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STANDING ASYMMETRY AND FUNCTIONAL ABILITY IN RELATION TO GAIT PARAMETERS IN HEMIPARETIC STROKE PATIENTS

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الهدف : يتقصى البحث العلاقة بين بعض معايير جيت للتوهان المكاني أو الزماني والقدرة الوظيفية وعدم التناسق في الوقوف (التي تقاس كنسبة عدم توازن) لدى المرضى الذين يعانون شللا نصفيا . التصميم : تصميم بحثي إرتجاعي . حجم العينة : واحد وثلاثون مريضا (١٨ رجلا و١٢ أنثى) يعانون شللا نصفيا، تتراوح أعمارهم بين ٣٥ – ٦٥ سنة)، (11.53 ± 56.97) من العيادات الخارجية للعلاج الطبيعي لمستشفى نيجيريا التعليمي. المقاييس : جرى استخدام مقياسين لقياس توزيع الوزن النسبي لكل طرف من الأطراف السفلى وتحولت نتجة لذلك الى نسبة عدم تناسق في حين تم تحديد القدرة الوظيفية باستخدام مقياس التقويم الحركي المعدل.وتم تقويم معايير جيت بإستخدام تحليل بصمة القدم التي تم أخذها خلال اختبار مشي لمسافة ١٠ أمتار . وجرى احتساب مصفوفة الترابط بيرسونز لتحديد العلاقة عند معامل الارتباط ألفا 0.05 . النتائج : أظهرت النتائج وجود رابط سلبي بين نسبة عدم التناسق وكل من طول حركة المشي والقدرة الوظيفية (p<0.05) ، بينما كانت هناك علاقة إيجابية بين الأداء الحركي وطول الخطوة وإيقاعها ، وسرعة المشي وزمن الخطوة (p<0.05) . الخلاصة : كلما قل عدم التناسق في الوقوف لدى مرضى الجلطات الدماغية ، كلما كانت وظائفهم الحركية وأداء المشي أفضل. الخلاصة :البرامج التي تهدف إلى تعزيز أنشطة تحمل الوزن بوساطة الأطراف السفلية المصابة بالشلل، للحصول على تناسق في الوقوف يمكن استخدمها لتقوية القدرة الوظيفية والحصول على وظائف مشي أفضل لدى المرضى بعد إصابتهم بالجلطة.

Objective: Relationships between some temporospatial gait parameters and each of functional ability and standing asymmetry (measured as asymmetry ratio) in hemiparetic stroke patients were investigated. ***Design:*** Ex-post facto research design. ***Sample Size:*** Thirty-one (18 males and 13 females) patients with hemiparesis, aged between 35 and 65 years (56.97 ± 11.53) were consecutively recruited from the physiotherapy out-patient facility of a Nigerian teaching hospital. ***Measurements:*** Two weighing scales were used to measure relative standing weight distribution on each lower limb and subsequently converted to asymmetry ratio (AR), while functional ability was determined using the modified motor assessment scale. Gait parameters were assessed using foot print analysis, obtained during a 10-metre walk test. Pearson's correlation matrix (r) was calculated to establish relationship at 0.05 alpha. ***Results:*** Results showed a significantly negative correlation between asymmetry ratio and each of stride length, step length and functional ability ($p<0.05$). Significantly positive correlation was found between motor function and each of stride length, step length, cadence, walking speed and step time ($p<0.05$) were obtained. ***Conclusion:*** The lesser the standing asymmetry in stroke patients, the better their motor functions and gait performance. Programmes aimed at enhancing weight bearing activities through the paretic lower limb, to attain standing symmetry, may be used to enhance functional ability and produce better gait functions in post-stroke patients.

Key Words: *Stroke, Hemiparesis, Functional Ability, Standing Asymmetry, Gait*

INTRODUCTION

Balance impairment or loss of postural control is a long term problem in a high percentage of stroke survivors[1]. This impairment can be assessed by determining weight bearing symmetry, postural sway and limits of stability[2]. Weight bearing asymmetry, represented as imbalance of weight distribution and loss of alignment of head and trunk, is a recognised measure of balance impairment in stroke patients[3].

The gait pattern displayed by stroke patients is often characterised by over-activity of the affected upper limb flexors and lower limb extensors, circumduction and hiking of the pelvis required for foot clearance. They also display limited function due to poor gait pattern and fatigue, as well as impaired functional mobility skills which are related to motor and perceptual impairments[4,5]. In rehabilitation of individuals who have suffered a

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stroke, an important goal of physiotherapy is restoration of functional abilities and independence. This can be done using specific physical procedures to train these two functions or by facilitating the physico-clinical attributes (such as balance and gait) that may translate to better function and greater independence. Importance of studies exploring the inter-relationships among the variables, such as gait and balance, that interact to produce specific clinical outcomes such as functional abilities can not be over emphasised. This study was undertaken to determine the relationship between weight symmetry and each of functional ability and some temporospatial gait parameters in hemiparetic stroke subjects.

