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Relationship between hamstrings–quadriceps strength ratio and the performance of tasks in Berg's Balance Scale among stroke survivors in Abakaliki, Nigeria

Nonso Christian Asouzu ,[1] Emeka Mong,[2] Maximin Agha,[3] Nwabumma Cynthia Asouzu,[4] Emelie Moris Anekwu,[1] Davidson Okwudili John,[1] Emmanuel Chiebuka Okoye,[5] Sam Chidi Ibeneme[6]

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ABSTRACT

Aim The study was designed to establish the relationship between hamstrings–quadriceps (H–Q) strength ratio and the performance of tasks in Berg's Balance Scale among stroke survivors.

Method Twenty-five stroke survivors participated in the study. The hamstrings and quadriceps muscle strengths of both the paretic and non-paretic sides were determined at 60° knee flexion with an electronic tensiometer. The participants undertook the tasks in Berg's Balance Scale.

Results The moment of correlation between the paretic H–Q strength ratio and the total score of the Berg's Balance Scale was 0.630, while the non-paretic was −0.144. Tasks such as standing unsupported (0.360), sitting unsupported (0.348) and standing with eyes closed (0.262) showed a weak correlation with the paretic H–Q strength ratio. Sitting to standing (0.469), standing to sitting (0.405), transfers (0.470), standing with feet together (0.565), retrieving an object from the floor (0.544), turning to look behind (0.400), turning 360° (0.589) and one leg stance (0.649) showed moderate correlation with the paretic H–Q strength ratio; while reaching forward (0.768), placing alternate foot on stool (0.710) and tandem standing (0.744) showed strong correlation with the paretic H–Q strength ratio.

Conclusion The study concluded that the H–Q strength ratios of the paretic limbs of stroke survivors showed significant relationships with the performance of tasks in Berg's Balance Scale. It is recommended that the H–Q strength ratio is considered as a clinical measurement tool in the balance rehabilitation of stroke survivors.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Poor balance is a major limitation to achieving functional independence among stroke survivors, and Berg's Balance Scale has been considered a standard for assessing functional balance.

WHAT THIS STUDY ADDS

⇒ This study adds essential insight into the integration of biomechanics into stroke rehabilitation.

⇒ Increased Hamstrings–Quadriceps strength ratio of stroke survivors' paretic limb corresponded to increased task performance in Berg's Balance Scale. Thus, the study maintains that balance requires good synergies and interaction between the quadriceps and hamstring muscle groups.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The study's outcome will awaken rehabilitation professionals to consider muscle synergies, especially the hamstrings–quadriceps interaction, in balance training and rehabilitation among individuals with motor deficits such as stroke.

⇒ The Hamstring-Quadriceps strength ratio should be considered a goal-oriented outcome measure and a rehabilitation tool in mobility and balance training of stroke survivors.

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For numbered affiliations see end of article.

Correspondence to
Dr Nonso Christian Asouzu; nonsoasouzu@gmail.com

INTRODUCTION

The weakness of muscles responsible for stance and locomotion is a major contributor to the loss of balance among stroke survivors, which is a major disability found among stroke survivors. Stroke is a major health burden contributing to major disabilities and approximately 11% of deaths worldwide.[1] A stroke occurs when an artery to the brain becomes blocked or ruptures, resulting in the death of an area of brain tissue due to loss of its blood supply (cerebral infarction) and symptoms that occur suddenly, lasting more than 24 hours or leading to death.[2] Those who have survived the stroke are referred to as stroke survivors.

