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Does grip strength of the less-affected side of ischemic stroke survivors influences performance of self-care activities?

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Abstract

Background and aim: Adequate grip strength is needed to execute various self-care activities. This study was aimed to assess the influence of grip strength of the less-affected side of ischemic stroke survivors on performance of self-care activities, and also to determine the reference values of less-affected grip strength needed for independent performance of each of the self-care activities.

Methods: Seventy-three consenting patients with ischemic stroke participated in this cross-sectional study. Hand-held dynamometer was used to measure grip strength of the less-affected hand, while functional independence measure was used to evaluate self-care activities (eating, grooming, bathing, dressing of upper body, dressing of lower body and toileting) as independent and dependent. Data was analyzed using inferential statistics of Pearson's correlation, binomial logistic regression, and receiver operating characteristics. Alpha level was set at $p < 0.05$.

Results: The mean hand grip strength, functional independence measure and trunk control test scores were 23.8 kg, 29.9 kg, and 68.2 kg respectively. Grip strength was significantly associated with independence in all of the self-care activities ($p < 0.05$). Less-affected grip strength of 19.5 kg (sensitivity, 80.4%; specificity, 80.1%; area under curve, 0.85), 23.7 kg (sensitivity, 79%; specificity, 72.2%; area under curve, 0.79), 24.8 kg (sensitivity, 70.2%; specificity, 65.2%; area under curve, 0.75), 24.7 kg (sensitivity, 82.1%; specificity, 80.1%; area under curve, 0.84), 23.7 kg (sensitivity, 80.1%; specificity, 76.1%; area under curve, 0.84), and 19.9 kg (sensitivity, 76.9%; specificity, 76.2%; area under curve, 0.79) was needed for independent performance in eating, grooming, bathing, dressing of upper body, dressing of lower body, and toileting respectively.

Conclusion: The less-affected grip strength of patients with ischemic stroke influences their ability to independently perform self-care activities. The reference values of less-affected grip strength in association with other stroke-related characteristics may help clinicians to estimate independence in eating, grooming, bathing, dressing of upper body, dressing of lower body, and toileting among patients with ischemic stroke.

Keywords: Stroke, Activities of daily living, Grip strength, Sarcopenia, Rehabilitation

Introduction

Worldwide, stroke is the second leading cause of death and third leading cause of disability [1]. According to the current Global Burden of Disease data on stroke, there are 80.1 million (74.1 to 86.3) prevalent cases of stroke globally; 41.1 million (38.0 to 44.3) in women and 39.0 million (36.1 to 42.1) in men [2]. Also, there are 5.5

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million deaths and 116·4 million disability adjusted life years due to stroke [2]. Globally, 70% of stroke cases and 87% of both stroke-related deaths and disability adjusted life years (DALYs) occur in low- and middle-income countries including Nigeria [3]. In Nigeria, the prevalence of stroke among the general populace is 1.14 per 1000, and is reportedly higher among men [4]. The 30-day case fatality rate of stroke in Nigeria is reported to be 40% [4].

Approximately two-third of stroke survivors have residual neurological deficits that persistently impair function characterized by disorders of sensory, motor, perceptive, cognitive, and language functions, as well as mobility or functional disorders on the side of the body opposite to the stroke region [5]. Many survivors still display muscular weakness and spasticity of the extremities, imbalance, hypertonia, and dysesthesia leading to loss of motor control [6] and impair optimum performance of self-care activities by the stroke survivors [7]. There is evidence that neuro-rehabilitation programs enhance and help stroke survivors to some possible independence in self-care activities [8]. Thus, stroke survivors are able to perform in self-care activities like grooming, dressing, and bathing by using the less-affected grip strength [6, 9–13]. While the relationship between less-affected grip strength and ability to carry out functional activities among stroke survivors is apparent; however, it is more anecdotal than empirical [9, 10, 14].

Many self-care activities require grip strength, as it is necessary for manipulating, gripping, hooking, grasping and holding of various surfaces and objects needed in carrying out such functions [15]. However, less-affected grip strength is a consistent representation of the sensorimotor, balance and strength of the extremity and total body performance [14, 16]. The grip strength of the ipsilateral side is reported to be affected as well in patients with stroke [17–20], and emerging evidence suggest that stroke survivors still present with upper limb impairment of the less-affected side even years after stroke onset [20]. Specifically, a self-care activity or purposeful daily task as little as drinking from a glass with the less-affected upper extremity is known to display some movement deficits when compared to the healthy individuals [18]. Unfortunately, impairment of less-affected upper limb among stroke survivors is often subtle and sometimes neglected by clinicians during assessments [18]. Available studies indicate that focusing only on the more-affected side is counterproductive to the effectiveness of stroke evaluation [18] and rehabilitation [21].

Consequent to the foregoing, focusing and reinforcing on the adaptive means by which stroke survivors may recover or maintain their independence in functional abilities rather than focusing only on the impairments during assessment and management have been stressed [22–25]. While the more-affected (contralateral) side or limb should continue to be the main focus in stroke rehabilitation, the clinical community should consider and integrate sensori-motor integrity and functions in the less-affected upper limb to enhance optimum recovery post-stroke and increases possibility of maximum independence and function [17]. Therefore, the awareness and assessment of the less-affected upper extremity of stroke survivors is necessary to formulate effective rehabilitation strategies and programs [19].

