DOI: 10.1590/1809-2950/e22013423en

ORIGINAL RESEARCH

Relationship between lower limb motor impairment and biomechanical strategies used during mobility activities in post-stroke individuals

Relação entre comprometimento motor de membro inferior e estratégias biomecânicas utilizadas durante atividades de mobilidade em indivíduos pós–acidente vascular encefálico

Relación entre el deterioro motor de las extremidades inferiores y las estrategias biomecánicas utilizadas durante las actividades de movilidad en individuos pos accidente cerebrovascular

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ABSTRACT | Motor impairment and mobility limitations are frequently observed in post-stroke individuals and are associated with functional dependence and low perceived quality of life. Therefore, evaluating the association between motor impairment and the biomechanical strategies used by post-stroke individuals in performing mobility activities is necessary. This study aimed to evaluate the correlation between lower limb motor impairment assessed by the motor section of the Fugl-Meyer assessment (FMA) scale and the mobility of post-stroke individuals considering the biomechanical strategies assessed by the timed "up and go" assessment of biomechanical strategies (TUG-ABS). This exploratory cross-sectional study included 100 individuals in the chronic phase after stroke with a mean age of 55.02±12.57 years. The FMA was used to assess lower limb motor impairment and the TUG-ABS to assess mobility during the following activities performed sequentially: changing from sitting to standing position, walking, turning 180°, and changing from standing to sitting position. Spearman's correlation was used to evaluate the relationship between variables (α=5%). Lower limb motor impairment and mobility considering the biomechanical strategies adopted by post-stroke individuals in the aforementioned activities (changing from sitting to standing position, walking, turning 180°, and changing from standing to sitting position) showed a significant ($p<0.001$), positive correlation of moderate magnitude ($rs=0.60$). This indicates that motor impairment is an important outcome to be considered during the rehabilitation of post-stroke individuals with mobility limitations, as assessed by the TUG-ABS.

Keywords | Stroke; Mobility Limitation; Lower Extremity.

RESUMO | O comprometimento motor e a limitação da mobilidade são frequentemente observadas em indivíduos após o acidente vascular encefálico (AVE) e estão associadas à dependência funcional e à baixa percepção da qualidade de vida. Portanto, é preciso investigar a relação do comprometimento motor e as estratégias biomecânicas utilizadas por indivíduos pós-AVE na realização de atividades de mobilidade. O objetivo deste estudo foi avaliar a correlação entre o comprometimento motor de membro inferior, avaliado pela seção motora da escala de Fugl-Meyer (EFM), e a

Study conducted at the Departamento de Fisioterapia of the Universidade Federal de Minas Gerais (UFMG) – Belo Horizonte (MG), Brazil.
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Financing source: CAPES; FAPEMIG; CNPq; Graduate Research Program of the Universidade Federal de Minas Gerais (PRPq/UFMG) – Conflict of interests: nothing to declare – Presentation: July 3rd, 2020 – Accepted for publication: June 2nd, 2022 – Approved by the Research Ethics Committee: Protocol No. 51454115.6.0000.5149.

mobilidade de indivíduos pós-AVE considerando as estratégias biomecânicas avaliadas pelo teste *timed "up and go" assessment of biomechanical strategies* (TUG-ABS). Trata-se de um estudo transversal exploratório, no qual participaram 100 indivíduos na fase crônica pós-AVE, com média de idade de 55,02±12,57 anos. Foi utilizada a EFM para avaliação do comprometimento motor de membro inferior e o teste TUG-ABS para avaliação da mobilidade durante as atividades de sentado para de pé, marcha, giro e de pé para sentado realizadas sequencialmente. Foi realizada a correlação de Spearman para verificar a relação entre as variáveis (α=5%). O comprometimento motor de membro inferior e a mobilidade considerando as estratégias biomecânicas adotadas por indivíduos pós-AVE durante as atividades propostas apresentaram correlação significativa (p<0,001), positiva e de moderada magnitude (rs=0,60). Isso indica que o comprometimento motor é um desfecho importante para se considerar no processo de reabilitação de indivíduos pós-AVE que apresentam limitações de mobilidade como as avaliadas pelo TUG-ABS.

