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ORIGINAL RESEARCH

Handgrip strength as a predictor of sensorimotor recovery evaluated by the Fugl-Meyer scale

Força de preensão manual prediz moderadamente a recuperação sensório-motora avaliada pela escala Fugl-Meyer

Fuerza de prensión manual predictiva moderada en la recuperación sensoriomotora evaluada por la escala de Fugl-Meyer

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ABSTRACT | Cerebrovascular accidents can leave neurological, motor and sensory sequelae. To assess and monitor the patient's prognosis, several functional measuring instruments are used, such as the Fugl-Meyer scale, which, although widely used to estimate the sensorimotor recovery, is a long evaluation that requires training. Therefore, the objective of this study is to analyze if the handgrip strength (HGS), the Timed up and Go test (TUG) and the Functional Independence Measure (FIM) can predict the results of the Fugl-Meyer scale, in order to optimize time during sensorimotor recovery assessment, both to monitor treatment responses and for scientific research. Thus, the HGS of 35 chronic hemiparetic patients was evaluated and then applied to Fugl-Meyer Scale, which evaluates motor recovery, the FIM, which evaluates motor activities and the TUG, which is an indicative of functional mobility. Statistical analysis was performed using multiple regression (*r2*). The HGS was predictive of motor recovery (*r2*=0.46; *p*=0.001), while mobility (*r2*=0.255; *p*=0.007) and functional independence (*r2*=0.054; *p*=0.2) were not capable of predicting the results of the Fugl-Meyer scale. After analysis, it was concluded that HGS is a moderate predictor of motor recovery after cerebrovascular accident, while mobility and functional independence are not.

Keywords | Stroke; Hemiplegia; Muscle Strength; Muscle Strength Dynamometer.

RESUMO | O acidente vascular encefálico pode deixar sequelas neurológicas, motoras e sensitivas. Para avaliar e acompanhar o prognóstico do paciente, são usados diversos instrumentos funcionais de medida, como a escala de Fugl-Meyer, que apesar de amplamente utilizada para estimar a recuperação sensório-motora, é uma avaliação longa e que exige treinamento. Diante disso, o objetivo deste estudo é analisar se a força de preensão manual, o *timed up and go* e a medida de independência funcional podem predizer os resultados da escala Fugl-Meyer, com o intuito de otimizar o tempo de avaliação da recuperação sensório-motora, tanto para o acompanhamento da resposta ao tratamento quanto para pesquisas científicas. Para tanto, avaliou-se a força de preensão manual de 35 hemiparéticos crônicos, e em seguida foram aplicadas à escala Fugl-Meyer, que avalia a recuperação motora, a medida de independência funcional nas atividades motoras e o *timed up and go*, indicativo de mobilidade funcional. Para análise estatística utilizou-se a regressão linear múltipla (*r2*). A força de preensão manual mostrou-se preditora da recuperação motora (*r2*=0,46; *p*=0,001), enquanto a mobilidade (*r2*=0,255; *p*=0,007) e a independência funcional (*r2*=0,054; *p*=0,2) não foram capazes de predizer os resultados da escala Fugl-Meyer. Após análise, pôde-se inferir que a força de preensão manual é preditora moderada da recuperação motora pós-acidente vascular encefálico, enquanto mobilidade e a independência funcional, não.

Descritores | Acidente Vascular Cerebral; Hemiplegia; Força Muscular, Dinamômetro de Força Muscular.

RESUMEN | El accidente cerebrovascular puede ocasionar secuelas neurológicas, motores y sensoriales. Para evaluar

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y monitorear el pronóstico del paciente, se utilizan diversos instrumentos funcionales, como la escala de Fugl-Meyer, que aunque es ampliamente utilizada para estimar la recuperación sensoriomotor, presenta una evaluación larga y que requiere entrenamiento. Teniendo en cuenta lo anterior, este estudio pretende analizar si la fuerza de prensión manual, el *timed up and go* y la medición de independencia funcional pueden predecir los resultados de la escala de Fugl-Meyer para que se mejore el tiempo de evaluación de la recuperación sensorial y motora, tanto para monitorear la respuesta al tratamiento como para estudios científicos. Por tanto, se evaluó la fuerza de prensión manual de 35 hemiparéticos crónicos, y luego se aplicaron a la escala de Fugl-Meyer, que evalúa la recuperación motora, las medidas de la independencia funcional en las actividades motoras y el *timed up and go*, indicativo de movilidad funcional. Para el análisis estadístico se utilizó la regresión lineal múltiple (r2). La fuerza de prensión manual ha demostrado ser predictiva de la recuperación motora ($r2$=0,46; p=0,001), mientras que la movilidad ($r2$=0,255; p=0,007) y la independencia funcional ($r2$=0,054; p=0,2) no fueron capaces de predecir los resultados de la escala de Fugl-Meyer. Del análisis se puede inferir que la fuerza de prensión manual es una predictora moderada en la recuperación motora posaccidente cerebrovascular, mientras que no lo son la movilidad y la independencia funcional.