Apart from less-affected grip strength, reports have shown that factors not limited to trunk control [11], sensori-motor function of the paretic limb [26], cognition [27, 28], and balance [29, 30] are vital for performance of self-care activities among stroke survivors. However, it has been observed that assessment of these variables are subjective, time consuming, and laborious to evaluate and sometimes infeasible especially in a typical busy stroke clinic [11]. For example, it takes approximately 20 min to complete the Berg balance scale (BBS), a known index in the assessment of toileting independence among patients with stroke [11, 31]. Meanwhile, ability to independently perform self-care activities is essential to self-esteem of stroke survivors [11]. To be functionally dependent in these activities, places, physical, and psychological strain on stroke survivors and their caregivers [23]. Therefore, an assessment that could be completed easily and quickly, and that is capable of providing objective data in estimating and classifying patients in self-care performance is needed. Grip strength assessment is quick, objective, reproducible, and easy to measure [11]. Thus, this study aimed to assess the relationship between less-affected grip strength and performance of self-care activities (eating, grooming, bathing, dressing of upper body, dressing of lower body, and toileting) in patients with ischemic stroke, and to determine the reference values of less-affected grip strength needed for independent performance in each of eating, grooming, bathing, dressing of upper body, dressing of lower body, and toileting self-care activity.

Material and method

Participants

Participants in this cross-sectional study were patients with unilateral ischemic stroke attending outpatient Physiotherapy clinic of the Osun State University Teaching Hospital, Osogbo, Nigeria from January 2021 to September 2021. Stroke survivors with non-stroke-related musculoskeletal problems preventing them from self-care activities, with severe cognitive impairment having less than 10 score on Mini Mental State Examination, and with history of recurrent stroke were excluded from the study. The result of cranial computed tomography was used to confirm the diagnosis of ischemic stroke of all the included participants. Sample size calculation using Eng's [32] sample size formula indicated that 62 participants were required for this study. However, a total of 73 participants were consecutively recruited.

Procedure and instrumentation

Ethical clearance was obtained from the Ethical Review Committee of the Osun State University Teaching Hospital, Osogbo, Nigeria (Ref: UTH/EC/2021/07/527). The purpose of the research was explained to each participant and his/her written informed consent was obtained before the commencement of the study. The stroke-related and socio-demographic characteristics of the participants (age, sex, height, weight, duration of stroke, paretic side, handedness, employment, marital, and educational status) were obtained by a self-developed proforma. Participants' educational status was categorized as none (no formal education), high (tertiary education) and low (primary and secondary education) while their monthly income was classified as low (< #30,000) and high (≥ #30,000) using Nigerian minimum wage. Participants with stroke onset that was up to 6 months or greater than 6 months duration were classified as subacute and chronic stroke survivors [33].

The CAMRY Digital Hand Dynamometer (MODEL: EH101; Zhongshan Camry Electronic Co. Ltd., Zhongshan, China) was used to measure the less-affected grip strength of the participants. The CAMRY Digital Hand Dynamometer has been previously employed to assess grip strength of stroke survivors [34]. The participants were made to sit on a on a straight-backed armless chair with their feet flat on the floor, elbow flexed at 90°, and dynamometer was held by the testing hand in a neutral grip without support in line with protocols of the American Society of Hand Therapists [34–36]. The mean value of three trials, with 60 s rest between each trial, was recorded in kilograms.

The level of self-care activities of the participants was measured by the functional independence measure (FIM). The FIM was used to measure and grade the self-care activities of the participants based on the level of assistance they required. The FIM is an 18-item (13 motor and 5 social-cognitive items) tool with score ranges from 18 (total assistance in all areas of function) to 126 (complete function in all areas). The motor subscale of the instrument consists of self-care, sphincter, transfer, and locomotion items. The FIM score ranges from 1 (total assistance) to 7 (complete independence) for each item. The FIM is well validated in assessing functional independence among stroke survivors [37, 38]. The first 6 items, i.e., self-care items (eating, grooming, bathing, dressing of upper body, dressing of lower body and toileting), used in this study, were scored separately for each activity (ranged from 1 (minimum) to maximum (7) score), and the score of the total FIM self-care activities were summed up and ranged from 6 (minimum) to 42 (maximum). Furthermore, participants who scored at least 6 points in any of these self-care items were categorized as independent in the performance of any of the activities while participants who scored 5 points or lower were categorized as dependent in those activities [11, 39].

The level of trunk control of the participants was evaluated by the trunk control test (TCT). The CTC measures participants' ability to roll to weak side and strong side, balance in sitting position on the edge of the bed with the feet off the ground for at least 30 s, and to sit up from lying down. Participants were scored 0 (if they are unable to achieve these without assistance), 12 (if they are able to do so using non-muscular help or in an abnormal style, e.g., using arms to steady self when sitting), and 25 (if they are able to complete task normally) [40]. The minimum score is 0 while the maximum score is 100 with high score indicating good trunk control. The test has been reported to correlate with eventual walking ability of stroke survivors [40]. The measurements of less-affected grip strength and functional status of the participants were made by the independent authors to eliminate bias.

Data analysis

Descriptive statistics of frequency, percentage, mean, median and standard deviation was used to summarize data obtained. Pearson correlation statistics was used to determine the association of less-affected grip strength with each of self-care activities scores (eating, grooming, bathing, dress upper body, dress lower body, and toileting) and clinical variables. Independent *t*-test, chi-square test, and Mann-Whitney *U* test were used to compare the factors associated with dependence and independence in self-care activities among the participants. A one-sample *t* test was used to compare the less-affected grip strength of the participants with the nominal values. Nominal values of grip strength among Nigerian adult population obtained by Adedoyin et al. [41] were used for the one-sample test analysis.

