSA. It is possible that younger stroke survivors, who may be at the prime of their lives, may easily develop PSA on what the future holds for them or how they will be accepted in society or at the workplace. Older survivors, who may have "seen it all," may not be prone to a similar experience and the attendant PSA. Anxiety disorder has been reported to naturally decline with older age among the general population [30].

The findings of the current study showed that PSD was significantly associated with level of functional independence in stroke survivors, while PSD and PSA were associated with survivors' stroke severity. The correlation coefficients obtained in this study indicated that functional dependence and increasing stroke severity tend to worsen the depressive and anxiety symptoms of stroke survivors. This observation was reported in the recent Scientific Statement/Review on PSD by the American Heart Association/American Stroke Association and other researchers [5, 24]. Moreover, a systematic review and meta-analysis on factors associated with PSA by Wright et al. [8] and a cohort study on the predictors of anxiety among community dwelling stroke survivors reported earlier that stroke severity was a major determinant of PSA [24]. Therefore, it is imperative that clinicians pay close attention to the mental health of stroke survivors with poor levels of functional independence as well as those with more severe stroke so as to obtain better rehabilitation outcomes.

The prevalence of PSD and PSA and other related results obtained in this study are limited to the Hospital Anxiety and Depression Scale (HADS), which cannot be compared to the comprehensive psychiatric evaluation needed for a definite diagnosis of depression and anxiety. However, it is important to note that HADS is a validated instrument in screening for depression and anxiety among stroke survivors [15]. This study did not evaluate the pre-stroke history of depression or anxiety of the survivors which may limit the study's findings. Furthermore, the participants in this study were only recruited from one hospital center; therefore, the results from this study may only be generalizable to a similar context but not to a wider population of stroke survivors. Nonetheless, the stroke survivors in this study are representative of Nigerian stroke population and similar contexts in Sub-Sahara Africa. The small sample size weakened the statistical power of this study, which necessitates the need for further studies with larger sample sizes. Moreover, as this is a cross-sectional study, the significant association obtained in this study cannot be taken as a cause-effect relationship.

Conclusion

Handgrip and quadriceps strength are not significant predictors of PSD and PSA in stroke survivors. However, handgrip strength was significantly correlated with PSD, while age was a negative predictor of PSA in stroke survivors. There was also a bi-directional relationship between PSD and PSA, indicating the need for clinicians to screen for PSD in stroke survivors with PSA and vice versa.

Conflict of Interest: None declared.

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