Palabras clave | Accidente Cerebrovascular; Hemiplejía; Fuerza Muscular, Dinamómetro de Fuerza Muscular.

INTRODUCTION

Cerebrovascular accidents (CVA) have an annual mortality rate of approximately 5.5 million people worldwide . In Brazil, it is the fourth cause of death[2], being considered the third largest cause of disability in the world[3], generating a great economic and social impact.. Caused by the occlusion or rupture of a local blood vessel, the CVA refers to neurological alterations that result in brain injuries. About 90% of the affected individuals deal with sequelae[4], characterized by psychological, cognitive and sensorimotor deficits, such as hemianopsia and diplopia, aphasia, and, mainly, unilateral motor impairment, affecting functional independence and, consequently, daily activities[5].

Several functional measuring and motor recovery instruments were developed over time to assess and monitor the post-CVA prognosis. Among them, the Fugl-Meyer Scale (FMS) stands out, which predicts the sensorimotor recovery in patients affected by CVA, based on the Brunnstrom[6] stages. Although widely used in clinical researches[7,8], it is a test with a long application, which takes an average of 30 to 45 minutes to be finalized, bringing an excessive load both to the patient and evaluator, who must be well prepared[9]. Thus, it is necessary to investigate whether other clinical measures are capable of predicting the FMS results of sensorimotor recovery.

In this context, the assessment of the hand grip strength (HGS) is the most used tool to measure the degree of morbidity in upper limbs and can indicate the overall muscular strength, being a form of intervention for motor function and functional mobility[10]. The timed up and go (TUG) test and the functional independence measure (FIM) also stand out, which assess, respectively, functional mobility and balance through walking[10], and the performance of daily activities and functional independence in the post-CVA recovery. Both instruments are of great importance for their easy applicability and handling, favoring a quick assessment[10].

In this study, we sought to analyze if the HGS, the TUG and the FIM can predict FMS results, in order to optimize the sensorimotor recovery assessment, both to monitor treatment responses and to develop scientific researches.

METHODOLOGY

Participants

This is an observational, cross-sectional study, which recruited individuals with chronic hemiparesis due to CVA and treated by the service of Outpatient Physiotherapy of the Universidade Nove de Julho. Inclusion criteria were: having clinical diagnosis of primary or recurring CVA for more than six months, presenting weakness and/or spasticity in the affected side of the body, and being able to walk, even with the aid of a device, except for a walker. Individuals who had another clinical condition associated with hemiparesis due to CVA, who had motor or receptive aphasia and who had cognitive impairment tracked through a mini mental state examination, considering the cut-off points described by Bertolucci[11], were excluded of the study.

Sampling calculation

To determine the number of individuals in the sample, a calculation was performed from the correlation results between HGS and the total FMS score, obtained in the pilot-study with the first 10 evaluated individuals, considering α=0.05 and β=0.2 (power of 80%), and assuming r=0.70 resulting from the pilot study. For this calculation, the following formula was used:

$$n=4+\{(1.96+0,84)/[0.5\times nl(1+r)/(1-r)]\}^2$$

In the equation, 1.96 corresponds to Z of $\alpha/2$ (α=0.05) and 0.84 corresponds to Z of the β error (β = 0.2), nl = natural logarithm and r = correlation based on r between the pilot-study scores. Thus, the value of n=15 subjects was obtained, and, adding 30% of possible losses during the study, the final n of at least 19 individuals was obtained.

Ethical aspects

This study followed the principles of the Declaration of Helsinki and the Regulatory guidelines and norms of research involving human beings, formulated by the National Health Council, Ministry of Health, established in October 1996, in Brazil. All participants signed an informed consent form and were informed of the possibility to withdraw from the research at any stage, without penalty. This study was analyzed and approved by the Research Ethics Committee of the Universidade Nove de Julho (CoEP-UNINOVE), São Paulo, Brazil (protocol no. 362.861/10).