Binomial logistic regression analysis expressed in odds ratio and 95% confidence interval was used to evaluate the relationship between independence in self-care activities and less-affected grip strength of the participants. Receiver operating characteristics (ROC) analysis was performed to determine the cut-off values of the less-affected grip strength needed for the performance of each of the self-care activity using Index of Union (IU) [42, 43]. Alpha level was set at $p < 0.05$. Data analysis was

Table 1 General characteristics of the participants ($N = 73$)

Variable	Mean (SD)	Frequency	Percentage
Socio-demographics			
Age (years)	59.8 (10.3)		
Gender (M/F)		48/25	65.8/34.2
Marital status (married/single[a])		58/15	79.5/20.5
Employment (none/employed)		4/69	5.5/94.5
Education (none/low/high)		2/31/40	2.7/ 42.5/54.8
Income (low/high)		21/52	28.8/71.2
Physical characteristics			
Weight (kg)	68.7 (9.1)		
Height (m)	1.61 (0.08)		
BMI (kgm^{-2})	26.6 (3.85)		
Dominant handedness (R/L)		68/5	93.2/6.8
Clinical characteristics			
Time since stroke (months)	6.0 (22.0)[b]		
Sub-acute		40	54.8
Chronic		33	45.2
Hemiplegic side (R/L)		40/33	54.8/45.2
FIM self-care score	29.9 (11.9)		
TCT score	68.2 (27.1)		
Less-affected grip Strength (kg)	23.8 (9.9)		

M Male, *F* female, *R* right, *L* left, *BMI* body mass index, *FIM* functional independence measure, *TCT* trunk control test

[a] Included the unmarried, widowed, or separated

[b] Median (interquartile range)

carried out using SPSS 21.0 version software (SPSS Inc., Chicago, IL, USA).

Results

The general characteristics of the participants are presented in Table 1. The mean age of the participants was 59.8 ± 10.3 years. Majority of the participants were male (65.8%), married (79.5%) and had high income level (71.2%). 68 (93.2%) of the participants were right handed while 54.8% had right-side hemiplegia. The mean less-affected grip strength and FIM self-care scores of the participants were 23.8 ± 9.9 kg and 29.9 ± 11.9 (Table 1). As shown in Fig. 1, the results of one-sample t test indicate that the less-affected grip strength of the stroke survivors was significantly lower by 6.3 kg (95% CI 3.9 to 8.6) than the normative value of a typical healthy adult (23.8 kg vs. 30.1 kg; $t = -5.414$; $p < 0.001$). The result also show that the less-affected grip strength of the male participants was significantly lower by 7.7 kg (95% CI, 5.2 to 10.4) when compared with normative value of male population (27.4 kg vs. 35.2 kg; $t = -6.008$; $p < 0.001$) and that of female participant was significantly lower by 8.0 kg (95% CI, 4.8 to 11.3) than the normative value of healthy female (16. 9 kg vs. 24.9 kg; $t = -5.098$; $p < 0.001$) (Fig. 1).

The correlation of less-affected grip strength with the self-care activities and other clinical variables is shown in Table 2. The Pearson product-moment correlation coefficients show that less-affected grip strength is significantly and moderately correlated with total self-care score ($r = 0.55$; $p < 0.001$) and each of the self-care activity including eating ($r = 0.35$; $p = 0.002$),

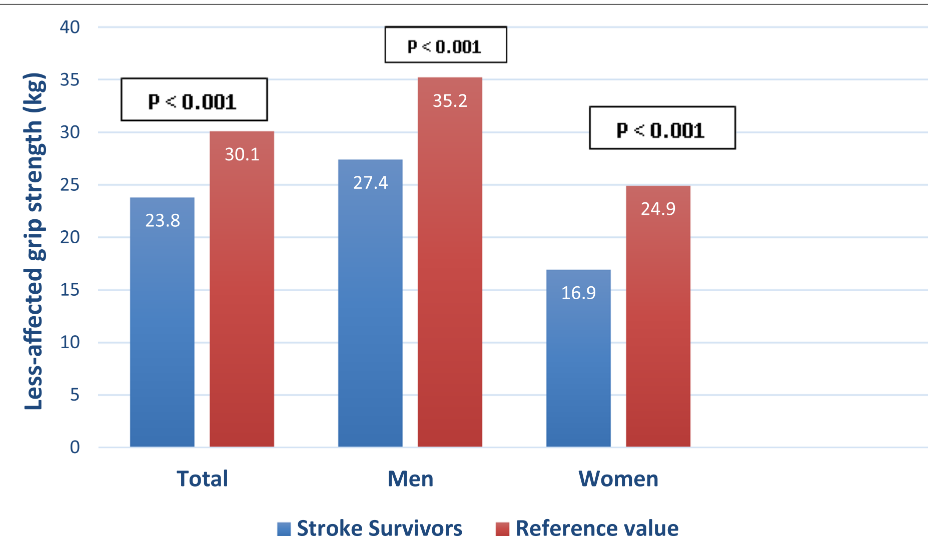

Fig. 1 Bar chart showing less-affected grip strength of stroke survivors compared to the reference of healthy adults. Data are shown in mean and standard deviation

Table 2 Association of less-affected grip strength with self-care activities and clinical variables

Less-affected grip strength	Correlation (*r*)	*P* value
Age	− 0.03	0.827
Body mass	− 0.13	0.265
Total self-care score	0.55	0.001*
Eating	0.35	0.002*
Grooming	0.53	0.001*
Bathing	0.48	0.001*
Dress upper body	0.58	0.001*
Dress lower body	0.54	0.001*
Toileting	0.33	0.004*
Time since stroke	0.17	0.152
Trunk control	0.52	0.001*

* indicates significant correlation at $p < 0.001$

grooming ($r = 0.53$; $p < 0.001$), bathing ($r = 0.48$; $p < 0.001$), dressing of upper body ($r = 0.58$; $p < 0.001$), dressing of lower body ($r = 0.54$; $p < 0.001$), and toileting ($r = 0.33$; $p = 0.004$). Also, the less-affected grip strength is moderately correlated with trunk control ($r = 0.52$; $p < 0.001$). However, there is no significant correlation between the less-affected grip strength and body mass, age, stroke duration ($p > 0.05$).

Table 3 shows that participants are mostly independent in eating ($n = 54$) compared to other self-care activities while participants were mostly dependent in bathing ($n = 39$). Group comparison show significant higher scores for trunk control and less-affected grip strength in the independent group compared to dependent group in self-care activities ($p < 0.05$). Furthermore, male participants were significantly more independent in all self-care activities compared to female participants ($p < 0.05$). However, there was no significant difference for age, side affected, and time since stroke between the independent and dependent groups ($p > 0.05$).

