

GAIT, BALANCE, AND FUNCTIONAL INDEPENDENCE LEVEL IN STROKE PATIENTS

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ABSTRACT

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Introduction: Most stroke patients present limited movement, which alters gait speed and balance. This study aimed to correlate balance and gait speed, and weight distribution and balance in post-stroke patients.

Methods: In total, 36 participants were included. Data collection occurred as follows: filling out the assessment form; assessment with the Berg Balance Scale (BBS); assessment with the baropodometric platform; performing the 10 Meter Walk Test (10mWT) with accelerometer; measurements with the modified Rankin Scale (mRS); the Functional Ambulation Classification (FAC); and the Barthel Index (BI).

Results: A negative correlation between FAC and mRS ($r = -0.708$; $p < 0.05$) and between BI and mRS ($r = -0.716$; $p < 0.05$) was found. The correlation between BI and FAC was positive ($r = 0.591$). There was a strong positive correlation between the 10mWT values and the BBS score ($r = 0.708$; $p < 0.05$). Moreover, a weak negative correlation was observed between BBS values and lower limb weight distribution ($r = -0.378$; $p < 0.05$).

Conclusion: We found a correlation between the functional ambulation and the degree of independence. This study showed that the better the balance, the greater the gait speed, and the lower the difference on lower limbs weight distribution, the better the balance in post-stroke patients.

Keywords: *Gait speed; baropodometry; stroke; Functional Ambulation Classification*

INTRODUCTION

Gait performance and balance are often compromised after brain lesions¹. Gait disorders are a clinical problem for stroke survivors². In stroke-related impairments, hemiparesis, variations in sensorimotor function, standing, and weight distribution are largely associated with altered balance^{3,4}. Thus, loss of balance is an important factor in predicting the success of activities of daily living (ADLs) performed independently by patients⁵.

Walking speed is strongly influenced by the severity of motor paralysis in post-stroke patients⁶. The degree of locomotor disability after a stroke varies, but most patients present reduced gait speed, due to balance deficit, and abnormal kinematics^{7,8}. The swing phase of the uninjured leg is not properly performed; it is anticipated as a result of the affected leg lacking good balance and being forced to transfer and support the weight on the injured limb⁹.

Safe and effective mobility is usually the goal for individuals living with the sequelae of stroke. Thus, balance is usually the focus in rehabilitation⁴. Researchers also believe that the best way to reduce these patients' functional dependence is to improve their walking ability¹⁰, one of the most common goals mentioned by them¹¹.

In the literature regarding patients with stroke sequelae, only a few studies have assessed the correlation between balance and hemiparetic gait; therefore, very little is known about the possible correlations between these variables^{12,13}. Thus, this study searched for subsidies to confirm the hypothesis that balance and gait speed, and balance and weight distribution, have positive correlations.

METHODS

This is a study with an *ex post facto* correlational design. It was approved by the Research Ethics Committee of the Hospital de Clínicas of Porto Alegre (HCPA) under No. CAAE 54527116.5.2001.5327.

The sample was selected by convenience, consecutively during the study period, in which individuals who waited for a previously scheduled medical appointment in the waiting room of the Neurovascular Clinic at HCPA were selected. The patients were invited to participate in the research as volunteers and, when they accepted, they were taken to a room to data collect.

The following inclusion criteria were used: patients who had only suffered one stroke; patients who were able to stand without help, with or without supervision; patients who were able to walk with or without walking aids; and patients without cognitive impairment. The study excluded those who had other associated neurological pathologies; traumatic orthopedic injuries in the lower limbs in the last year, or who had suffered a transient ischemic attack. Two physical therapy students participating in the research and previously trained were responsible for evaluating all patients in the study.

The neurological impairment post-stroke was evaluated with the modified Rankin Scale (mRS)¹⁴. The Barthel Index (BI) was used to quantify the functional independence of the sample. A score equal to or greater than 60 points corresponded to functional independence, and below that value, dependence to perform their usual activities and previous tasks¹⁵.

Balance was assessed using the Berg Balance Scale (BBS)¹⁶. In this scale, the value of each item ranges from 0 (unable to perform the task) to 4 (normally performs the task), totaling a maximum of 56 points.

