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The spasticity in the motor and functional disability in adults with post-stroke hemiparetic

A espasticidade no comprometimento motor e funcional de hemiparéticos pós acidente vascular cerebral

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Abstract

Introduction: Spasticity acts as a limiting factor in motor and functional recovery after Stroke, impairing the performance of daily living activities. **Objective:** To analyze the influence of spasticity on main muscle groups and to associate it with motor impairment and functional level of chronic hemiparetic patients after stroke. **Methods:** Twenty-seven chronic hemiparetic patients of both sexes were selected at the Physical Therapy and Occupational Therapy Service of the Unicamp Clinics Hospital. Assessments were carried out in two sessions, in the first one the motor impairment (Fugl-Meyer Assessment - FM) and functional impairment (Barthel Index - BI) were evaluated, and in the second, the degree of spasticity of the main muscle groups (Modified Ashworth Scale - MAS). **Results:** A negative correlation was detected between upper limb spasticity and motor and functional impairment. No muscle group evaluated in the lower limbs showed correlation between muscle tone and the level of impairment of the lower extremity on FM and the functional

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level measured by BI. Conclusion: Spasticity has been shown to be a negative influence factor in the level of motor and functional impairment of the upper limbs of chronic hemiparetic patients after stroke.

Keywords: Stroke. Hemiparesis. Spasticity.

Resumo

Introdução: *A espasticidade atua como um fator limitante na recuperação motora e funcional após o Acidente Vascular Cerebral (AVC), prejudicando a realização das atividades de vida diária.* ***Objetivo:*** *Analisar a influência da espasticidade nos principais grupos musculares e associá-la ao comprometimento motor e ao nível funcional de pacientes hemiparéticos crônicos pós-AVC.* ***Métodos:*** *Vinte e sete pacientes hemiparéticos crônicos, de ambos os sexos, foram selecionados no Serviço de Fisioterapia e Terapia Ocupacional do Hospital de Clínicas da Unicamp. As avaliações foram realizadas em duas sessões: na primeira foi avaliado o comprometimento motor (Protocolo de Desempenho Físico de Fugl-Meyer - FM) e funcional (Índice de Barthel - IB), e na segunda, o grau de espasticidade dos principais grupos musculares (Escala Modificada de Ashworth – EMA).* ***Resultados:*** *Foi detectada uma correlação negativa entre a espasticidade dos membros superiores com o comprometimento motor e funcional. Nenhum grupo muscular avaliado nos membros inferiores apresentou correlação entre o tônus muscular e o nível de comprometimento da subseção da extremidade inferior FM e o nível funcional mensurado pelo IB.* ***Conclusão:*** *A espasticidade mostrou ser um fator de influência negativa no nível de comprometimento motor e funcional dos membros superiores de pacientes hemiparéticos crônicos pós-AVC.*

Palavras-chave: *Acidente Vascular Cerebral. Hemiparesia. Espasticidade.*

Introduction

Stroke hemiparetic patients often develop motor disorders associated with imbalance of neural activity, such as spasticity, recognized as a component of upper motor neuron syndrome (1). Spasticity is defined as increased resistance to passive muscle stretching being dependent on the velocity (2). Spasticity prevalence after stroke varies from 18% (3) to 60% (4), and it is more frequent in the upper limbs than in lower limbs (3).

Clinically, spasticity is related to increased muscle tone, exaggerated reflexes, pain, and possible joint contractures. Along with these, impairment in motor control, muscle strength deficit and balance deficit lead to several disabilities, influencing the rehabilitation process and performance of functional tasks, as well as the quality of life of individuals with spasticity (5, 6).

The first clinical instrument developed to measure muscle tone was the Ashworth Scale and the Modified Ashworth Scale (7, 8). They are the most commonly used instruments for this purpose. Despite the shortcomings in manual methods (speed, angle, and acceleration are not standardized), it is the simplest and the most widespread, besides being a validated quantitative instrument that is easy to apply (9).

Some authors (10, 11) have reported that abnormal reflexes associated with spasticity are the main determinants of motor impairment. It is currently believed that spasticity itself is one of the contributing factors for motor and functional loss after stroke (12), but it is not an isolated agent, since other primary conditions may be associated, such as muscle weakness (13). Conditions secondary to upper motor neuron injury, such as pain and muscle contracture, also impair the appearance and maintenance of voluntary movements (6) and they are, to a certain degree, associated with the acute and/or chronic rehabilitation process that the individuals underwent. In the United States and Europe, these patients receive more support during recovery, especially in the first six or twelve months following stroke (14), which is not the case in Brazil.

Thus, the purpose of this study was to analyze the effects of spasticity in the main muscle groups of the upper and lower limbs and to associate it with motor impairment and the functional level of chronic hemiparetic patients after stroke.