By using the factors that were significantly associated with self-care activities in the bivariate analyses (less-affected grip strength, trunk control, and gender) as independent variables, the results of binomial logistic regression analysis indicate that less-affected grip strength significantly predicted independence in each of eating (odd ratio 1.1 (1.0–1.2); $p < 0.05$), grooming (odd ratio 1.1 (0.9–1.2); $p < 0.05$), bathing (odd ratio 1.1 (0.9–1.2); $p < 0.05$), dressing of upper body (odd ratio 1.1 (1.0–1.3); $p < 0.001$), dressing of lower body (odd ratio 1.2 (1.0–1.3); $p < 0.001$), and toileting (odd ratio 1.1 (0.9–1.2); $p < 0.05$). Similarly, trunk function significantly predicted independence performance of all the self-care activities ($p < 0.05$). However, gender did not significantly predict independence in any of the self-care activities ($p > 0.05$) (Table 4).

The results of receiver operating characteristics analysis providing the cut-off points for the less-affected grip strength at which independence in each of the self-care activities was differentiated from dependence are presented in Table 5. The results indicate that grip strength of 19.5 kg (sensitivity, 80.4%; specificity, 80.1%; area under curve, 0.85), 23.7 kg (sensitivity, 79%; specificity, 72.2%; area under curve, 0.79), 24.8 kg (sensitivity, 70.2%; specificity, 65.2%; area under curve, 0.75), 24.7 kg (sensitivity, 82.1%; specificity, 80.1%; area under curve, 0.84), 23.7kg (sensitivity, 80.1%; specificity, 76.1%; area under curve, 0.84), and 19.9 kg (sensitivity, 76.9%; specificity, 76.2%; area under curve, 0.79) is needed for the independent performance in eating, grooming, bathing, dressing of upper body, dressing of lower body, and toileting respectively.

Discussion

This study was primarily aimed to assess the relationship between less-affected grip strength and performance of self-care activities in patients with ischemic stroke, and to determine the reference values of less-affected grip strength needed for independent performance of each of the self-care activity. In line with the reports of previous researchers [9–11], the findings of this study showed that less-affected grip strength of patients with ischemic stroke is associated with the ability to independently perform self-care activities. In this study, the less-affected grip strength was associated with the functional independence measure (FIM) total self-care score and each of eating, grooming, bathing, dressing of upper body, dressing of lower body, and toileting self-care activity, even after adjusting for other significant factors.

The most plausible hypothesis adduced to the significant relationship between less-affected grip strength and activities of daily living among stroke survivors is that whole body performance, which is necessary for independence in daily activities, is associated with less-affected grip strength [11]. Previously, it has been reported that less-affected grip strength of stroke survivors conveniently predict the functional outcome in stroke management [10], and that it represent the global muscle strength of the ipsilateral side in patients with stroke [14, 16]. Moreover, the significant relationship between less-affected grip strength and self-care activities as obtained in this study can be further explained by the essence of grip strength in performing functional activities. Grip strength is needed to grasp, hold or manipulate objects and surfaces for effective performance of activities of daily living [15].

Table 3 Comparison of factors associated with dependence and independence in self-care activities ($N = 73$)

	Eating		Grooming		Bathing		Dress upper body		Dress lower body		Toileting	
	I ($N = 54$)	D ($N = 19$)	I ($N = 38$)	D ($N = 35$)	I ($N = 34$)	D ($N = 39$)	I ($N = 37$)	D ($N = 36$)	I ($N = 39$)	D ($N = 34$)	I ($N = 52$)	D ($N = 21$)
Age (years)	59.2 ± 10.9	61.3 ± 8.3	60.7 ±11.0	58.7 ± 9.5	58.8 ± 12.1	60.7 ± 8.6	59.7 ± 11.1	59.9 ± 9.5	59.1 ± 10.8	60.5 ± 9.8	59.2 ± 11.2	61.0 ± 7.7
[a]Male (%)	74.1	42.1*	84.2	45.7*	79.4	53.8*	83.8	47.2*	79.5	50.0*	73.1	47.6*
[a]Right hemiplegia (%)	50.0	68.4	57.9	51.4	58.8	51.3	59.5	50.0	58.9	50.0	50.0	66.7
Less-affected grip strength (kg)	26.9 ± 8.5	14.7 ± 7.9*	28.8 ± 8.3	18.3 ± 8.7*	28.4 ± 8.9	19.7 ± 8.9*	29.6 ± 7.9	17.9 ± 8.2*	29.3 ± 7.9	17.9 ± 8.2*	26.8 ± 8.7	16.3 ± 9.1*
TCT	77.9 ± 21.7	40.2 ± 20.7*	83.9 ± 18.1	51.1 ± 24.9*	83.8 ± 17.7	54.5 ± 26.8*	83.4 ± 18.4	52.5 ± 25.8*	84.2 ± 17.6	49.7 ± 24.0*	78.7 ± 21.5	42.1 ± 21.5*
[b]Stroke duration (months)	39.2	30.7	35.3	38.8	40.6	33.8	35.3	38.7	37.3	36.7	39.2	31.5

I independent, *D* dependent, *TCT* trunk control test

[a] Chi-square test

[b] Mann-Whitney *U* test

[*] indicates significant difference at $p < 0.05$

Table 4 Binomial logistic regression analysis evaluating independence in self-care activities

