RESUMO | INTRODUÇÃO: O acidente vascular cerebral é uma das principais causas de deficiências neurológicas no mundo, podendo levar a um amplo espectro de deficiências físicas, inclusivo no desempenho da marcha. Essas anormalidades de marcha têm um impacto substancial nas atividades funcionais, no estilo de vida, bem como nas percepções do indivíduo sobre a functionalidade da vida diária e bem-estar após o acidente vascular cerebral. OBJETIVO: Avaliar o desempenho da marcha, identificando quais os componentes da marcha associados à deterioração da qualidade de vida em sobreviventes de AVC. MÉTODOS: Indivíduos com marcha independente após um acidente vascular cerebral, com ou sem o uso de ajudas para caminhar, como muletas ou bastões, foram incluídos no estudo. Os dados sócio-demográficos e clínicos foram gravados, em seguida, foram avaliados alguns testes, com o teste de caminhada de 6 minutos (TC6M), teste de caminhada de 10 metros (TC10M), Timed Up & Go (TUG), Índice de Barthel modificado (IBM), National Institutes of Health Stroke Scale (NIHSS) e European Quality of Life - 5 dimensões (EQ-5D). Um modelo de regressão logística multivariada Stepwise avaliou preditores de qualidade de vida comprometida. RESULTADOS: Foram incluídos 124 indivíduos com idade média de 66 anos e mediana de NIHSS de 3 pontos. A média de EQ-5D foi de 0,44 (DP 0,38) e 91 indivíduos (73%) tiveram qualidade de vida comprometida. Houve uma correlação positiva entre o TC6 e o EQ-5D ($r = 0,48$, $p <0,001$). O aumento da idade, capacidade funcional, TC6, TC 10MW, gravidade do AVC e sexo feminino foram associados com comprometimento da QV ($p <0,05$). Na análise multivariada, TC6M (Aumento de OR 0,94 por 10m, $p = 0,046$), capacidade funcional (OR 0,66, $p = 0,022$) e idade (OR 0,54 por aumento de 10 anos, $p = 0,002$) estiveram associados com qualidade de vida comprometida. CONCLUSÃO: A distância percorrida no TC6M foi o aspecto de marcha mais forte associado independentemente com a qualidade de vida em indivíduos com moradia comunitária com marcha independente após um acidente vascular cerebral.

PALAVRAS-CHAVE: Qualidade de vida. Marcha. AVC. capacidade funcional.

RESUMO | INTRODUÇÃO: Stroke is one of the major causes of neurological deficiencies in the world, and can lead to a wide spectrum of physical deficiencies, including gait performance. These gait abnormalities have a substantial impact on functional activities, lifestyle, and the individual’s perceptions about the functionality of daily life and well-being after stroke. OBJECTIVE: To evaluate gait performance, identifying determining which gait components were associated with impaired quality of life in stroke survivors. METHODS: Individuals with independent gait after a stroke, with or without the use of walking aids such as crutches or canes were included in the study. The socio-demographic and clinical data were recorded, then some tests were evaluated, with a 6-minute walk test (6MWT), 10-meters walk test (10MWT), Timed Up & Go (TUG), modified Barthel Index [mBI], National Institutes of Health Stroke Scale (NIHSS) and European Quality of Life – 5 dimensions (EQ-5D). A stepwise multivariable logistic regression model assessed predictors of impaired QoL. RESULTS: A total of 124 individuals with a mean age of 66 years and median NIHSS of 3 points were included. The mean EQ-5D was 0.44 (SD 0.38) and 91 individuals (73%) had impaired QoL. There was a positive correlation between 6MWT and EQ-5D ($r = 0.48$, $p <0.001$). Increasing age, functional capacity, 6MWT, 10MWT, stroke severity and female sex were associated with impaired QoL ($p<0.05$). In the multivariable analysis, 6MWT (OR 0.94 per 10m increase, $p=0.046$), functional capacity ($OR 0.66, p=0.06$, $p=0.022$) and age ($OR 0.54 per 10 year increase, p=0.002$) were associated with impaired QoL. CONCLUSION: Distance walked in 6MWT was the strongest gait aspect independently associated with quality of life in community-dwelling individuals with independent gait after a stroke.