Methods

This study was cross-sectional with twenty-seven post-stroke hemiparetic patients recruited at the Physical Therapy and Occupational Therapy Service of the Unicamp Clinics Hospital. They were informed and consented to participate in the research, which was approved by the research ethics committee of Unicamp (#110/2004).

The patients selected had a single unilateral stroke sequela, from non-traumatic origin, for a period of more than six months, of both sexes and aged between 35 and 70 years. Participants had to be able to understand simple instructions and not to have associated orthopedic or neurological conditions. The exclusion criterion was the loss of joint range of motion due to pain or muscle shortening.

Motor impairment was assessed using the Fugl-Meyer Assessmentscale (FM) (15). This scale has a total score of 66 points for the upper limb and 34 for the lower limb. The items are scored on ordinal scale: 0 = no achievement, 1 = partial achievement and 2 = complete achievement. FM is a standard instrument, validated in Brazil and widely used in several research centers (16, 17).

The degree of spasticity was assessed using the Modified Ashworth Scale (MAS) (7) which included the following scores: 0 (zero), no increase in muscle tone; 1 (one) slight increase in tone, manifested by minimal resistance at the end of the range of motion when the affected part is moved in extension or flexion; +1 (+ one), slight increase in muscle tone manifested by blockade, followed by minimal resistance throughout the remainder of the range of motion (less than half); 2 (two), marked increase in muscle tone, despite the absence of joint range of motion impairment, but the affected parts move slowly; 3 (three), considerable increase of muscle tone hindering passive movement; 4 (four), stiffness in the affected parts for flexion or extension. The muscle groups evaluated in the upper limb were: flexors, extensors, adductors, abductors, internal and external rotators of the shoulder, elbow flexors and extensors, forearm pronators and supinators, and flexors and extensors of wrist and fingers. In the lower limb: flexors, extensors, adductors, abductors, internal and external rotators of the hip, knee flexors and extensors, plantar flexors and dorsiflexors. The presence of spasticity was defined as a score ≥ 1 in a muscle group.

Barthel Index (BI) evaluates activities of daily living (ADLs), reaching a total of 100 points for individuals who are independent to perform the tasks (18). The BI is a frequently used measure with well-established validity, reliability and acceptability (19).

Evaluations were carried out in two sessions (on different days). In the first one, FM and BIwere applied, and on the following day the muscular tone evaluation was performed in dorsal decubitus, by passive movement of the upper limb (shoulder, elbow, forearm, wrist and fingers) and lower limb (hip, knee and ankle), according to MAS criteria. The evaluations were performed by two experienced physical therapists familiar with the scales.

Descriptive statistics of continuous variables were established by mean values and standard deviation. Correlation between scores was then performed using Spearman Correlation Coefficient. This coefficient was used due to the absence of normal distribution and reduced sample size. The significance level adopted for the statistical tests was 5% ($p < 0.05$).

Results

Among the selected patients, 40.7% (N = 11) were female and 59.3% (N = 16) males, mean age of 49.48 (± 11.49) years, and mean time of 3.43 (± 3.18) years post-stroke. Left ischemic stroke had higher prevalence (40.7%/N = 11). FM mean score in the upper limb was 33.81 (± 19.68), in the lower limb was 18.55 (± 8.34), presenting a total score of 52.37 (± 24.72). In BI, the mean was 91.11 (± 6.41).

Spasticity in the upper limb was detected in 66.6% (N = 18) of the 27 patients evaluated. Muscle groups of forearm pronators and flexors of the elbow, wrist and fingers were spastic in more than 60% of the patients (N = 17) (Table 1). At the lower extremity, spasticity in plantar flexors occurred in 66.6% of the patients.

Six subjects did not present spasticity in any muscle groups of the evaluated upper limb (FM - upper limb subsection 61.5 ± 2.96 / BI 98.33 ± 2.58). Seven subjects scored 0 at Ashworth for all lower limb muscle groups (FM - lower limb subsection 22.12 ± 11.21 / BI 93.75 ± 6.49).