Variable	Eating		Grooming		Bathing		Dress upper body		Dress lower body		Toileting	
	OR (95% CI)	***P* value**	**OR (95% CI)**	***P* value**	**OR (95% CI)**	***P* value**	**OR (95% CI)**	***P* value**	**OR (95% CI)**	***P* value**	**OR (95% CI)**	***P* value**
Less-affected grip strength	1.1 (1.0–1.2)	< 0.05	1.1 (0.9–1.2)	< 0.05	1.1 (0.9–1.2)	< 0.05	1.1 (1.0–1.3)	< 0.001	1.2 (1.0-1.3)	< 0.001	1.1 (0.9–1.2)	< 0.05
Gender (0, female; 1, male)	0.9 (0.2–4.6)	0.964	0.3 (0.006–1.42)	0.134	0.7 (0.2–3.2)	0.727	0.7 (0.1–2.3)	0.397	1.1 (0.2-6.0)	0.827	1.2 (0.2–5.7)	0.795
TCT	1.0 (1.0–1.1)	< 0.001	1.0 (1.0–1.1)	< 0.001	1.0 (1.0–1.1)	< 0.001	1.0 (1.0–1.1)	< 0.05	1.1 (1.0-1.2)	< 0.001	1.1 (1.0–1.1)	< 0.001

OR odds ratio, *CI* confidence interval, *TCT* trunk control test

Table 5 The receiver operating characteristics of less-affected grip strength in the performance of self-care activities

Variable	Less-affected grip strength (cut-off value) (kg)	Sensitivity (%)	Specificity (%)	Area under curve (95% CI)
Eating	19.5	80.4	80.1	0.85 (0.73–0.96)*
Grooming	23.7	79	72.2	0.79 (0.69–0.90)*
Bathing	24.8	70.2	65.2	0.75 (0.64–0.86)*
Dress upper body	24.7	82.1	80.1	0.84 (0.75–0.93)*
Dress Lower body	23.7	80.1	76.1	0.84 (0.75–0.93)*
Toileting	19.9	76.9	76.2	0.79 (0.67–0.91)*

CI confidence interval, *kg* kilogram, % percentage

[*] indicates significance at $p < 0.001$

Contrary to the results of similar studies [9, 11], independent performance of self-care activities was significantly influenced by gender. Male stroke survivors were more significantly independent in all of the self-care activities investigated in this study than their female counterparts. As there exist a significant positive association between less-affected grip strength and self-care activities as reported in this study and aforementioned studies, and men (even stroke survivors) generally have higher grip strength than women, it is plausible for male stroke survivors to be more independent in self-care activities than their female counterparts. In this study, the mean difference in grip strength of the female stroke survivors from the healthy female population was higher when compared with the mean difference of the male stroke survivors to their healthy counterparts. The reason for the difference in relationship between gender and ability to perform self-care activities obtained in this study and that of previous ones could be attributed to differences in methodology, sample population, and sample size. For instance, we recruited only stroke survivors with ischemic stroke while the aforementioned studies investigated both patients with ischemic and hemorrhagic stroke. However, it should be noted that the multivariate analysis showed that gender was not an independent determinant in ability to perform self-care activities in this study. Further studies investigating the influence of gender on ability to independently perform basic activities of daily living among stroke survivors may be warranted.

The results of this study indicated that the trunk function of the stroke survivors is strongly related to their ability to independently perform self-care activities. This relationship has been observed by the findings of the previous studies [23, 31, 44, 45]. It has been stated earlier that independent performance of toileting, for instance, requires good trunk control whether in sitting or standing position, even though adequate grip strength is still needed for the patients to be able to manipulate the garments [23, 44]. Ability to independently undertake basic activities of daily living by stroke survivors, albeit strongly depend on good less-affected grip strength, can possibly be compromised in patients with poor trunk control [44]. The results of the multivariate analysis showed that trunk control was a significant predictor of independence in all self-care activities investigated in this study. However, the significant association between less-affected grip strength and self-care activities was maintained even after adjusted for trunk control of the stroke survivors. This implies that the reference values of less-affected grip strength for self-care activities derived in this study are not compromised by the trunk control of the stroke survivors and therefore possess wide applicability. Stroke survivors move the trunk forwards, backwards, left, and right when performing basic activities of daily living [44] indicating the need for clinicians to consider and pay more attention on the trunk functionality of the stroke survivors during rehabilitation.

In this study, the calculated reference values of the less-affected grip strength for the independent performance of eating, grooming, bathing, dressing of upper body, dressing of lower body, and toileting among stroke survivors were 19.5 kg, 23.7 kg, 24.8 kg, 24.7 kg, 23.7 kg, and 19.9 kg respectively. These values can serve as benchmarks for assessing or estimating the various self-care activities by rehabilitation professionals. There is dearth of data by which the estimated reference values of the less-affected grip strength obtained in this study can be compared with; however, the reference value for independent toileting reported in this study (19.9 kg) is comparable to the 3 points cut-off value on Stroke Impairment Assessment Set (SIAS) Kisara et al. [11] obtained for toileting independence. The 3 points on Stroke Impairment Assessment Set is said to be equivalent to the grip strength of 25 kg and higher [46]. The difference in the values may be attributed to the different assessment tools. We used handheld dynamometer in this study while the Kisara et al. [11] employed SIAS in the measurement of the less-affected grip strength of the stroke survivors.

The mean values of the receiver operating characteristics (ROC) area under the curve obtained in this study showed that the calculated reference values of the less-affected grip strength are acceptable in estimating or predicting independence in each of the self-care activities. The mean ROC area under curve in this study was between 0.75 and 0.85. The area under curve of values between 0.70 and 0.90 in receiver operating characteristics is considered to be a good accuracy of any tests in question [47]. The highest and lowest reference values of less-affected grip strength were seen in bathing and eating self-care activities. This observation revealed that stroke survivors require more grip strength (24.8 kg) to independently perform bathing than for any other self-care activity while they require the lowest grip strength (19.5 kg) to be independent in eating. Anecdotally, process of bathing requires more manipulation and is more difficult to perform thereby demands grater grip strength compared to eating. Ordinarily, each self-care activity involves different technique, maneuvering and exertion to perform successfully and this may explain the reasons for differences in reference values of less-affected grip strength reported in this study.