Descritores | Acidente Vascular Cerebral; Limitação da Mobilidade; Extremidade Inferior.

RESUMEN | El deterioro motor y la limitación de la movilidad se observan con frecuencia en individuos pos-accidente cerebrovascular (ACV) y se asocian con una dependencia funcional y baja percepción de la calidad de vida. Por ello, es importante evaluar la relación entre el deterioro motor y las estrategias biomecánicas que utilizan los individuos pos-ACV durante las actividades de movilidad. El objetivo de este estudio fue evaluar la correlación entre el deterioro motor de las extremidades inferiores, evaluado por la sección motora de la escala de Fugl-Meyer (EFM), y la movilidad de los individuos pos-ACV, teniendo en cuenta las estrategias biomecánicas evaluadas por la prueba *timed "up and go" assessment of biomechanical strategies* (TUG-ABS). Se trata de un estudio transversal, exploratorio, en el cual participaron 100 individuos en la fase crónica pos-ACV, de edad media de 55,02±12,57 años. Para evaluar el deterioro motor de las extremidades inferiores se utilizó la EFM, y se aplicó la prueba TUG-ABS para evaluar la movilidad durante las actividades de sentarse a ponerse de pie, caminar, girar y ponerse de pie a sentarse, realizadas secuencialmente. La correlación de Spearman se realizó para verificar la relación entre las variables (α=5%). El deterioro motor de las extremidades inferiores y la movilidad teniendo en cuenta las estrategias biomecánicas adoptadas por los individuos pos-ACV durante las actividades propuestas mostraron una significativa correlación (p<0,001), positiva y de magnitud moderada (rs=0,60). Esto indica que el deterioro motor es importante para tener en cuenta en el proceso de rehabilitación de individuos pos-ACV con limitaciones de movilidad como las evaluadas por el TUG-ABS.

Palabras clave | Accidente Cerebrovascular; Limitación de la Movilidad; Extremidad Inferior.

INTRODUCTION

Stroke is one of the most common and disabling diseases worldwide and is a major public health problem in the physical, psychological, and social spheres[1]. Post-stroke physical impairments are highly prevalent and have a significant functional impact[2,3]. Hemiparesis contralateral to the brain lesion is a common motor impairment in the affected population[2,3]. Moreover, post-stroke individuals often have mobility limitations[3]. These impairments and limitations can affect the individual's social participation, however, intervention strategies can improve post-stroke mobility[4].

Post-stroke individuals often have mobility limitations[5], which are associated with functional dependence[6], reduced walking speed and gait ability[7], changes in balance, falls[7], and low perceived quality of life[6]. Thus, evaluating the factors that may be associated with post-stroke mobility, such as motor impairment, is important for a better understanding of the limitations found in this outcome.

The Fugl-Meyer assessment (FMA) scale has been recommended to assess motor impairment in post-stroke individuals[8,9]. This tool has adequate reliability and is widely used in research and clinical practice[9]. However, no study has evaluated the relationship between motor impairment assessed by the FMA and the biomechanical strategies used by post-stroke individuals when performing mobility activities. This outcome can be measured by the timed "up and go" assessment of biomechanical strategies (TUG-ABS)[10,11], which assesses the biomechanical strategies adopted by post-stroke individuals during

the performance of sequential activities in the timed "up and go" (TUG) test: sit-to-stand, walking, turning 180°, and stand-to-sit[6].

Understanding the relationship between motor impairment and the biomechanical strategies used by post-stroke individuals can help professionals in the rehabilitation of these patients in choosing appropriate assessment tools and developing clinical reasoning. Therefore, considering the relevance of motor dysfunctions resulting from stroke and its possible effect on mobility, this study aimed to evaluate the correlation between motor impairment of the paretic lower limb—measured by the FMA—and the mobility of individuals in the chronic phase after stroke, considering the biomechanical strategies assessed by the TUG-ABS.