Gait ability was assessed by the Functional Ambulation Classification (FAC), a scale that characterizes the individual's need for assistance from one or more individuals during gait. Scores range from 0 (non-functional walking) to 5 points (walking independence)¹⁷.

Gait speed quantification was carried out using the 10 Meter Walk Test (10mWT)⁷. Prior to the start of the walk, a Velcro strap was placed on the participant with an accelerometer (Acelerômetro® Loran Engineering) at the lumbar spine level (L5 vertebra), according to the manufacturer's specifications for gait parameters, which included stepping cadence, stride duration, time leaning on the compromised hemibody, and stepping length.

Weight distribution and location of the center of pressure (COP) were measured using a baropodometric plate (Baropodometria® Loran Engineering)⁹. The subject remained standing for approximately 30 seconds to acquire the variables using the Biomech Studio software version 1.6.

All subjects, able and agreeing to participate in the study, signed an informed consent form.

After signing the consent form, the researchers collected descriptive data from the selected participants. The assessment while standing on the baropodometric plate was performed later, keeping the individual stable for approximately 15 seconds to collect the values of COP and the lower limbs weight distribution.

After ending the assessment with the baropodometric plate, balance was assessed using the BBS. Before the 10mWT, the participants could rest for some time, so that the previous efforts did not influence the 10mWT result.

Sample calculation was performed using the G Power 3.1.7 software with the Z test family (Pearson's Correlation test – dependent). Also, the following values were assumed: a 0.53 correlation, a 0.05 alpha, a 0.70 effect size, and an 80% power. The minimum sample estimated for this study was 32 individuals.

Data analysis was performed using the Statistical Package for Social Science software version 22.0 (SPSS, IBM®, USA) and considering a 0.05 significance level for all analyses. Continuous variables were described by mean and standard deviation. The Spearman's Correlation Coefficient was used to measure the correlation of the variables.

RESULTS

In total, 36 patients with mean age of 59.9 years old (± 13.6) were assessed. Of these, 66.88% were women and 94.5% had suffered ischemic strokes, of which only 27.7% were subjected to thrombolysis. Table 1 shows other clinical characteristics of the patients.

Table 1 – Characteristics of the sample. Values are presented as mean and standard deviation (SD).

	Mean (SD)
Sex (Male/Female)	13 (33.12%)/23 (66.88%)
Age (years old)	59.9 (± 13.6)
Stroke (Ischemic/Hemorrhagic)	34 (94.5%)/2 (5.5%)
Stroke time (days)	267.8 (± 379)
Length of hospital stay (days)	12.8 (± 8.8)
Thrombolysis (yes)	10 (27.7%)
Affected side (Right/Left)	21 (58.3%)/15 (41.7%)
Functional Ambulation Classification (FAC)	4.3 (± 0.9)
Barthel Index (BI)	93.4 (± 9.3)
Modified Rankin Scale (mRS)	1.5 (± 0.9)

Most patients in the study were considered independent according to the BI and with the ability to perform their usual activities and previous tasks as verified by mRS (mode = 1). By the Functional Ambulation Classification, most patients obtained a classification that categorized them as able to ambulate on unlevel and level terrain (mode = 5).

There was a negative correlation between FAC and mRS ($r = -0.708$; $p < 0.05$) and between BI and mRS. The higher the value in the modified Rankin Scale (the worst degree of functional capacity) the lower the value in FAC and BI (the lower the capacity for functional ambulation and the degree of functional independence, respectively). The correlation between BI and FAC was positive ($r = 0.591$; $p < 0.05$), i.e., the better the ability to walk, the greater the degree of independence in stroke patients.

Regarding balance, the participants presented a mean of $49.5 (\pm 9.22)$ points in the BBS, characterizing them as presenting balance alteration, but without risk of falling. Regarding weight distribution, 51.9% (± 6.91) of the participants distributed the weight to the non-affected side. 22 participants (61.1%) used the non-affected side as the COP. Of these, 21 (58.3%) also presented posterior COP.

The average value of the gait speed presented by the patients was $0.95 \text{ m/s} (\pm 0.34)$, demonstrating a decrease in comfortable gait speed. Table 2 shows the other parameters for gait and baropodometric.

Table 2 – Values obtained with the 10mWT with accelerometer and static baropodometric. The table separately shows the values of the accelerometer (top) and baropodometric (bottom). Values are presented as mean and standard deviation.