Table 1 - Frequency and percentage of spasticity in upper and lower limb muscle groups

Muscles	Modified Ashworth Scale - MAS							
	0	1	+1	2	3	4	N	%
Shoulder Flexors	26	1	-	-	-	-	1	3.7
Shouder Extenders	12	6	6	2	1	-	15	55.5
Shoulder Adductors	14	12	-	1	-	-	13	48.1
Shouder Abductors	21	6	-	-	-	-	6	22.2
Internal Shoulder Rotators	11	2	10	4	-	-	16	59.2
External Shoulder Rotators	22	4	1	-	-	-	5	18.5
Elbow Flexors	9	9	8	1	-	-	18	66.6
Elbow Extenders	12	10	4	1	-	-	15	55.5
Forearm Pronators	10	11	4	2	-	-	17	62.9
Forearm Supinators	26	-	1	-	-	-	1	3.7
Handle Flexors	9	10	5	3	-	-	18	66.6
Handle Extenders	27	-	-	-	-	-	-	-
Fingers Flexors	9	10	3	4	1	-	18	66.6
Fingers Extenders	27	-	-	-	-	-	-	-
Hip Flexors	27	-	-	-	-	-	-	-
Hip Extenders	27	-	-	-	-	-	-	-
Hip Adductors	25	1	1	-	-	-	2	7.4
Hip Abductors	27	-	-	-	-	-	-	-
Internal Hip Rotators	18	7	2	-	-	-	9	33.3
External Hip Rotators	23	4	-	-	-	-	4	14.8
Knee Flexors	21	5	1	-	-	-	6	22.2
Knee Extenders	23	2	1	1	-	-	4	14.8
Plantar Flexors	9	11	7	-	-	-	18	66.6
Flexors Dorsum of the ankle	27	-	-	-	-	-	-	-

Note: n, Number of patients; %, Percentage of patients.

Negative correlation was found between muscle tone of the extensors, adductors and internal rotators of the shoulder, flexors and extensors of the elbow, and flexors of the wrist and fingers, and the level of motor impairment in the upper limb on FM. Regarding functional level, negative correlation was also observed between the muscle tone of extensors, adductors and internal rotators of the shoulder and flexors and extensors of the elbow (Table 2).

No muscle group assessed in the lower limbs showed correlation between muscle tone and level of impairment of lower extremity on FM and the functional level measured by BI.

Significant positive correlation was found between total FM and BI (r = 0.6169; p = 0.0001), and between the upper limb FM subsection and BI (r = 0.6747; p = 0.0001).

Table 2 - Statistical significance between the Modified Ashworth Scale – MAS scores with the Fugl-Meyer Assessment – FM and the Barthel Index - BI

Muscles	Motor Impairment (FM)	Functional Evaluation (BI)
Shoulder Flexors	r = -0.24	r = -0.22
Shouder Extenders	r = -0.73 [a]	r = -0.57 [b]
Shoulder Adductors	r = -0.71 [a]	r = -0.60 [a]
Shouder Abductors	r = -0.21	r = -0.37
Internal Shoulder Rotators	r = -0.70 [a]	r = -0.69 [a]
External Shoulder Rotators	r = -0.20	r = -0.24
Elbow Flexors	r = -0.63 [a]	r = -0.54 [b]
Elbow Extenders	r = -0.71 [a]	r = -0.55 [b]
Forearm Pronators	r = -0.49 [b]	r = -0.48 [c]
Forearm Supinators	r = -0.30	r = 0.15

(To be continued)

(Conclusion)

Table 2 - Statistical significance between the Modified Ashworth Scale – MAS scores with the Fugl-Meyer Assessment – FM and the Barthel Index - BI

Muscles	Motor Impairment (FM)	Functional Evaluation (BI)
Handle Flexors	r = -0.58 [b]	r = -0.46 [c]
Fingers Flexors	r = -0.58 [b]	r = -0.37
Hip Adductors	r = -0.21	r = -0.23
Knee Flexors	r = -0.41 [c]	r = -0.28
Knee Extenders	r = -0.30	r = -0.15
Plantar Flexors	r = -0.29	r = -0.03

r = Spearman correlation coefficient; [a] $p < 0.001$; [b] $p < 0.01$; [c] $p < 0.05$

Discussion

Spasticity is one of the main factors contributing to the loss of selective motor control, especially in individuals who manifest severe motor impairment after stroke (12). According to FM scale,upper limbs total motor score of patients in this study shows a level of impairment classified as severe to moderate (score between 5 and 46) (20). The lower limb presented FM mean score corresponding to 54.56% of motor recovery. Movement disorders following stroke may also be due to loss of strength and motor ability, because of disconnected interarticular coordination or pathological synergies (21).

In a study on the prevalence of spasticity, 20% of 66 patients evaluated had some level of spasticity. This number increased to 34% when considering hemiparetic subjects (22). Lundströnet al. (3) observed that 17% of the patients had upper limb spasticity after one year of stroke. In this study, 66.6% of the patients presented upper and/or lower limb spasticity. These values are above the average of other studies and may be explained by the high level of motor impairment (measured by total FM = 52.37 ± 24.52) of the selected patients and by the effects of lesion chronicity. According to Thilmannet al. (23), after three months of stroke, spasticity seems to be also due to intrinsic factors, such as decrease in the number of sarcomeres in series that result in slow movement and difficulty in selectivity (co-contraction) (24). In this study, all patients were chronic, that is, with more than six months of injury. Therefore, we can infer that the difficulty in performing voluntary movements (which caused a reduced score in FM scale) may be due to these neuromuscular changes occurring in the chronic phase after stroke, and also to the control deficit in superior motoneurons firing.