**Introduction**

Stroke is one of the major causes of adult neurological impairments in the world\(^1\), with persistent physical disability in 50 to 65% of stroke survivors\(^2\), thus having a significant impact on patients’ emotional and socio-economical life, their families, and health care services\(^1\). Disabilities are the reflection of restrictions or lack of ability to perform one activity in a way or in a normal range of motion.

Clinical manifestations of stroke are diverse and depend on type of stroke, lesion site and extent of brain injury, resulting in heterogeneous impairment levels and rehabilitation outcomes\(^1\). Damage to motor pathways of the central nervous system can lead to a broad spectrum of physical impairments including in gait performance. For these patients, gait recovery is a major priority\(^3,4\). Post stroke patients usually exhibit functional ambulation marked by changes in gait pattern such as decrease gait speed and total running distance, with increasing energy expenditure. These gait abnormalities have a substantial impact on functional activities, life style, as well as on the individual’s perceptions of daily life functionality and well being after the stroke\(^3\).

A variety of instruments have been used to assess the likelihood of a patient with stroke being able to ambulate. These tools encompass several aspects of gait performance such as speed, endurance and balance\(^5,6\). The six-minute walk test (6MWT) is a submaximal tool used to measure functional walking capacity and endurance in daily activities\(^3,6,7\). Walking speed can be evaluated by the 10MWT as the patient self-select gait speed to cover a 10-meter distance. The 10MWT is considered a functional capacity measure of the individual in the community\(^7\). The Timed Up & Go test (TUG) is an easy to administer tool largely used to assess mobility and fall risk in a wide range of population\(^8\).

Health-related quality of life (HRQoL) reflects patient’s perception of the illness impact on their social and emotional life and well-being\(^1,9\). Restoration of walking, often reported as the major goal in the rehabilitation program, plays an important role on a patient’s quality of life. Thus, the purpose of this study was to assess the association of functional capacity and gait performance with quality of life on stroke survivors.

**Methods**

**Participants**

We conducted a cross-sectional study of a consecutive patients with stroke recruited from two outpatients stroke clinics in Salvador, BA, Brazil from March 2010 to September 2011. All patients received a clinical-radiological diagnosis of ischemic or hemorrhagic stroke, regardless of the number of events. The inclusion criterion was independent gait with or without the use of walking aids such as crutches or canes. Patients with impaired comprehension to tests instructions, blood pressure higher than 170x110mmHg on study admission and comorbidities affecting gait performance such as orthopedic diseases were excluded. Data collection was performed on recruitment day by a single investigator and informed consent was obtained from all participants. The study was approved by the SESAB Human Research Ethics Committee (Department of Health of the State of Bahia - protocol number 030/2010).

**Sociodemographics and clinical data**

For all patients, we collected demographic and clinical data such as age, sex, side of injury, time since stroke onset, number of strokes and diagnostic of depression. Medical records were verified for additional clinical information.

**Stroke severity and Functional capacity**

We used the National Institutes of Health Stroke Scale (NIHSS) to quantify stroke severity with higher values related to more severe deficits. Functional capacity was evaluated with the modified Barthel Index (mBI). To avoid collinearity of scale items evaluating gait, mBI was segmented in two parts: mBI-W and mBI-NW. The mBI-W comprehended the ambulation assessment where the patient was asked to walk up and down stairs and to walk on a regular floor and the mBI-NW evaluated activities of daily living (feeding, bathing, grooming, dressing, bowels, bladder, toilet use and transfers)\(^10\).
Gait performance assessment

Three tests were used to assess gait performance, TUG, 10MWT and 6MWT and there were at least five minutes rest between them. Subjects were individually instructed and all participants used a walking aid when needed.

TUG

Each patient was asked to lift from a standardized chair, walk 3 meters, turn around, walk back to the original chair and sit down with total time measured in seconds using a digital chronometer.

10MWT

Gait speed was assessed via 10-meter walking test (10MWT) in a 14-meter-wide corridor, with a dynamic start to allow 2-m acceleration, a timed 10-m distance and 2-m deceleration, where subjects were asked to walk at their normal comfortable pace.

6MWT

Subjects were instructed to walk as far as possible during 6 minutes in a 14-meter-wide corridor with distance marks on the floor - they were allowed to rest and then continue walking and no verbal encouragement was given during the test.