The sudden loss of any capacity due to stroke causes severe stress not only to the survivors but also to the family and the healthcare system. Despite huge resources that are put into rehabilitation after stroke, the majority of the survivors do not reach their desired level of functional independence,[3] including the recovery of adequate balance. Therefore, for many years, poor balance has been an object of study by many researchers in stroke rehabilitation. Balance is the ability to maintain the body's centre of gravity over its base of support.[4] Studies of balance impairments consistently have shown that stroke survivors have greater postural sway than age-matched healthy volunteers.[5] In rehabilitation, outcome measures are frequently employed to assess changes attributable to interventions or other variables. One of the most commonly used outcome measures of balance is Berg's Balance Scale (BBS). The scale is generally considered the gold standard for functional balance tests.[6] The balance scale is a widely used clinical test of a person's static and dynamic balance abilities and is validated for use among stroke survivors.[7]

Good strength of the hamstrings in relation to that of the quadriceps is necessary for adequate balance in normal individuals and thus deserves great consideration in the rehabilitation of stroke survivors. Any imbalance in the strength ratio may lead to abnormal walking patterns. The hamstrings–quadriceps (H–Q) strength ratio is the strength ratio between the two muscle groups.[8] The acceptable and desirable ratio for a healthy knee is 50%–80% (ratio of 0.5–0.8),[8 9] though some authors[8 9] argue that a ratio greater than 80% is more desirable. It has been shown that many muscle synergies of stroke survivors during the performance of tasks are reduced in a manner that predicts the degree of impairment.[10] Park *et al*[11] beautifully stated that by evaluating the intermuscular coordination in the paretic (affected) limb under various biomechanical task constraints, the impact of a stroke on motor control can be analysed, and intermuscular coordination-based rehabilitation strategies can also be developed. To develop a rehabilitation strategy for balance among stroke survivors, there is a need to evaluate the strength ratio of the flexors and extensors, which are involved in the intermuscular coordination of balance and to establish the relationship between their strength ratio and performance of tasks that are balance indicators. Therefore, the study's purpose was to establish the relationship between the H–Q strength ratio (ratio) and the performance of tasks in BBS among stroke survivors.

METHOD

Design

This study adopted the correlational research design. This design was expedient for this study because neither the H–Q strength ratio nor the tasks in BBS were manipulated to establish the relationship between them.

Patient and/or public involvement

Patients and/or the public were not involved in this study's design, reporting or dissemination plans.

Participants

The data were collected from the entire population of stroke survivors who attended the physiotherapy clinics of Alex Ekwueme Federal University Teaching Hospital Abakaliki, Nigeria, who were eligible and consented during the study period. Twenty-five participants, 14 males and 11 females, were involved in the study.

Inclusion criteria

The following inclusion criteria were considered relevant for this study:

- One-time stroke survivors who can ambulate independently.
- One-time stroke survivors between the ages of 18 and 65 years.
- Stroke survivors who are medically stable to undergo gait rehabilitation.

Exclusion criteria

The following exclusion criteria were considered relevant for this study:

- Stroke survivors who had repeat stroke.
- Stroke survivors with other comorbidities that impair gait.
- Medically unstable stroke survivors.

Instruments

The instruments for data collection were a H–Q strength test and a balance test with the BBS. The instruments were standard tools whose validity and reliability have been established by many studies.[12–14]

Procedures

The maximum force determines the hamstrings' and quadriceps' muscle strengths the muscle can generate to overcome resistance. This was measured at 60 degrees knee flexion with an electronic tensiometer, fastened on the lower one-third of the leg and secured on a fixed point. The force was tested by three trials within each muscle group with 2 min rest between trials. A 5 min rest was observed between the muscle groups. The maximum force generated during the three trials was recorded for each muscle group. Both the paretic and non-paretic legs of the participants were tested. The same procedure was used for all the participants, and the test was administered to all by the same researcher, a qualified and experienced physiotherapist.

A balance test with the BBS was administered using standard protocol for each task. BBS is a 14-item list of tasks scored on a 5-point ordinal scale ranging from 0 to 4, with 0 indicating the lowest level of performance and 4 the highest level of performance. The participant was tasked with the 14 items of the scale. The tasks are as follows: sit to stand, standing unsupported, sitting unsupported, standing to sitting, transfer, standing with eyes closed, standing with feet together, reaching forward, retrieving an object from the floor, turning to look behind, turning 360, placing alternate foot on a stool, tandem standing and one leg stance. Each of the tasks was scored according to the performance of the participant. Each participant was told to maintain balance while