The less-affected grip strength of the stroke survivors in this study was significantly lower than the grip strength of an average apparently healthy adult. It has been reported by several authors that sarcopenia, which is mostly expressed by decreased skeletal muscle index and hand grip strength, is an attendant effect of stroke [34, 48–50]. Even though aging is a significant factor in developing sarcopenia, evidence has shown that sarcopenia is more pronounced among stroke survivors when compared with the age-matched healthy control [49, 50], and it has been reported that muscle mass or power decrease at faster and greater rate in stroke survivors than in healthy aging adults [51]. However, despite the various effects of sarcopenia in stroke survivors including reduction in independent performance of daily living, only few studies are investigating this phenomenon [34]. Park et al. [34] in their study investigating the effect of decreased skeletal muscle index and hand grip strength on functional recovery in sub-acute ambulatory stroke patients had recommended additional strengthening exercises and nutritional support in stroke patients with sarcopenia in order to reduce functional dependency. Moreover, going by the evidence of stroke-related sarcopenia in terms of reduced less-affected grip strength in this study and others, attention should be placed on the phenomenon by the clinicians to reduce or prevent its attendant effect. This is more so as evidence has shown that the decline in muscle mass of the less-affected side or upper limb among stroke survivors is reversible through exercise [52].

The term 'unaffected' side or grip strength has been observed to be misleading as the ipsilesional side or upper limb is well affected among stroke survivors [9, 17] and this fact has made some researchers to come up with alternative terms like 'less affected', 'slightly affected side' or 'relatively unaffected side' [9, 17]. The change in terms was proposed by these authors in the hope that clinicians may acknowledge that the ipsilateral side is also impaired in stroke and as a result pay more attention to the ipsilateral side of the stroke survivors during rehabilitation. Furthermore, the change in the nomenclature was muted to discourage clinicians from using the ipsilateral side of the stroke survivors as a reference for clinical improvement of the contralateral side or to serve as a control [9, 17].

The main pathophysiological mechanisms adduced for the deficits in the ipsilateral side or upper limb in stroke provide some corticospinal pathways (approximately 10–15%) that run from cortex to the peripheral muscles are also affected following stroke as they run uncrossed through the spinal cord and thereby affect the function of the ipsilateral upper limb [17, 53–56], and that infarction of one cerebral hemisphere in stroke disturbs the neural processes or connections between the hemispheres [54, 57] especially the primary motor and lateral premotor cortex which are connected to both hemispheres by corpus callosum in order to function as a single cortical unit for voluntary movements [53–56]. This disturbance in hemispheric connections are said to negatively affect global task performance, execution of complex tasks and impair the sensori-motor functions of the less-affected side or upper limb of the stroke survivors [58–60].

The stroke-related sarcopenia appears more pronounced among female stroke survivors than their male counterparts in this study. The findings of this study showed that the mean difference of less-affected grip strength among female stroke survivors is higher than that of the male survivors when compared with the normative grip strength of their respective gender. Since the results of this study showed that the higher reduction of less-affected grip strength among female stroke survivors significantly led to decrease in their level of independence in self-care activities when compared to men, future studies may be needed to compare stroke survivors to sex-matched healthy control to investigate the effect of stroke on muscle mass or strength in relation to gender.

The findings of this study may be limited by the use of a relatively small sample size necessitating the need for future studies with a larger sample size. The findings of this study are also limited to stroke survivors with ischemic infarction. Hemorrhagic stroke survivors may present with different relationship between less-affected grip strength and self-care activities. Therefore, further studies may be needed to investigate if the reference values of less-affected grip strength obtained in this study are applicable to patients with hemorrhagic stroke. However, it should be noted that previous studies found no significant relationship between the less-affected grip strength and self-care activities in terms of stroke type [9–11]. We did not evaluate the effect of other stroke-related characteristics, e.g., sensori-motor dysfunction of the affected side, unilateral spatial neglect and apathy which may serve as potential limitation to this study. Meanwhile, as this is a cross-sectional study, causality cannot be inferred between less-affected grip strength and performance level in self-care activities.

Conclusion

The less-affected grip strength of patients with ischemic stroke influences their ability to independently perform self-care activities. The reference values of less-affected grip strength in association with other stroke-related characteristics may help clinicians to estimate independence in self-care activities among patients with ischemic stroke.

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Authors' contributions
ABA was involved in the conceptualization and design of the study. ABA, CEM, OAS, OEM, WAF, and IAA were involved in the acquisition, analysis, and interpretation of data. The first draft of the manuscript was written by ABA and critically reviewed by CEM. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets used and/ or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Ethical clearance was obtained from the Ethical Review Committee of the Osun State University Teaching Hospital, Osogbo, Nigeria (Ref: UTH/EC/2021/07/527).

Consent for publication
Not applicable

Competing interests
The authors declare that they have no competing interests.