Quality of Life

The Euro-QoL – 5 dimensions (EQ-5D) scale was used for QoL assessment, measures 5 domains (mobility, pain/discomfort, self-care, anxiety/depression and usual activities) and patients indicate one of three levels of impairment for each domain (no, some/moderate and extreme). A composite QoL score was calculated based on previously published criteria, where scores varied between 0 to 1, with death receiving 0 and 1 being the best state of health. As a reference mark, patients with a score below 0.78 were considered to have impaired QoL.

Data analysis

For statistical analyses, we used the Statistical Package for the Social Sciences (SPSS) version 16.0. For continuous variables, we performed normality diagnostics based on histogram visual inspection, skewness, kurtosis, normal probability plots and Kolmogorov Smirnov tests. Comparisons between non-impaired and impaired QoL groups were performed using t test or Mann Whitney test for continuous variables and Fisher’s exact test for categorical variables. Correlations between continuous scale measurements were analyzed using Spearman test. Model building for factors associated with impaired QoL started with the most significant variable on unvariable analyses, adding each successive variable with the smallest marginal p-value. In order to avoid collinear variables but still account for confounding, variables were kept in the model either if its marginal p-value was less than 0.05 or if they changed the beta-coefficient of the existing variables in the model by more than 20%. For gait tests as factors associated with impaired QoL, ROC curves were constructed based on the trapezoidal rule, using Youden’s index to identify the ideal cut-off value with optimal sensitivity and specificity.

Results

We evaluated 124 patients with a mean age of 66 years (SD 14), ranging from 24 to 94 years, 71 (56%) female. The majority of subjects (77%) had a clinical history of only one episode of stroke. (Table 1) Functionally, individuals ranged from moderate dependence to complete independence, with median mBI of 48 (range 30 to 50).
Ninety-one subjects (73%) had EQ-5D < 0.78, with EQ-5D mean score of 0.44 (SD 0.38). The most frequently involved domains were usual activities (33% and 34% of patients reporting moderate or extreme changes, respectively), followed by mobility (61% and 2%), anxiety/depression (36% and 24%), pain (40% and 16%) and self-care (37% and 6%). Stroke severity and functional performance according to QoL categories is shown in Table 2. Patients with impaired QoL were younger, more commonly female, used walking aids, with more severe stroke (NIHSS), presented a worse functional capacity (mBI) and poorer performance in gait tests (TUG, 10MWT, 6MWT).

Table 1. Sociodemographic and clinical characteristics of the individuals with stroke.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Impaired QoL (EQ-5D &lt; 0.78), (n=91)</th>
<th>Non-impaired QoL (EQ-5D ≥ 0.78), (n=33)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years), mean (SD)</td>
<td>65 (15)</td>
<td>70 (10)</td>
<td>.084</td>
</tr>
<tr>
<td>Female sex, n (%)</td>
<td>57 (63)</td>
<td>14 (42)</td>
<td>.064</td>
</tr>
<tr>
<td>Days since stroke onset, median (IQR)</td>
<td>21 (24)</td>
<td>24 (30)</td>
<td>.314</td>
</tr>
<tr>
<td>Right-hemisphere lesion, n (%)</td>
<td>48 (53)</td>
<td>22 (67)</td>
<td>.247</td>
</tr>
<tr>
<td>Walking aid, n (%)</td>
<td>23 (25)</td>
<td>2 (6)</td>
<td>.021</td>
</tr>
<tr>
<td>Depression, n (%)</td>
<td>17 (19)</td>
<td>4 (12)</td>
<td>.389</td>
</tr>
</tbody>
</table>

SD: standard deviation; IQR: interquartile range; EQ-5D: European Quality of Life-5 Dimensions; QoL: quality of life

Table 2. Stroke severity and functional performance of the individuals with stroke.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Impaired QoL (EQ5D &lt; 0.78), (n=91)</th>
<th>Non-impaired QoL (EQ5D ≥ 0.78), (n=33)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIHSS, median (IQR)</td>
<td>3 (3)</td>
<td>2 (3)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>mBI, median (IQR)</td>
<td>47 (8)</td>
<td>50 (2)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>mBI NW, median (IQR)</td>
<td>38 (7)</td>
<td>40 (1)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>TUG(s), median (IQR)</td>
<td>18.2 (18.5)</td>
<td>13.3 (8.3)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>10MWT(s) median (IQR)</td>
<td>12 (12)</td>
<td>8 (4)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>6MWT(m), median (IQR)</td>
<td>228 (184)</td>
<td>322 (125)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