Table 1 Reference table for correlation Interpretation[14]

Correlation coefficient (r)	Interpretation
0.00–0.10	No correlation
0.10–0.39	Weak correlation
0.40–0.69	Moderate correlation
0.70–0.89	Strong correlation
0.90–1.00	Very strong correlation

Table 2 Mean scores of the variables (N=25)

Variable	Mean	SD
P_H–Q	0.05	0.06
N_H–Q	0.59	0.15
Sit to stand	3.20	1.29
Standing unsupported	3.72	0.68
Sitting unsupported	3.80	0.50
Standing to sitting	3.36	1.15
Transfer	3.32	1.07
Standing with eyes closed	3.36	1.35
Standing with feet together	3.12	1.20
Reaching forward	2.92	0.91
Retrieving an object from the floor	3.24	1.05
Turn to look behind	3.36	1.32
Turn 360	2.04	0.89
Placing alternate foot on a stool	2.12	1.67
Tandem standing	2.52	1.39
One leg stance	1.92	1.52
BBS	42.00	13.63

BBS, Berg's Balance Scale; N_H–Q, hamstrings–quadriceps strength ratio of the non-paretic (unaffected) limb; P_H–Q, hamstrings–quadriceps strength ratio of the paretic (affected) limb.

attempting the tasks. The choices of which leg to stand on or how far to reach were left to the participants.

Data analysis

The generated quantitative data were coded in the SPSS V.25 batch system. Pearson's product moment of correlation coefficient was used to test the hypotheses. The test measures the direction and how strong a linear correlation is between the H–Q strength ratio and the performances of tasks in BBS. The reference values determined the strength of the relationship following the works of Schober *et al*,[15] shown in table 1.

The strength of the relationship applied certain cut-offs to the absolute correlation coefficients to precisely describe the magnitude of the correlation. Significance was inferred at a p<0.05.

RESULT

The mean score of the H–Q strength of the paretic limbs were 1.01±1.40N and 13.83±8.30N, respectively, which gave a ratio of 0.05, while the H–Q strength ratio of the non-paretic limb was 0.59. The mean scores and SD of the H–Q strength ratio and the score of each task in BBS, as well as the mean total score, are presented in table 2.

The mean score for each task of BBS is presented as assessed on a 5-point ordinal scale ranging from 0 to 4, with 0 indicating the lowest level of function and 4 the highest level of function. Sitting unsupported had the highest score of 3.8 among the stroke survivors, while standing on one leg had the least score of 1.9.

The result of Pearson's product moment correlation coefficient between the H–Q strength ratio of both the paretic (affected) and the non-paretic (unaffected) limbs and tasks in the BBS among the stroke survivors is presented in table 3.

The BBS tasks that showed a weak correlation with the H–Q strength ratio of the paretic (affected) limbs include standing unsupported, sitting unsupported and standing with eyes closed. Tasks such as sitting to standing, standing to sitting, transfers, standing with feet together, retrieving objects from the floor, turning to look behind, turning 360° and one leg stance showed moderate correlation with the paretic H–Q strength ratio. In contrast, tasks such as reaching forward, placing the alternate foot on a stool and tandem standing showed a strong correlation with the H–Q ratio on the paretic limbs.

Generally, the moment of correlation between the H–Q strength ratio of the affected limb and the total score of the BBS is 0.630. The result showed that there is a moderate positive significant correlation between the paretic H–Q strength ratio and the balance score of BBS (p<0.05). However, the mean H–Q strength ratio of the unaffected limbs has no significant correlation (−0.144) with the balance score among the stroke survivors (p>0.05).