Differently from other studies, the sample studied here showed similar spasticity in both extremities, but it was present in more muscles of the upper extremity than in the lower one. It is not yet defined why spasticity affects upper limb motor performance more than lower limbs (25). It is believed that it may be due to the fact that locomotion is also present in spinal levels and that spasticity may help orthostatism, contributing to maintain body weight (9, 25).

When we selected only patients who did not present spasticity in any of the muscle groups of the evaluated upper limb (six subjects), we noticed that FM scores in the subsection of upper limb and BI (FM 61.5 ± 2.96 / BI 98.33 ± 2.58) were higher than the rest of the group (FM 25.90 ± 14.34 / BI 89.4 ± 5.61). Lundströnet al. (3) and Watkins et al. (26) identified that the rate of patients dependent on activities of daily living according to BI was higher in those patients with spasticity when compared to those without spasticity. In contrast, Sommerfeld et al. (12) demonstrated that severe motor and functional problems are observed with the same frequency in spastic and non-spastic patients. The exact influence of spasticity on motor impairment and limitations after stroke is difficult to measure because the level of spasticity may change according to the positioning and the task demands (12).

The medial descending pathways (medial corticospinal, medial and lateral vestibulospinal,tectospinal and medialreticulospinal) and lateral descending pathways (lateral corticospinal, rubrospinal and lateral reticulospinal) commands the axial and distal muscles. After stroke, some of these pathways may be damaged, leading to loss of dexterity, strength and voluntary movement. Several plastic processes of the central nervous system act after injury in order to restore motor and functional control, such as reorganization of intracortical connections, appearance of collateral cortico-spinal projections from other regions of the primary motor cortex or other areas of the brain,increased cortical activation of descending pathways from the midbrain and increased activity of ipsilateral cortico-spinal projections from the unaffected cortex (27, 28). However, the loss of distal selective motricity due to injury to the cortico-spinal tract is not repaired and/or replaced (29). It explains why spasticity, which is one of the main effects of upper motor neuron injury, was found mainly in distal muscles of the upper and lower limbs in this study (Table 1). Also on the descending pathways, midbrain motor areas lose influence of cortical projections after stroke, leading to abnormal control over the muscles and causing the classic and antigravity pattern of extensor muscles of the lower limbs and flexors of the upper limbs (28). This antigravity pattern is present in patients from this study, and may be observed by the higher spasticity incidence in muscles that compose this abnormal synergy.

The level of upper limb motor impairment and the functional capacity of hemiparetic patients in this study were affected by the presence of spasticity. Those with spasticity showed decreased FM and BI scores. Lin et al. (25), using different measurement instruments from the ones in this study, reported significant inverse correlation between the degree of spasticity of the wrist joint and voluntary motor performance, including functional tasks such as Box and Blocks test. Watkins et al. (26) also reported that patients with spasticity (measured by MAS) were more functionally impaired than those without spasticity. Welmer et al. (22) correlated upper limb spasticity (measured by MAS) with measures of voluntary motor mobility (Birgitta Lindmark Motor Assessment Scale - LMAS, Rivermead Mobility Index - RMI) and BI, and found moderate to high correlation.

Regarding lower limbs, there was no relationship between spasticity and the level of motor and functional impairment of hemiparetic individuals. This finding is similar to those of Welmer et al. (22) that reported low correlation between lower limbs spasticity with RMI and BI. Katz et al. (29) also observed no correlation between the degree of spasticity of the lower extremity muscles and the scores on FM scale.

Correlations between spasticity and motor and functional impairment in the upper and lower limbs are not similar due to some factors. First, spasticity may manifest differently in different muscle groups, since skill, motor dexterity, and functional requirements are different for each structure. Second, measurement tools fail because they are not able to differentiate between a functional motor response and a compensatory strategy (30). In addition, it is important to highlight that several factors may contribute to this event, such as injury time, level of motor impairment, intrinsic (non-neural) muscular factors, among others (13).

Similar to that found by Oliveira et al. (30), it was observed that a better FM score is also accompanied by an increase in BI, indicating that motor impairment is inversely proportional to satisfactory functional performance.

Conclusion

Thus, spasticity is characterized as a factor of negative influence on motor and functional impairment of the upper limbs of chronic hemiparetic patients after stroke, that is, spasticity acts as a limiting factor for motor and functional recovery.

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