NIHSS: National Institutes of Health Stroke Scale; mBI: Modified Barthel Index; mBI-NW: Modified Barthel Index without walking and stairs items; TUG: Timed Up& Go; 6MWT: six minute walking test; 10MWT: ten meter walking test; SD: standard deviation; IQR: interquartile range.
To correct for potential confounders after univariate analysis, variables with possible association (P < .1) were included in a multivariable logistic regression model (Table 3). The following variables remained independent factors associated with impaired QoL: mBI without walking and stair items (mBI-NW) (OR 0.66 for every increase in 1 point, p = 0.022), age (0.54 for every increase in 10 years, p = 0.002) and 6MWT (0.94 for every increase in 10 meters, p = 0.046), after additional adjustment for stroke severity (NIHSS).

We also tested for a possible interaction between age and 6MWT; and between NIHSS and 6MWT; both were non-significant (p > 0.1). Table 4 describes the correlation between the QoL domains and each independent factors associated with impaired QoL. Both 6MWT and mBI were correlated with worse QoL scores in domains of usual activities, mobility and self care; and age had a slightly protective effect on QoL, but we could not identify which domain was responsible for the effect.

Table 3. Multivariate analysis for independent factors associated with impaired quality of life (EQ-5D < 0.78). Model c-statistic = 79.7%.

<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio</th>
<th>CI (95%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6MWT</td>
<td>0.94 for every increase of 10 meters</td>
<td>0.88 to 0.99</td>
<td>.046</td>
</tr>
<tr>
<td>Age</td>
<td>0.54 for each increase of 10 years</td>
<td>0.36 to 0.80</td>
<td>.002</td>
</tr>
<tr>
<td>mBI-NW</td>
<td>0.66 for each increase of 1 point</td>
<td>0.46 to 0.94</td>
<td>.022</td>
</tr>
</tbody>
</table>

Note: adjusted by age, 6MWT and mBI. 6MWT: six minute walking test; mBI-NW: Modified Barthel Index without walking and stair items.

Table 4. Correlation between independent factors associated with impaired QoL and each EQ-5D domain.

<table>
<thead>
<tr>
<th>EQ-5D domains</th>
<th>6MWT</th>
<th>Age</th>
<th>mBI-NW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility</td>
<td>-0.45**</td>
<td>-0.04</td>
<td>-0.42**</td>
</tr>
<tr>
<td>Self-care</td>
<td>-0.39**</td>
<td>0.02</td>
<td>-0.71**</td>
</tr>
<tr>
<td>Usual activities</td>
<td>-0.54**</td>
<td>0.16</td>
<td>-0.70**</td>
</tr>
<tr>
<td>Pain</td>
<td>-0.14</td>
<td>-0.17</td>
<td>-0.12</td>
</tr>
<tr>
<td>Anxiety/depression</td>
<td>0.15</td>
<td>-0.16</td>
<td>-0.17</td>
</tr>
</tbody>
</table>

6MWT: six minute walking test; mBI-NW: Modified Barthel Index without walking and stairs items. *p < 0.05; **p < 0.01
Discussion

The present study demonstrated that gait impairment, reduced functional capacity and younger age have a deleterious impact on community-dwelling individuals' quality of life after a stroke.

Gait performance as evaluated by 6MWT was the factor most strongly associated with quality of life in patients after stroke. 6MWT allows to evaluate the individual's ability in maintaining a moderate level of physical activity during a fixed time period, which indirectly reflects the potential to perform activities of daily living (ADL). We found a significant correlation among the 6MWT and the five QoL domains. Muren et al. described similar findings using the Stroke Impact Scale where strongly correlated with QOL.

The 6MWT was originally developed for patients with decreased cardiorespiratory reserve. Only modest association has been seen between 6MWT distance and aerobic capacity in these patients, thus providing evidence that distance in this test does not properly reflect cardiorespiratory aptitude in this population. Cardiovascular performance may be limited in stroke survivors and this might be due stroke-specific impairments such as muscular weakness, balance deficit and spasticity, which can limit walking ability and performance in a submaximal test.