DISCUSSION

The findings from this study showed a significant relationship between the H–Q strength ratio and performance of tasks in BBS of stroke survivors. The relationship is such that the performance of the tasks increases as the H–Q strength ratio increases on the affected limbs of the stroke survivors. This is congruent with the position of Jeon and Hwang,[16] who concluded in a study that lower limb strengthening exercises significantly improved balance as measured with BBS, among other gait and balance parameters. In this study, the mean score of the balance among the participants, as assessed with BBS, is 42. According to Berg *et al*,[13] a score of less than 45 indicates that the individual may be at greater risk of falling. That is to say, stroke survivors studied had poor balance and were thus at risk of falls. Falls are common among stroke survivors. Weerdesteyn *et al*[17] reported that 40% of patients who had a stroke have serious falls in the first year

Table 3 Table of correlation between H–Q strength ratio and BBS (N=25)

Tasks in BBS		P_H–Q	N_H–Q
Sit to stand	Pearson correlation	0.47	–0.14
	Sig. (two tailed)	0.018	0.493
Standing unsupported	Pearson correlation	0.36	–0.27
	Sig. (two tailed)	0.077	0.196
Sitting unsupported	Pearson correlation	0.35	–0.23
	Sig. (two tailed)	0.088	0.268
Standing to sitting	Pearson correlation	0.41	–0.19
	Sig. (two tailed)	0.045	0.363
Transfer	Pearson correlation	0.47	–0.01
	Sig. (two tailed)	0.018	0.952
Standing with eyes closed	Pearson correlation	0.26	–0.2 6
	Sig. (two tailed)	0.205	0.216
Standing with feet together	Pearson correlation	0.57	0.0 1
	Sig. (two tailed)	0.003	0.971
Reaching forward	Pearson correlation	0.77	0.4 5
	Sig. (two tailed)	<0.001	0.025
Retrieving an object from the floor	Pearson correlation	0.54	0.0 2
	Sig. (two tailed)	0.005	0.927
Turn to look back	Pearson correlation	0.40	–0.2 1
	Sig. (two tailed)	0.048	0.319
Turn 360^0	Pearson correlation	0.59	0.1 1
	Sig. (two tailed)	0.002	0.615
Placing alternate foot on a stool	Pearson correlation	0.71	0.47
	Sig. (two tailed)	<0.001	0.019
Tandem standing	Pearson correlation	0.74	0.25
	Sig. (two tailed)	<0.001	0.231
One leg stance	Pearson correlation	0.65	0.44
	Sig. (two tailed)	<0.001	0.027

.BBS, Berg's Balance Scale; N_HQ, hamstrings–quadriceps strength ratio of the non-paretic limb; P_HQ, hamstrings–quadriceps strength ratio of the paretic limb.

after their stroke because of poor balance. Beyaert *et al*[18] report that about 70% of stroke survivors living at home reported falling within a year of their stroke. Kossi *et al*,[19] in their study to determine the frequency and factors associated with balance impairments among stroke survivors at the University Hospital of Parakou, reported balance impairments among stroke survivors discharged from the centre. This suffices to say that strengthening exercises targeted at increasing the strength of weak muscles of stroke survivors and targeting to increase the flexors-extensors strength ratio of the muscles will improve balance among stroke survivors.

It was shown from this study that the H–Q strength ratio of the unaffected limbs is approximately 0.6, while that of the affected (paretic) limb is 0.05. Recall that the normal value of the H–Q strength ratio is from 0.5 to 0.8, according to Al-Johani *et al*,[20] even though Trevor8 argued that a higher value is desirable. It can be deduced from the study that the H–Q strength ratio of the unaffected (non-paretic) limb is within the normal range, while that of the affected (paretic) side is abysmally poor. This could have explained the poor balance experienced by the stroke survivors. Thus, a good – strength ratio is necessary for regaining optimal balance among stroke survivors. The performance of certain tasks in BBS involves maintaining a good fixed support base in standing on two lower limbs. Such tasks as reaching forward, placing the alternate foot on a stool, and tandem standing showed a strong correlation with the affected limbs' H–Q strength ratio. These tasks are measures of stability and balance. An adequate H–Q strength ratio will ensure stability on the knee on which the body relies for balance while performing such tasks. For instance, this study's findings showed a significant relationship between the H–Q strength ratio and stroke survivors' ability to reach forward. The relationship is such that the ability to reach forward increases as the H–Q strength ratio increases. This agrees with Jeon and Hwang,[16] who stated that lower limb strengthening exercises for balance and walking significantly improved the functional reach test among stroke survivors. The functional reach test is a clinical assessment tool and outcome measure for determining dynamic balance in one simple task.