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References

1. Johnson W, Onuma O, Owolabi M, Sachdev S. Stroke: a global response is needed. Bull World Health Organ. 2016;94(9):634.
2. Johnson CO, Nguyen M, Roth GA, Nichols E, Alam T, Abate D, et al. Global, regional, and national burden of stroke, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet Neurol. 2019;18(5):439–58.
3. Feigin VL, Forouzanfar MH, Krishnamurthi R, Mensah GA, Connor M, Bennett DA, et al. Global and regional burden of stroke during 1990–2010: findings from the Global Burden of Disease Study 2010. Lancet. 2014;383(9913):245–55.
4. Sanya EO, Desalu OO, Adepoju F, Aderibigbe SA, Shittu A, Olaosebikan O. Prevalence of stroke in three semi-urban communities in middle-belt region of Nigeria: a door to door survey. Pan Afri Med J. 2015;13(20):33.
5. Saunders DH, Sanderson M, Hayes S, Johnson L, Kramer S, Kramer DD, Mead GE. Physical fitness training for stroke patients. Cochrane Database Syst Rev. 2020;3(3):CD003316.
6. Kim D. The effects of hand strength on upper extremity function and activities of daily living in stroke patients, with a focus on right hemiplegia. J Phys Ther Sci. 2016;28(9):2565–7.
7. Scorrano M, Ntsiea V, Maleka D. Enablers and barriers of adherence to home exercise programmes after stroke: caregiver perceptions. Int J Ther Rehabil. 2018;25(7):353–64.
8. Kara S, Ntsiea MV. The effect of a written and pictorial home exercise prescription on adherence for people with stroke. Hong Kong J Occup Ther. 2015;26:33–41.
9. Bae JH, Kang SH, Seo KM, Kim DK, Shin HI, Shin HE. Relationship between grip and pinch strength and activities of daily living in stroke patients. Ann Rehabil Med. 2015;39(5):752.
10. Yi Y, Shim JS, Byung-Mo O, Seo HG. Grip strength on the unaffected side as an independent predictor of functional improvement after stroke. Am J Phys Med Rehabil. 2017;96:616–20.
11. Kisara Y, Fujita T, Ohashi T, Yamane K, Sato A. Relationship of unaffected grip strength and trunk function with toileting performance in stroke patients. Asian J Occup Ther. 2018;14(1):17–21.
12. Michielsen ME, Selles RW, Stam HJ, Ribbers GM, Bussmann JB. Quantifying nonuse in chronic stroke patients: a study into paretic, nonparetic, and bimanual upper-limb use in daily life. Arch Phys Med Rehabil. 2012;93(11):1975–81.
13. Kwakkel G, Veerbeek JM, van Wegen EE, Wolf SL. Constraint-induced movement therapy after stroke. Lancet Neurol. 2015;14(2):224–34.
14. Takahashi J, Nishiyama T, Matsushima Y. Does grip strength on the unaffected side of patients with hemiparetic stroke reflect the strength of other ipsilateral muscles. J Phys Ther Sci. 2017;29(1):64–6.
15. Ademoyegun A, Ibitoye A, Mbada C, Malomo O, Adelowokan O, Aghedo I, et al. Handgrip and quadriceps strength as independent predictors of post-stroke depression and anxiety. J Rehabil Sci Res. 2022;9(1):47–52. https://doi.org/10.30476/jrsr.2021.91566.1176.
16. Ekstrand E, Lexell J, Brogårdh C. Grip strength is a representative measure of muscle weakness in the upper extremity after stroke. Top Stroke Rehabil. 2016;23(6):400–5.
17. Kitsos GH, Hubbard IJ, Kitsos AR, Parsons MW. The ipsilesional upper limb can be affected following stroke. ScientificWorldJournal. 2013;2013:684860. https://doi.org/10.1155/2013/684860.
18. Bustrén E-L, Sunnerhagen KS, Murphy MA. Movement kinematics of the ipsilesional upper extremity in persons with moderate or mild stroke. Neurorehabil Neural Repair. 2017;31(4):376–86.
19. Hsu H-Y, Ke C-W, Kuan T-S, Yang H-C, Tsai C-L, Kuo L-C. Impacts of sensation, perception, and motor abilities of the ipsilesional upper limb on hand functions in unilateral stroke: quantifications from biomechanical and functional perspectives. PM&R. 2018;10(2):146–53.
20. Barry AJ, Triandafilou KM, Stoykov ME, Bansal N, Roth EJ, Kamper DG. Survivors of chronic stroke experience continued impairment of dexterity but not strength in the nonparetic upper limb. Arch Phys Med Rehabil. 2020;101(7):1170–5.
21. Haaland KY, Mutha PK, Rinehart JK, Daniels M, Cushnyr B, Adair JC. Relationship between arm usage and instrumental activities of daily living after unilateral stroke. Arch Phys Med Rehabil. 2012;93:1957–62.
22. Gillen G. Stroke rehabilitation: a function-based approach. 3rd ed. St Louis: Mosby; 2011. p. 716–34.