	Mean (SD)
Speed (meters/seconds)	0.95 (± 0.34)
Cadence (steps/minutes)	50.33 (± 9.03)
Stride time (seconds)	2.53 (± 0.98)
Leaning time (%)	62.60 (± 3.45)
Step length of the affected LL (%)	50.07 (± 6.4)
Step length of the non-affected LL (%)	49.93 (± 6.4)
Δ of the step length between lower limbs (%)	9.26 (± 8.69)
Weight distribution affected/non-affected side (%)	48.08/51.91
COP anterior to the non-affected side	01/36
COP anterior to the affected side	03/36
COP posterior to the non-affected side	21/36
COP posterior to the affected side	11/36

10mWT: 10 Meter Walk Test; LL: Lower limbs; Δ : Variation; COP: Center of pressure.

A strong correlation ($r = 0.708$; $p < 0.05$) was observed in the analysis of the influence of BBS scores on the 10mWT, showing that the higher the BBS scores, the

higher the values in the 10mWT, that is, the better the balance, the higher the gait speed in these patients. Figure 1 shows the scatter plot analyzed.

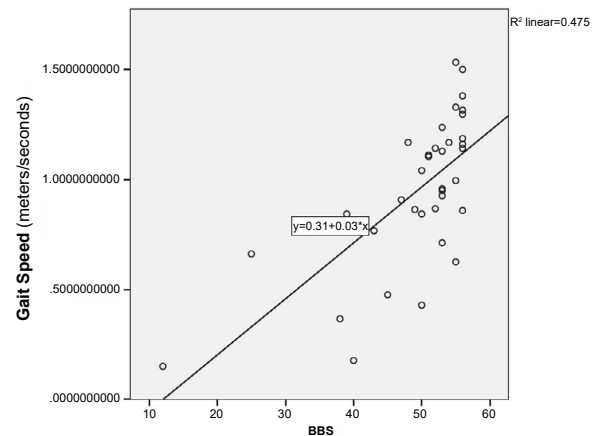


Figure 1 – Scatter plot showing the significant result ($p < 0.001$) between gait speed and BBS score. The regression equation and the R^2 value are shown in the plot. r value = 0.708 (Spearman's Correlation Coefficient).

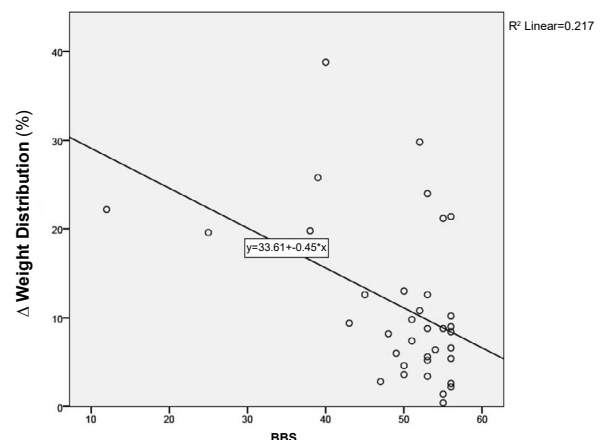


Figure 2 – Scatter plot showing the significant result ($p = 0.023$) between BBS score and difference in weight distribution in lower limbs. The regression equation and the R^2 value are shown in the plot. r value: $r = -0.378$ (Spearman's Correlation Coefficient).

We found strong negative correlations between the 10mWT times and the stride duration analyzed by the accelerometer ($r = 0.786$; $p < 0.05$), demonstrating that the higher the gait speed, the shorter the duration time to complete the stride cycle. Stride duration has a strong negative correlation with stepping cadence ($r = 0.978$, $p < 0.05$), that is, the shorter the time to complete the stride cycle, the higher the stepping cadence. Finally, a strong positive correlation was observed between gait speed and stepping cadence ($r = 0.780$; $p < 0.05$), demonstrating that the higher the stepping cadence the greater the gait speed presented by hemiparetic patients due to stroke.

When correlating the BBS scores with the percentages of lower limbs weight distribution, a negative correlation was observed ($r = -0.378$; $p < 0.05$) (Figure 2). This shows that the higher the BBS score, the smaller the difference in the lower limbs weight distribution on the baropodometric plate. Thus, the better the balance, the greater the equity in weight distribution between the lower limbs in post-stroke patients.