Evaluation tools

Fugl-Meyer scale

To measure sensorimotor recovery, the Brazilian version of the FMS[12] was used, which is based on the neurological examination and on the sensorimotor activity of the upper and lower limbs, using a cumulative numeric score system that assesses six aspects: range of motion, pain, sensitivity, motor function of the upper and lower extremities, balance and coordination, and speed, totaling 226 points. A three-point ordinal scale is applied on each item: 0 – cannot be performed; 1 – partially performed; and 2 – completely performed. This scale has a total of 100 points for normal motor function, in which the maximum score for the upper limb (UL) is 66 and, for the lower limb (LL), 34 points[6,12]. Motor assessment includes measuring motion, coordination and reflex activity of the shoulder, elbow, fist, hand, hip, knee and ankle. Fugl-Meyer et al.[6] determined a score according to the level of motor impairment, in which less than 50 points indicate a severe motor impairment; 50-84 strong; 85-95 moderate; and 96-99 mild[6.12].

Handgrip strength

The HGS was measured in both upper limbs (UULL), through a Jamar® dynamometer (Enterprises Inc., Irvington, New York, USA), with the handle of the device in the second space. To perform the test, the participant remained sitting in a chair without armrest, with the shoulder in adduction, neutral rotation, elbow flexed at 90°, forearm in neutral position and fist in slight extension (between 0 to 30°)[13]. Three measures were recorded on each side to calculate the arithmetic mean, respecting a period of 20 seconds of rest between the two measurements of the same side[13].

Functional independence measure

To analyze the functional independence, the FIM was used, which is a quantitative measurement scale of disabilities in individuals with functional restrictions. The assessment is done through a self-report in which individuals expose their degree of dependence on a third party to perform daily tasks. A set of 18 tasks are assessed regarding subscales of selfcare, sphincter control, transfer, transportation, communication and social cognition. Each activity is given a score ranging from 1 (total dependence) to 7 (complete independence); the scores varies from 18 to 126 points. In this study, the motor FIM score was used, which varies from 13 to 91 points. The higher the score, the greater the functional independence[14]. The FIM is a clinically valid instrument, with adequate psychometric properties[14].

Timed up and go test

The TUG test, used as indicative of functional mobility, shows adequate measuring properties in individuals with CVA history and covers important daily activities that have a great risk of falls. The test consists of getting up from a chair, walking 3 meters, rotating 180° and returning to the chair. To apply the TUG, the protocol proposed by Podsiadlo et al.[15] was used. The average time of three repetitions was

measured with a digital timer. TUG time of 14 seconds or more is indicative of increased risk of falls[16].

Procedures for data collection

The volunteers went through individual interview and physical evaluation in order to ensure the control of inclusion and exclusion criteria. The evaluation was performed by two examiners with a theoretical and practical approach of the instruments. During the interview, the volunteers responded to a questionnaire on sociodemographic and clinical variables to characterize the sample regarding gender, age, time after CVA, CVA type, amount of CVA episodes and affected side of the body. Later, the individuals were assessed with the tools mentioned above.

Statistical analysis

To characterize the sample, descriptive statistics were used through mean and standard deviation for the quantitative variables, and frequency for the categorical variables, characterizing the sample regarding gender and affected side of the body. Non-parametric variables were summarized in median and interquartile range.

For multiple regression processing, initially, it was verified if the variables fulfilled the necessary conditions to elaborate a valid regression model. To do so, the correlation coefficient between the variables was analyzed, and the variables with Spearman's coefficient (r) ≥ 0.2 were included in the model. HGS, mobility and functional independence were considered as independent variables, while the sensorimotor recovery (result of FMS) was considered dependent. The Bonferroni correlation for multiple comparisons was not performed because this is an exploratory analysis and to avoid a type II error[17].

RESULTS

56 individuals with chronic hemiparesis were recruit; of these, 9 were excluded for having aphasia, 8 for having a positive cut-off point for cognitive deficit tracking and 4 for having another disease associated to CVA. Thus, the final sample was composed of 35 individuals, assessed in the physiotherapy out-patient clinics of the Universidade Nove de Julho. Their clinical-demographic characteristics are shown in Table 1.

Table 1. Clinical-demographic characteristics of the study volunteers

Variable	(n=35)
Gender	
M/F	19/16
Age (years)	
20 a 39	3 (30±8.7)
40 a 59	17 (52±5.9)
≥ 60	15 (70±7.3)
Time of brain lesion (months)	
< 12 months (n=7)	8±2.5
> 12 months (n=28)	63±5.1
Hemibody affected	
Right	13 (37%)
Left	22 (63%)

M: male; F: female. Data expressed as frequency, percentage, mean and standard deviation (SD).

Table 2 shows the descriptive statistics of the main outcome variables of the study. In this table, it can be observed that there was statistical difference between HGS of the paretic and non-paretic side of the body.