Other tasks on the scale, such as sitting to standing, standing to sitting, transfers, standing with feet together, retrieving objects from the floor, turning to look behind, turning 360° and one leg stance, showed a significant moderate correlation with the paretic H–Q strength ratio. These tasks involve changes in the body's centre of mass across the support base. In a study, Tsur and Segal[21] stated that most falls due to poor balance among stroke survivors occur during transfers from sitting to standing position or vice versa. The findings of this study agree with the associations and further maintain that exercises that strengthen the flexor and extensor muscles of the affected limbs of stroke survivors to achieve a better H–Q strength ratio will improve balance and coordination.

It was shown that there is a weak correlation between the H–Q strength ratio of the affected limbs and tasks such as standing unsupported, sitting unsupported and standing with eyes closed. The weak correlation between the tasks is quite understandable, as some tasks may require less activity of the affected limbs.

CONCLUSION

The study concluded that the H–Q strength ratio of the affected (paretic) limbs of the stroke survivors showed a significant relationship with the performance of tasks in BBS. Since the scale is a standardised balance assessment tool, it can be inferred that the H–Q strength ratio of the affected limbs of stroke survivors correlates well with their balance. Therefore, in the rehabilitation of stroke survivors, diligent effort to improve the strength of the hamstrings in addition to that of the quadriceps in such a way as to improve their strength ratio might be beneficial to the performance of tasks in the balance scale.

Implications of the study

This study adds essential insight into integrating knowledge of biomechanics into the clinical practice of stroke rehabilitation. The study's outcome guides rehabilitation professionals on necessary muscle synergy considerations in facilitating balance in individuals with motor deficits such as stroke. This insight provided in the study will improve stroke survivors' balanced rehabilitation outcomes and improve rehabilitation professionals' skills.

Strengths and limitations of the study

To the authors' knowledge, this study is the first to explore the relationship between the H–Q strength ratio and measures of balance among stroke survivors in Nigeria. This first step may help establish a better relationship between other flexors-extensors strength ratios and balance and guide rehabilitation professionals on strategies to enhance balance among stroke survivors. However, our findings must be interpreted in the context of potential limitations. It has been shown that the BBS, used as a primary outcome measure in our study, has floor and ceiling effects. Consequently, the frequency of balance impairments may have been underestimated or overestimated. However, the floor effect was eliminated by including only stroke survivors who could walk. The ceiling effect was not witnessed due to the serious balance challenges of the participants. This study involved a smaller population than initially anticipated. The population was the stroke survivors who, at the time of the study, were assessing rehabilitation services at the Physiotherapy Department of Alex Ekwueme Federal University Teaching Hospital Abakaliki, Nigeria, and met the selection criteria. This may not represent the entire population of stroke survivors in the geographical area because of the erroneous myth among the populace that stroke is not treated in the hospital. Only a few who believe otherwise seek rehabilitation in the hospital facility.

Author affiliations
[1]Department of Physiotherapy, Alex Ekwueme Federal University Teaching Hospital Abakaliki, Abakaliki, Ebonyi State, Nigeria
[2]Department of Human Kinetics and Health Education, Ebonyi State University, Abakaliki, Nigeria
[3]Department of Human Kinetics and Health Education, Ebonyi State University Faculty of Education, Abakaliki, Ebonyi, Nigeria
[4]Department of Nutrition and Dietetics, Alex Ekwueme Federal University Teaching Hospital Abakaliki, Abakaliki, Ebonyi, Nigeria
[5]Department of Medical Rehabilitation, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria
[6]Department of Medical Rehabilitation, University of Nigeria - Enugu Campus, Enugu, Nigeria

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ORCID iD
Nonso Christian Asouzu http://orcid.org/0009-0004-0011-4953

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