METHODOLOGY

This cross-sectional study recruited individuals living in Belo Horizonte from August 2017 to May 2018 by contacting health centers and using flyers and social media to disseminate the study. All participants were informed about the study objectives and signed an informed consent form. The following inclusion criteria were considered: stroke diagnosis ≥6 months, age ≥20 years old, and ability to perform the TUG test[6]. Individuals with cognitive impairments according to the mini mental state examination (MMSE)[12], patients unable to respond to verbal commands, and those who reported pain were excluded.

Mobility assessment

Mobility was assessed by the TUG-ABS, a measurement test developed to assess the biomechanical strategies adopted by post-stroke individuals during the TUG test[6,10,13-17]. The TUG analyzes the mobility of post-stroke individuals considering the time spent to perform a sequence of daily activities: changing from sitting to standing position, walking three meters, turning 180°, walking back, and changing from standing to sitting position[6,13-16]. Although simple, the single TUG score—the time spent performing this sequence—does not allow a qualitative assessment of the individuals' performance. Time does not allow for the identification of which characteristics might be associated with better or worse performance. Moreover, time is limited regarding observation and direct and objective articulation of the constructs related to the function[6,10,17,18]. On the other hand, the TUG-ABS includes 15 items for qualitative assessment of the biomechanical strategies used during the TUG activities. Its ordinal scale score has three response categories, ranging from 1 to 3, resulting in a total score of 45 points[6,10]. This tool has adequate content, concurrent criterion, and construct validity, as well as appropriate test-retest reliability and inter-evaluators for the assessment of post-stroke individuals[6,10].

In the change from sitting to standing position, the support of the upper limbs, the number of attempts to perform the action, and the impulse generated by the trunk and lower limbs are evaluated[6,10]. In gait, the step symmetry, the initial heel-to-toe contact, the hip extension in the support phase, the swing phase, and the progression of the lower limb are the biomechanical strategies analyzed[6,10]. In turning, the assessment items include the steps for its performance, the external and internal foot relationship, the body rotation for the change of direction, and the gait-turning-gait sequence[6,10,19]. Finally, the change from standing to sitting position is assessed considering three items: the continuity of movement when performing the action, the sequence and control of the individual when bringing the pelvis and trunk close to the chair, and the positioning of the lower limbs when sitting[6,10].

The participants performed the TUG in a space with demarcations for the test. Each individual was instructed to sit in a standardized chair with their back supported. On the command "go," participants would get up from the chair, walk three meters at a comfortable speed, turn 180°, walk back, and sit down on the chair again, following the standardized and recommended procedures[11,20,21].

A video camera was used to record the individuals' performance on the TUG (Figure 1). After familiarization with the test[10], only one sequence was recorded[10]. The camera was positioned diagonally, four meters away from the chair. The videos were analyzed by a single evaluator, who watched the tests at normal speed, from one to four times, without pausing the movements, for the application of the TUG-ABS[10,11].

Figure 1. Performance of the timed "up and go" assessment of biomechanical strategies (TUG-ABS) test

Motor impairment assessment

To assess motor impairment, the Brazilian version of the FMA was used, which has adequate validity and reliability[9]. Each item of the tool has an ordinal scale of three response categories, where "0" corresponds to "task not accomplished"; "1" to "task partially accomplished"; and "2" to "task fully accomplished"[22]. The total score for motor function is 100 points, of which 66 refer to the upper limb and 34 to the lower limb[9].

This tool was applied by a trained evaluator. Participants were positioned with head and trunk aligned, and all test items were demonstrated on the unaffected side to ensure understanding. Only the lower limb motor impairment score was used[23], as the TUG primarily assesses this body segment.

In lower limb motor function, movement with and without synergy, reflex activity, hip, knee and ankle flexor and extensor synergy, and coordination were assessed[8,9]. To characterize the sample, participants were classified into subgroups according to the level of motor impairment: mild (>29 points), moderate (23–28 points), strong (18–22 points), and severe (<17 points)[23]. For the statistical analysis, the total score was used[23].

Statistical analysis

Descriptive statistics were used for both sample characterization and the main outcome variables. Spearman's correlation coefficient was used to evaluate the relationship between lower limb motor impairment and mobility. Analysis was performed in SPSS for Windows, version 22 (α=5%).