Table 2. Values of central tendency and dispersion of the variables analyzed in the study

Variable	n=(35)
Sensitive-motor alteration	
Fugl-Meyer motor (total)	80 (55/94)
Fugl-Meyer MS	53 (26/64)
Fugl-Meyer MI	29 (21/33)
Handgrip strength	
Upper limb affected (Kg)	11.8±8.8*
Upper limb not affected (Kg)	30.2±10.0*
Functional Mobility	
Timed Up and Go test (s)	16.4±7.4
Functional independence	
Functional independence measure	80 (78/84)

Nonparametric data shown in median and interquartile range; parametric datum (functional mobility) shown in mean and standard deviation. * p=0.001.

In the prediction modeling, analyzed through multiple regression, it can be observed that the HGS was capable of moderately predicting the motor impairment of both affected UL and LL, represented by the FMS score. However, the FIM and TUG (functional mobility) results were not capable of predicting it (Table 3).

Table 3. Analysis of multiple regression between sensorimotor recovery (FMS) and independent variables: handgrip strength, functional independence (FIM) and mobility (TUG).

Variable independent	β coefficient standardized	Error estimate	r^2	*p* value
HGSp	0.306	0.097	0.46*	0.001*
FIM	0.691	0.607	0.054	0.2
TUG	-0.505	0.819	0.255	0.007*

HGSp: handgrip strength of the paretic upper limb; FIM: functional independence measure; TUG: timed up and go. *Expressive r^2 value ($r^2 \geq 0,4$) and statistically significant ($p \leq 0,05$)

DISCUSSION

The choice of an appropriate measurement instrument is crucial to the success of any study that seeks to assess the effectiveness of a treatment proposal and, given the high prevalence of CVA, it is fundamental that physiotherapists have an adequate knowledge of instruments of post-CVA functional assessment. In this sense, the objective of this study was to assess if the HGS, TUG and FIM can predict FMS results. After analyzing the results, it can be observed that the HGS was a moderate predictor of sensorimotor recovery, while TUG and FIM were not capable of doing so.

The clinical outcomes analyzed by the FMS are based on neurological exams and sensorimotor activity of upper and lower limbs, seeking to identify the selective activity and synergistic patterns of patients who suffered a CVA. The FMS assumes that, in a patient with hemiparesis, the reflex return precedes voluntary motion action, followed by complete dependence on synergies, and the active movement will be progressively less dependent on reflexes and primitive reactions and, finally, the complete voluntary motor functional with normal motor reflexes can be achieved[6]. Thus, the HGS and the overall muscular strength have an important influence in the sensorimotor function. In this study, the HGS was a moderate predictor of the sensorimotor recovery, assessed through total FMS score (r^2=0.46; p=0.001), which means that the HGS explains in 46% the sensorimotor recovery after CVA, showing that the greater the HGS, the greater will be the sensorimotor recovery after a CVA.

The FMS has been used both to describe the sensorimotor recovery of patients who suffered CVA[18] and to classify them regarding the severity of the sequela[19]. It is a widely used instrument used to assess the effects of different treatment modalities, however, a trained evaluator is necessary to apply it, and the assessment is long, taking from 30 to 45 minutes[20]. Therefore, to identify if the HGS, which is a measure of reliable evaluation[21] with easy clinical applicability, is capable of indicating sensorimotor recovery may assist the functional diagnosis and accelerate treatment responses, saving the professional's time.

The functional mobility, assessed through the TUG test, is used to estimate the individual's functional level and risk of falls[15]. The test involves four basic activities: to stand up, walk, rotate 180° and sit. These activities depend not only on the recovery of muscular strength, but also on other conditions, such as muscle tone, articular mobility and balance. Probably, for this reason only the TUG was not able to predict the sensorimotor recovery assessed through the FMS.

Functional independence was not predictive of sensorimotor recovery. One must take into consideration that the FIM does not analyze the qualitative aspects of the tasks, disregarding compensatory strategies normally used by individuals in the post-CVA chronic stage. From this period, individuals learn to deal with their limitations, despite not fully recovering muscle strength or sensibility, winning independence by using the non-paretic member, assistive technology or by developing tasks with compensations.

It is important to highlight the limitations of this study, which refers to the composition of the studied sample, formed by individuals with chronic hemiparesis, which may have influenced the results regarding the non-association of FIM and TUG with sensorimotor recovery. Despite such limitations, the obtained results are extremely relevant for the fields of physiotherapy and neurology, since they contribute with effective strategies to assess the sensorimotor recovery and to optimize the professional's time.

In summary, considering the main results of this study, it was observed that the HGS is a moderate predictor of the post-CVA sensorimotor recovery, while mobility and functional independence cannot predict it.

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