23. Koike Y, Koeda S, Sumigawa K, et al. Need for, and possibility of, training in seated dressing during toileting in stroke patients with poor standing balance. Igaku To Seibutsugaku. 2013;157:688–95.
24. Fisher AG. Occupational therapy intervention process model: A model for planning and implementing top-down, client-centered, and occupation based interventions. Fort Collins: Three Star Press; 2009.
25. Neistadt ME. Occupational therapy evaluation for adults: a pocket guide. Baltimore: Lippincott Williams & Wilkins; 2000.
26. Song BK. Effect of somatosensory stimulation on upper limb in sensory, hand function, postural control and ADLs within sensorimotor deficits after stroke. J Korean Phys Ther. 2012;24(5):291–9.
27. Stephens S, Kenny RA, Rowan E, Kalaria RN, Bradbury M, Pearce R, et al. Association between mild vascular cognitive impairment and impaired activities of daily living in older stroke survivors without dementia. J Am Geriatr Soc. 2005;53(1):103–7.
28. Nijboer T, Van de Port I, Schepers V, Post M, Visser-Meily A. Predicting functional outcome after stroke: the influence of neglect on basic activities in daily living. Front Hum Neurosci. 2013;7:182.
29. Karthikbabu S, John MS, Manikandan N, Bhamini KR, Chakrapani M, Akshatha N. Role of trunk rehabilitation on trunk control, balance and gait in patients with chronic stroke: a pre-post design. Neurosci Med. 2011;2(2):61–7.
30. Miklitsch C, Krewer C, Freivogel S, Steube D. Effects of a predefined mini-trampoline training programme on balance, mobility and activities of daily living after stroke: a randomized controlled pilot study. Clin Rehabil. 2013;27(10):939–47.
31. Sato A, Okuda Y, Fujita T, Kimura N, Hoshina N, Kato S, et al. Cognitive and physical function related to the level of supervision and dependence in toileting on stroke patients. Phys Ther Res. 2016;19(1):32–8.
32. Eng J. Sample size estimation: how many individuals should be studied? Radiology. 2003;227(2):309–13.
33. Bernhardt J, Hayward KS, Kwakkel G, Ward NS, Wolf SL, Borschmann K, et al. Agreed definitions and a shared vision for new standards in stroke recovery research: the stroke recovery and rehabilitation roundtable taskforce. Int J Stroke. 2017;12:444–50.
34. Park JG, Lee KW, Kim SB, Lee JH, Kim YH. Effect of decreased skeletal muscle index and hand grip strength on functional recovery in subacute ambulatory stroke patients. Ann Rehabil Med. 2019;43(5):535–43.
35. Taekema DG, Gussekloo J, Maier AB, et al. Handgrip strength as a predictor of functional, psychological and social health. A prospective population-based study among the oldest old. Age Ageing. 2010;39:331–7.
36. Stock R, Thrane G, Askim T, Anke A, Mork PJ. Development of grip strength during the first year after stroke. J Rehabil Med. 2019;51(4):248–56.
37. Linacre JM, Heinemann JW, Wright BD, Granger CV, Hamilton BB. The structure and stability of the functional independence measure. Arch Phys Med Rehabil. 1994;75:127–32.
38. Daving Y, Andren E, Nordholm L, et al. Reliability of an interview approach to the functional independence measure. Clin Rehabil. 2001;15:301–10.
39. Data Management Service of the Uniform Data System for Medical Rehabilitation and the Center for functional Assessment Research. Guide for the Uniform Data Set for Medical Rehabilitation, Version 3.0. New York: State University of New York at Buffalo; 1990.
40. Collin C, Wade D. Assessing motor impairment after stroke: a pilot reliability study. J Neurol Neurosurg Psychiatry. 1990;53:576–9.
41. Adedoyin RA, Ogundapo FA, Mbada CE, Adekanla BA, Johnson OE, Onigbinde TA, et al. Reference values for handgrip strength among healthy adults in Nigeria. Hong Kong Physiother. J. 2009;27:21–9.
42. Perkins NJ, Schisterman EF. The inconsistency of"optimal" cut-points using two ROC based criteria. Am J Epidemiol. 2006;163(7):670–5.
43. Unal I. Defining an optimal cut-point value in roc analysis: an alternative approach. Comput Math Methods Med. 2017;2017:3762651. https://doi.org/10.1155/2017/3762651.
44. Koike Y, Sumigawa K, Koeda S, Shiina M, Fukushi H, Tsuji T, et al. Approaches for improving the toileting problems of hemiplegic stroke patients with poor standing balance. J Phys Ther Sci. 2015;27(3):877–81.
45. Fujita T, Sato A, Togashi Y, Kasahara R, Ohashi T, Yamamoto Y. Contribution of abdominal muscle strength for various activities of daily living in stroke patients with mild paralysis. J Phys Ther Sci. 2015;27(3):815–8.
46. Chino N, Sonoda S, Domen K, Saitoh E, Kimura A. Stroke impairment assessment set (SIAS). In: Functional evaluation of stroke patients. Tokyo: Springer; 1996. p. 19–31.
47. Fischer JE, Bachmann LM, Jaeschke R. A readers' guide to the interpretation of diagnostic test properties: clinical example of sepsis. Intensive Care Med. 2003;29(7):1043–51.
48. English C, McLennan H, Thoirs K, Coates A, Bernhardt J. Loss of skeletal muscle mass after stroke: A systematic review. Int J Stroke. 2010;5(5):395–402.
49. Scherbakov N, Sandek A, Doehner W. Stroke-related sarcopenia: specific characteristics. J Am Med Dir Assoc. 2015;16:272–6.
50. Hunnicutt JL, Gregory CM. Skeletal muscle changes following stroke: a systematic review and comparison to healthy individuals. Top Stroke Rehabil. 2017;24:463–71.
51. Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, et al. American college of sports medicine position stand. exercise and physical activity for older adults. Med Sci Sports Exerc. 2009;41(7):1510–30.
52. Ryan AS, Ivey FM, Prior S, et al. Skeletal muscle hypertrophy and muscle myostatin reduction after resistive training in stroke survivors. Stroke. 2011;42:416e420.
53. Shumway-Cook A, Woollacott MH. Motor Control: Translating Research Into Clinical Practice. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 2012.
54. Morris JH, Van Wijck F. Responses of the less affected arm to bilateral upper limb task training in early rehabilitation after stroke: a randomized controlled trial. Arch Phys Med Rehabil. 2012;93:1129–37.
55. Grefkes C, Fink GR. Reorganization of cerebral networks after stroke: new insights from neuroimaging with connectivity approaches. Brain. 2011;134(5):1264–76.
56. Grefkes C, Fink GR. Connectivity-based approaches in stroke and recovery of function. Lancet Neurol. 2014;13:206–16.
57. Suzuki M, Omori Y, Sugimura S, et al. Predicting recovery of bilateral upper extremity muscle strength after stroke. J Rehabil Med. 2011;43:935–43.
58. Favre I, Zeffiro TA, Detante O, Krainik A, Hommel M, Jaillard A. Upper limb recovery after stroke is associated with ipsilesional primary motor cortical activity: a meta-analysis. Stroke. 2014;45:1077–83.
59. McCombe Waller S, Whitall J. Fine motor control in adults with and without chronic hemiparesis: baseline comparison to nondisabled adults and effects of bilateral arm training. Arch Phys Med Rehabil. 2004;85:1076–83.
60. Sunderland A. Recovery of ipsilateral dexterity after stroke. Stroke. 2000;31:430–3.

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