Methodology

Thirty-one patients (18 males and 13 females) with hemiparesis secondary to stroke participated in this study. Ten had suffered haemorrhagic and 21 had ischaemic cerebrovascular disease. The mean duration of stroke was 16.46 ± 4. 31 weeks. They were receiving physiotherapy on outpatient basis at the Physiotherapy clinic of the University College Hospital (UCH) Ibadan, Nigeria.

Only freely consenting patients who met the following inclusion criteria were recruited, using a consecutive sampling technique:

a. Subjects with unilateral, first episode of stroke causing hemiparesis
b. Absence of dysphasia, ability to comprehend instructions and give informed consent.
c. Ability to walk a distance of 10 metres continuously and unaided.
d. Obtaining a grade 2 spasticity level score in the upper and lower limbs on the modified Ashworth Scale[6].

The protocol for this study was approved by the Joint Ethical Committee of the University of Ibadan/University College Hospital. The steps involved in the procedure were explained to the participants before obtaining their written consent.

The hospital number, age, sex, date of stroke, side of affectation, height and total body weight of the participants were recorded. The following measurements were then carried out:

Standing Weight Distribution: This is the relative amount, in percentage, of the total body weight that the patient bears on each of the lower limbs in standing position. This was measured using two portable weighing scales which were placed beside each other, 10 cm apart on the floor at the research venue, and the subject stood fully upright and unsupported with a foot on each of the scales[7].

The two weighing scales were validated by placing a known standard weight (dumb bell) on each scale before use. Zero error was also corrected before each participant stepped on the scales. The subject, wearing vest and a pair of shorts, stood barefooted placing one foot on each of the weighing scales and maintained as upright balance as possible. This was ensured by making the participant stand upright on the scale and looking straight ahead. The value on each weighing scale was recorded to the nearest 1.0 Kg. Two measurement trials were carried out and the average of the two sets of values was used for computation. The respective values obtained were converted to percent of total body weight for each lower limb. Asymmetry ratio was then calculated, using the formula by Caldwell[8]:

$$\text{Asymmetry Ratio} = \frac{\text{\% of body weight on unaffected lower limb}}{\text{\% of body weight on affected lower limb}}$$

Functional Ability: The Modified Motor Assessment Scale[9] was used to assess functional ability. This is a measure of level of disability or dependence of a stroke patient. The subject carried out a series of tasks and the quality of performance and or time taken to carry out the tasks was assessed based on criteria for scoring each task. The scoring was on a seven - point scale, from zero to a maximum score of 6.

Gait Parameters: A plain paper walkway of 10 by 0.5 metres was taped on the floor of the gymnasium for each participant. Two trays, each containing ink pads of 2 different colours were also prepared. Subject stepped barefooted with one foot each on two ink pads of contrasting colours to coat the soles of the feet with ink. This was to obtain their footprints on the paper walkway. Subjects were then instructed to walk with their ink-stained soles on the walkway at their self-selected walking speed. The self selected walking speed is the natural speed of walking for an individual and is regarded as the most effective speed for that individual from the energy conservation point of view.

A trial run was first carried out before the actual test. The time taken to walk the central 6-metre area was noted with the aid of a stop-watch. The first and the last 2-metre length of the walkway were not timed. This was to eliminate the effects of acceleration and deceleration that occurs when beginning and ending walking on a mapped area. The stop-watch was started on the first contact of the heel of the unaffected foot on the walkway, immediately after the subject had passed the first 2-metre mark. Timing was stopped on the final contact of the heel of the unaffected foot with the walkway, before passing the beginning of the last 2-metre mark. The number of times the unaffected foot made contact with the ground within the central 6-metre of the paper walkway was also counted, ensuring that first contact was zero[10]. After the trial, the subject sat down on a chair provided to rest before carrying out the actual test run. The essence of the trial test was to enable the subject get used to the test protocol. All timing was carried out by the same tester.

The gait parameters were computed from the foot prints on the central 6-metre area of the paper walkway as follows:

a) *Stride Length:* This is the distance from one heel strike to another heel strike of the same foot[11]. It was measured in centimetres as the linear distance between the lines corresponding to two successive points of contact of the same foot.
b) *Step Length:* Step length is the distance from heel strike of one foot to heel strike of the other foot measured in centimetres[11]. It was measured as the linear distance between the lines corresponding to two successive points of contact of the right and left foot respectively.
c) *Step Width:* This is the distance between the midline of one foot and the midline of the other foot in centimetres[11]. It was measured as the linear distance between one foot and the opposite foot.
d) *Cadence:* Is the number of steps per minute[11]. The number of steps taken by each subject through the central 6-meter of the walkway was counted and divided by the time taken for the walk. This was recorded in steps per minute.
e) *Walking Speed:* This was measured as the distance covered by each subject (i.e. 6 metres) divided by the time taken to cover the distance[12]. It was recorded in centimetres per seconds.
f) *Stride Time:* This was the total time in seconds taken to cover the 6-metre walkway divided by number of strides taken[12].
g) *Step Time:* This was the total time in seconds taken to cover 6-metre area of the walkway divided by the number of steps taken[12].