RESULTS

This study included 100 individuals with a mean age of 55.02±12.57 years old and a mean post-stroke evolution time of 60.83±65.81 months. Table 1 presents the clinical and demographic data of the sample.

Table 1. Clinical and demographic data of the sample (N=100)

Characteristic	Results
Age (years old), mean (SD) [min-max]	55.02 (12.57) [21-82]
Time since stroke (months), mean (SD) [min-max]	60.83 (65.81) [6-300]
Men, n (%)	57 (57%)
Type of stroke, n (%)	
Ischemic	71 (71%)
Hemorrhagic	23 (23%)
Both	1 (1%)
Unknown	5 (5%)
Affected side, n (%)	
Right	53 (53%)
Use of orthosis, n (%)	
Yes	28 (28%)

SD: standard deviation; [min-max]: minimum-maximum.

According to the FMA classification of lower limb motor impairment, the subgroup with mild impairment included 60 individuals (60%), the moderate subgroup 23 (23%), the subgroup with strong impairment eight (8%), and the severe subgroup nine (9%). The median total score on the lower limb motor section of the FMA was 30±5.2 points. Regarding the biomechanical strategies adopted during the TUG (TUG-ABS score), the median was 41±7 points.

The correlation between lower limb motor impairment, assessed by the FMA, and mobility, assessed by the TUG-ABS, of post-stroke individuals was significant (p<0.001), positive, and had moderate magnitude (rs=0.60). Figure 2 shows the dispersion of data regarding the correlation between the FMA and TUG-ABS scores.

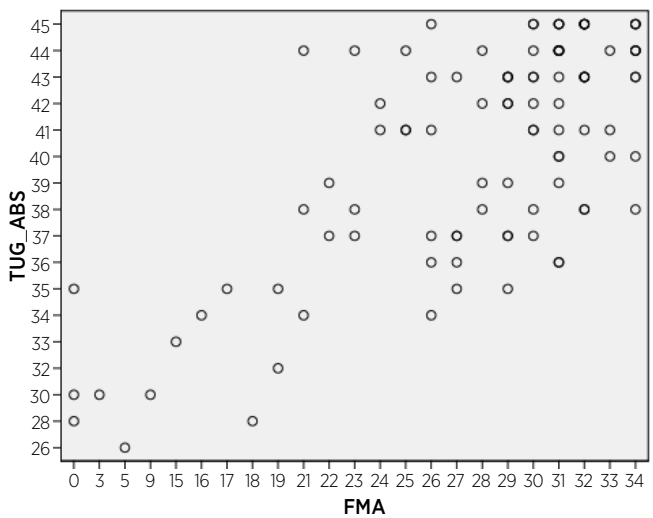

Figure 2. Relationship between scores on the Fugl-Meyer assessment (FMA) scale and the timed "up and go" assessment of biomechanical strategies (TUG-ABS) test

DISCUSSION

This study aimed to evaluate the correlation between lower limb motor impairment, assessed by the FMA, and mobility, assessed by the TUG-ABS, in post-stroke individuals. We observed a significant positive correlation of moderate magnitude between these two outcomes. Results show that individuals with mild lower limb motor impairment have better mobility, as measured from the biomechanical strategies adopted during the activities of changing from sitting to standing position, walking, turning 180°, and changing from standing to sitting position, performed sequentially.

In a recent study, Kwong and Shamay[24] found that the lower limb motor section of the FMA can predict the mobility level of individuals in the chronic phase after stroke. According to the authors, a score higher than 21 on the FMA is sensitive enough to distinguish the mobility functions of post-stroke individuals[24]. Individuals with better mobility had better balance, transfer, and locomotion[24]. These findings may explain the results of this study, since the median total score on the lower limb motor section was 30 points in the FMA and 41 in the TUG-ABS, showing that most individuals had mild lower limb motor impairment and good mobility. However, this correlation does not allow for predictions.