A positive correlation was observed between the values of BBS and FAC ($r = 0.702$; $p < 0.05$) and a negative correlation between the values of 10mWT and FAC ($r = -0.374$; $p < 0.05$), demonstrating that the better the balance and the gait speed the better the patients' functional walking ability. Negative correlation was observed between BBS and mRS values ($r = -0.750$; $p < 0.05$) and positive correlation between 10mWT and mRS values ($r = 0.396$; $p < 0.05$), suggesting that gait speed is related to the patients' ability to perform their usual activities and tasks prior to stroke.

Negative correlation between 10mWT and BI ($r = -0.134$; $p < 0.05$) and positive correlation between BBS and BI ($r = 0.587$; $p < 0.05$) were observed, that is, the better the balance and the walking speed, the greater the degree of functional independence in the patient post stroke.

DISCUSSION

The results suggest that balance and gait speed are closely correlated, corroborating previous studies^{18,19}.

Middleton et al.¹⁸ assessed aspects such as gait speed and balance with stroke patients. They analyzed 124 patients and found a positive correlation coefficient between the variables. Madhavan and Bishnoi¹⁹ carried out a study comparing the specificity and the sensitivity of balance scales (BBS and Mini-BESTest) and assessed gait speed in stroke patients. Among the results, there was a positive correlation between gait speed and balance, measured by the BBS. These studies had subjects with similar average age, but our study had a higher number of women and shorter time between the stroke and the assessments.

Healthy people have a symmetrical and rhythmic gait with an average speed of 1.3 m/s. Most adults have a stepping cadence of 90 to 120 steps per minute²⁰. The gait in stroke patients is characterized by lower speeds and asymmetries, such as longer leaning time, shorter swing time, and shorter step length²¹. The swing phase of the uninjured leg is not properly performed; it is anticipated as a result of the affected leg, which is unable to transfer and support the weight. This is related to deficits in static and dynamic balance, especially during the comfortable gait speed^{22,23}.

Among the results obtained in this study, we found that the average speed of the participants was below the

reference values for healthy individuals. The negative correlation between gait speed and stride time is our hypothesis for the decrease in average speed in stroke patients. Our results demonstrate an increase in stride time, which decreases stepping cadence. Considering that the step length in stroke patients is lower than that of healthy individuals²⁰, the covered distance will be shorter, which, together with a lower stepping cadence, will lead to a decreased gait speed.

We found a negative correlation between balance and weight distribution, that is, the lower the difference in weight distribution in the lower limbs, the better the score achieved in the BBS. To have good balance, individuals maintain their body mass center within their stability limits²⁴. However, stroke patients are more likely to support 57 to 75% of their body weight on the non-affected side than on the affected side while standing²⁵. This asymmetry in weight distribution between the lower limbs may decrease balance²⁶ and change the main position of the COP, due to the direct relationship between the variables²⁷, which we observed in this study.

Regarding the devices used, we can assume that baropodometry is a technology that can analyze the weight distribution and different types of postural behaviors, becoming an interesting evaluation tool to be used in clinics²⁸; however, there are few studies using baropodometry, which means that there is still a lack of standardization regarding the type of equipment or calibration used for data collection⁹. Similarly, the accelerometer is also a viable device for clinical practice, but there is still a great diversity of protocols and models that can be used in research. Thus, more studies using the accelerometer in clinical environments are needed.

The correlations evidenced in this study suggest that the hemiparetic gait can be treated in the clinical environment, aiming to increase comfortable gait speed by improving the unipodal support in the affected side and, consequently, increasing the step length, resulting in greater stability for the swing phase on the non-affected side.

Also, the balance can initially be improved by strengthening the affected lower limb, for better weight distribution. Techniques for postural improvement may be beneficial for balance in stroke patients, as their alignment, body symmetry and COP projection shift to a more central region of the body, providing greater stability.

As a positive point, we can mention that the findings expand the knowledge about gait in the stroke, contributing to the establishment of a specific exercise program by the physical therapist.

The better the weight distribution in the lower limbs of stroke patients, the better their balance and the greater the gait speed. Gait speed and balance interfere with the functional deambulation, the degree of functional independence, and with the patient's ability to carry out his usual activities and tasks prior to the stroke.

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