DATA ANALYSIS

Descriptive statistics of mean and standard deviation were computed. Pearson product moment correlation coefficient was used to (a) determine the relationship between weight bearing asymmetry and functional ability. (b) the relationship between weight-bearing symmetry and each of the selected gait parameters. (c) The relationship between functional ability and each of the selected gait parameters. The obtained r values were subjected to further test of significance. Alpha level was set at 0.05.

RESULTS

The physical attributes of the 18 males and 13 females participants are presented in Table 1. Fifteen had right side and 16 had right side hemiplegia. They have had stroke within 16 months period at the time of participation. The descriptive values of the measured variables are presented in Table 2. Asymmetry ratio were found have a significantly negative correlation ($p < 0.05$) with each of stride length and step length of the subjects (Table 3). There was however a significantly positive correlation between functional ability and each of stride length, step length, speed and step time at $p \leq 0.05$ (Table 3).

Table 1. Physical Attributes of the Subject (N = 31)

Variable	Mean (SD)
Age (years)	56.97 (11.53)
Weight (kg)	64.26 (8.85)
Height (cm)	163.70 (7.85)
Time from onset (months)	13.21 (2.73)

DISCUSSION

Maximisation of functional ability and restoration of normal gait functions are important goals of physiotherapy in stroke rehabilitation. Possible relationships between these 2 functions as well as between standing asymmetry and each of these two variables were assessed in this study. The outcome

Table 2. The Descriptive Values of the Measured Variables (N = 31)

Variables	Mean (SD)
MMAS Score	32.16 (14.06)
Asymmetry Ratio	1.81 (1.18)
Step Length (cm)	31.62 (17.49)
Stride Length (cm)	69.27 (26.19)
Step Width (cm)	18.24 (5.39)
Cadence (steps/min)	78.67 (19.4)
Speed (m/sec)	49.14 (23.72)
Stride Time (sec)	0.69 (0.15)
Step Time (sec)	1.31 (0.33)

Key:
MMAS - Modified Motor Assessment Scale

of the study indicates a linear relationship between functional ability scores and each of speed, stride length, cadence and step time. These relationships suggest that as a stroke patient attains better motor function, the gait performance improves, and vice versa. Impaired functional mobility skills in stroke have been related to motor impairments[4]. As motor control and function improves in a stroke patient, his walking pattern would be characterised by less time during stance phase and better weight transference to the unaffected lower limb. The latter will manifest as faster walking speed, higher step time, increased cadence and stride length. The higher the step time, the lesser the time the patients spends less time to cover a specified distance, and this can be related to walking speed and stride length of the patient.

Table 3. Correlation between Gait Parameters, Asymmetry Ratio and Modifies Motor Assessment Scale - MMAS (N = 31)

	Asymmetry Ratio (AR)	Modified Motor Assessment Scale
Stride Length (cm)	-0.38*	0.68*
Step Length (cm)	-0.44*	0.56*
Step Width (cm)	0.25	-0.29
Cadence (steps/min)	-0.19	0.42*
Speed (m/sec)	-0.34	0.71*
Stride Time (sec)	0.18	0.19
Step Time (sec)	-0.19	0.42*
Asymmetry Ratio	1.0	-0.37

Key:
* = Significant r value at $P \leq 0.05$ indicating correlation between the variables

Improved overall motor performance, determined using modified motor assessment scale in this study, is an indication of better motor activities on the hemiplegic side of the body. Motor functions include balance ability, a construct that can be measured by determining standing weight symmetry of the stroke patients. The standing weight symmetry was determined as asymmetry ratio in this study. We observed a negative association between asymmetry ratio and each of step length (-0.44) and stride length (-0.38) of the patients. This trend indicates that as upright and balanced standing posture (symmetry) is attained, the stride length and step length improves. This observation has a clinical significance because it has been reported that the hemiplegic gait tend to be slow with a decreased stride length and cadence when compared to normal individuals[13]. High significant correlation between functional ability and each of stride length, step length, cadence, walking speed and step time translates to improvement in gait. This may be because the decreasing degree of asymmetry results in improved self-confidence and resultant improvement in functional ability and also gait parameters of the post stroke individuals.

CONCLUSION

Whereas many factors including sensory and cognition impairment, may influence gait and functional ability, the results obtained in this study indicate a good inter-relationship between standing weight symmetry of post stroke individuals and each of their functional ability and some temporospatial parameters. This suggests that restoration of standing balance during stroke rehabilitation may facilitate gait pattern and enhance functional ability. However, generalisation of the findings of this study may be limited only to post stroke individuals who have attained the status of ability to walk like the participants in this study.

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