Chan et al.[25] observed that the TUG performance time showed a significant (p<0.001), negative correlation of moderate magnitude (r=–0.691) with the mean scores of the lower limb motor section of the FMA in post-stroke individuals. Thus, a lower FMA score, which indicates greater impairment of lower limb motor function, is associated with a longer time to complete the TUG, showing greater mobility impairment in post-stroke individuals. These findings are similar to the results of our study, which also highlight an association between lower limb motor impairment and mobility limitation. The difference lies in mobility, since the study by Chan et al.[25] assessed it only by the time spent to perform the activities (TUG), while this study considered the biomechanical strategies adopted during mobility activities (TUG-ABS).

In line with these findings, Menezes et al.[26] showed that, in a sample similar to this study (90 individuals, 53 men, mean age of 58±11 years old, and average time since stroke of 71.5 months, ranging from six to 380 months), the individuals who scored higher than 23 on the FMA for lower limb assessment had better mobility according

to the TUG and other mobility tests, such as the stair climbing test and the 10-meter walk test. This same study evaluated other outcomes related to motor impairment and found a significant relationship of lower limb strength and motor coordination with mobility assessed by walking speed, the rhythm of the steps, and the time to perform the TUG[26].

The results of Bonnyaud et al.[27] showed that the greatest predictor of performance variability in the TUG in individuals in the chronic phase after stroke, besides walking speed (r=–0.72; p=0.001) and rhythm of the steps (r=0.68; p=0.001), is the time spent on one foot on the paretic lower limb (r=–0.79; p=0.001). These results highlight the importance of evaluating the biomechanical strategies used by post-stroke individuals during mobility activities. As aforementioned, the TUG-ABS is an appropriate tool for the evaluation of these biomechanical strategies during important activities related to mobility, since it assesses not only gait, but also rotation and changes from sitting to standing position and vice versa.

The findings of this study corroborate a previous result[25] that showed a significant association between motor impairment and mobility, considering the total time to complete the mobility activity, such as the TUG. Moreover, new and relevant information point that the significant association between motor impairment and mobility is not only due to the time spent to perform mobility activity (such as the TUG), but also due to the biomechanical strategies used in mobility activities. Identifying the association between motor impairment and biomechanical strategies during sequential mobility activities (changing from sitting to standing position, walking, turning, and changing from standing to sitting position) may help the development of better strategies to evaluate and treat post-stroke individuals, besides guiding the development of further studies. Thus, considering the results of this study, professionals who work in clinical practice with the rehabilitation of post-stroke individuals should assess mobility by the TUG-ABS to better understand the biomechanical strategies and limitations of patients with lower limb motor impairment.

This was the first study to evaluate the correlation between lower limb motor impairment and mobility considering the biomechanical strategies assessed by the TUG-ABS. Although the sample size was large, we recruited a convenience sample, which was a limitation of the study. Therefore, our sample may not be representative of the population of individuals in the chronic phase after stroke, limiting the generalization of the results. Although biomechanical strategies to perform mobility activities are not different between the subacute and chronic phases[28], our results cannot be generalized to subacute individuals. Moreover, most individuals had mild lower limb motor impairment, which also limits the generalization of the results. Future studies should include more individuals with severe motor impairment.

CONCLUSION

This study found a significant, positive correlation of moderate magnitude between lower limb motor impairment, measured by the FMA, and the biomechanical strategies used during mobility activities, assessed by the TUG-ABS, in post-stroke individuals. This result points that individuals in the chronic phase after stroke with greater lower limb motor impairment possibly have greater mobility limitation. Motor impairment is an important outcome to be considered in the rehabilitation process of post-stroke individuals with mobility limitations, such as those assessed by the TUG-ABS. Therefore, assessing by the TUG-ABS the biomechanical strategies used during these activities by post-stroke individuals with lower limb motor impairment is important.

ACKNOWLEDGMENTS

We thank the Coordination for the Improvement of Higher Education Personnel (CAPES) – Finance Code 001; the Minas Gerais Research Foundation (FAPEMIG); the National Council for Scientific and Technological Development (CNPq); and the Graduate Research Program of the Universidade Federal de Minas Gerais (PRPq/UFMG) for supporting this study.

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