The ROC curve for 6MWT as independent factors associated with impaired QoL is shown in the Figure. As a single factors, 6MWT showed good discrimination, with area under the curve of 0.72 (95% CI 0.63 to 0.82). Optimal cut-off as evaluated by the Youden index was greater than or equal to 241 meters, which provided a sensitivity of 82% and specificity of 59%.

Figure 1: ROC curve for the 6-minute walking test as a independent factors associated with impaired quality of life. Area under the curve was 0.72 (95% CI 0.63 to 0.82), with optimal cut-off (Youden index) of 241 meters (sensitivity 82%, sensitivity 59%).
Other tests used in this study were the 10MWT and the TUG that measure resistance and functional mobility, respectively. Both of them did not correlate with QoL. Several studies have reported high correlations between 10MWT and 6MWT⁴, although Lord and Rochester¹⁵ stated that an increase in walking speed does not translate into a significant functional performance. However, Schmid et al.¹⁶ demonstrated that when the 10MWT outcome is stratify in groups, moving to a larger group of ambulation is associated with functional capacity and the QoL is considerably better.

When assessed in a clinical setting, the 6MWT has been demonstrated to be a significant predictor of walking in a natural environment, being superior to 10MWT, supporting the importance of submaximal endurance captured along six minutes¹². Our findings are in accordance with previous studies where the inability to maintain speed may interfere with walking performance in the community⁷,¹⁷. Furthermore, our results propose the 6MWT as factors associated with the quality of life on stroke survivors with good discrimination at a cut-off score of 241 meters. Moreover, gait impairment has an impact on the individual's perception of his/her daily life functionality and well-being after a stroke, as well as on his/her social participation³,⁴.

Functional capacity evaluated by the mBI-NW was associated with impaired quality of life. Individuals who suffered a stroke may have an impaired quality of life, even without significant limitations in functional capacity¹⁸. In accordance with these outcomes, we showed that individuals mildly dependent on mBI also exhibited important impairments on quality of life. As demonstrated on post stroke individuals with mild or moderate functional capacity, the mBI ceiling effect could have influenced this result. Furthermore, the mBI only evaluates functional capacity regarding ADL, not capturing important decreases in physical or psychological functions in post stroke individuals, which emphasizes the importance of QoL evaluation as an outcome in stroke studies¹⁹.

Stroke severity is expected to be associated with gait performance in walking tests. Stroke severity seems to modulate the magnitude of the relation between stroke-specific impairments, which are crucial factors for gait and distance in 6MWT³. Our results do not support these findings, as there was no association between stroke severity and 6MWT and QoL. This lack of effect of stroke severity might be due to a limitation of our study sample to patients who suffered relatively mild strokes (median NIHSS of 3).

The protective effect of age on QoL after stroke was unexpected in our study. While some studies suggest that QoL decreases with age due to reduced endurance or co-morbidities²,²⁰,²¹, others have found no significant relationship between aging and QoL in stroke survivors²². In our study, the majority of the population was composed of elderly (75%), with average age of 66 years and this might had a protective factor in our sample since based on theories supporting that elderly people have greater competence for emotional regulation, thus facing negative situations with greater well-being²³.

While some studies have described female gender as a determinant for poorer QoL²⁴,²⁵, our results do not point to an association between QoL and gender or depression. Other studies support our findings and show no differences in magnitude by gender in stroke²⁰,²². The retrospective collection approach to depression variable, may have underestimated its prevalence and consequently its association with quality of life.

**Conclusion**

In community-dwelling stroke survivors with independent gait, the 6MWT was the factor most strongly associated with impaired QoL, independently of stroke severity. The mechanism though which the gait performance is impaired after a stroke is heterogeneous, prospective studies should focus in the gait-specific impairments and in the functional performance outcomes in this population.
Author contributions

Camila Marinho participated in the study design, literature review, data collection, results interpretation and paper writing. Maliana Monteiro participated in the results interpretation and paper writing. Luciana Santos wrote the paper and translated it to English. Jamary Oliveira Filho participated in the statistical analysis, data interpretation, writing and English translation. Elen Beatriz Pinto participated in the study design, data interpretation and paper writing.

Competing interests

No financial, legal or political competing interests with third parties (government, commercial, private foundation, etc.) were disclosed for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

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