Balance analysis during the sit-to-stand movement of chronic hemiparetic individuals based upon their functional levels.

Análise do equilíbrio durante o movimento de sentado para de pé em hemiparéticos crônicos divididos pelo nível funcional.

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Abstract
Introduction: Balance deficits are frequently observed in individuals with hemiparesis and lead to disabilities in daily activities, such as the ability to walk. The sit-to-stand movement is essential for independent gait and balance is one of the main requirements for its performance. Objective: To analyse the balance parameters during the sit-to-stand movement in individuals with chronic hemiparesis, stratified according to the level of functional performance. Method: Individuals above 20 years of age with a time since the onset of the stroke of at least six months were divided into three functional groups, according to their walking speeds: Household ambulation (<0.4 m/s), limited community ambulation (0.4 to 0.8 m/s), and complete community ambulation (>0.8 m/s). The following balance parameters were assessed by the sit-to-stand test of the Balance Master System: (1) weight transfer time, (2) rising index and (3) the centre of gravity sway velocity. It was considered a significance level of $\alpha<0.05$. Results: Eight-six individuals (56 ± 13 years) participated. Statistically significant differences regarding weight transfer time were observed only between the household group and the others (limited community ambulation and complete community ambulation ($F=4.42$;$p=0.01$). Similarly, regarding the rising index, significant differences were observed only for the household ambulation group ($F=8.46$; $p<0.01$). Conclusion: Individuals with chronic hemiparesis, who had lower functional performance levels (household ambulation) spent more time to perform the sit-to-stand movement with less weight transfer to the lower limbs. These findings suggest that within clinical contexts when balance training is carried out to improve mobility and gait performance in individuals with household ambulation, parameters related to the transfer time and rising index should be emphasized.
Keywords: Stroke, Postural Balance, Walking.

Resumo
Introdução: Déficits de equilíbrio são frequentemente observados em hemiparéticos, gerando incapacidades nas atividades diárias, como na deambulação. O movimento sentado para de pé é essencial para a marcha independente, e o equilíbrio é um dos principais requisitos para sua execução. Objetivo: Analisar os parâmetros relacionados ao equilíbrio durante o movimento sentado para de pé em hemiparéticos crônicos estratificados de acordo com o nível de desempenho funcional. Método: Indivíduos com idade ≥20 anos e diagnóstico de Acidente Vascular Encefálico há pelo menos seis meses foram recrutados e divididos em três grupos de acordo com o nível funcional, avaliado através da velocidade de marcha: deambulação domiciliar ($<0,4$ m/s), limitada deambulação comunitária ($0,4$ a $0,8$ m/s) e completa deambulação comunitária ($>0,8$ m/s). O equilíbrio foi avaliado pelo *Balance Master System®* e o teste sentado para de pé foi usado para avaliar os parâmetros: (1) tempo de transferência, (2) índice de subida e (3) velocidade de oscilação do centro de gravidade. Foi considerado um nível de significância de $\alpha<0,05$. Resultados: Participaram deste estudo 86 indivíduos (56 ± 13 anos). Em relação ao tempo de transferência, observaram-se diferenças estatisticamente significativas entre o grupo deambulação domiciliar e os grupos limitada deambulação comunitária e completa deambulação comunitária ($F=4,42$;$p=0,01$). Similarmente, foram observadas diferenças estatisticamente significativas entre o grupo deambulação domiciliar e os demais grupos para o índice de subida ($F=8,46$;$p<0,01$). Conclusão: Hemiparéticos crônicos com pior desempenho funcional apresentaram maior tempo de transferência do sentado para de pé e realizaram uma menor transferência de peso os para membros inferiores durante o movimento de passar de sentado para de pé. Estes achados sugerem que no contexto clínico, em que o treino de equilíbrio é realizado com o objetivo de melhorar mobilidade e desempenho na marcha de indivíduos com deambulação domiciliar, o tempo de transferência e o índice de subida devem ser priorizados.
Palavras-chave: Acidente Vascular Cerebral, Equilíbrio Postural, Caminhada.

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INTRODUCTION

The stroke results in several consequences that impact various aspects of life of individuals, among them changes in the psychological, physical and social context.[1] The physical deficits are due to the contralateral hemiparesis brain injury associated with deficits in functional mobility. Among these deficits, we highlight the reduction in speed and walking capacity, fear of falling and balance disorders.[2]

Deficits related to balance are commonly observed post-stroke, resulting in limitations in activities of daily living.[3,4] It is known that the postural balance is essential for carrying out daily activities, from the simple, like brushing your teeth, to the most complex, how to move from a sitting to a standing position. Studies shows that deficits related to balance are associated with reduced walking capacity, which in turn lead to physical deconditioning, creating a vicious cycle.[5,6] Recently, it was observed that the assessment and balance training may also be needed for higher functional level, as determined by increased walk speed can be achieved in this population[2] since balance is a prerequisite for the achievement of various functional activities.

The sit-to-stand movement is a functional activity performed several times in the day-to-day and its implementation is fundamental to independent living. In the context of rehabilitation, the ability to get up leaving the sitting position is considered as a prerequisite for independent walking.[7,8] Among the demands related to this motion, the ability to move the body from a stable to an unstable situation in which the centre of mass is shifted to a higher position and ahead and the support base becomes narrower.[9]

Since balance is a prerequisite for the implementation of sit-to-stand, understand the parameters related to this movement in post-stroke individuals are the key to a better management in clinical practice in contexts that aim mobility and functionality of individuals. Thus, the aim of this study was to characterize and to analyze the parameters related to balance while moving from sit-to-stand in a large sample of chronic hemiparesis stratified according to the level of functional performance, determined by walk speed.

METHODS

Participants

For this observational cross-sectional study, participants were recruited from the metropolitan region of Belo Horizonte, MG, Brazil, according to the following inclusion criteria: age over 20 years; stroke for at least six months; muscle weakness and/or increased tone of the knee extensors or paretic plantar flexors; ability to ambulate with or without assistive devices; and present good understanding, determined by the Mini Mental State Examination with cut-offs established for the Brazilian population.[10,11]

This study was approved by the Ethics Committee of the Universidade Federal de Minas Gerais in the number 05380.0.203.000-09 and all participants signed an informed consent.

Measuring instruments and procedures

Initially, subjects underwent an interview and physical examination, to obtain demographic, anthropometric and clinical data related to age, gender, weight, height, time post-stroke evolution, paretic, history of falls in the past six months and medication use.

Level of functional performance

The regular walk speed test was used to determine the level of functional performance. The subjects were asked to walk, in a natural speed, a distance of 28 meters using the footwear which they are familiar and they could use orthotics and walking aids if needed. The time it takes to traverse the 24 central meters was recorded with a digital stopwatch. Three measurements were obtained and the average between them was computed and used to calculate the walk speed.[12] From this measurement, the sample was stratified into three clinically functional groups. Household ambulation (<0.4 m/s), limited community ambulation (0.4 to 0.8 m/s) and complete community ambulation (>0.8 m/s).[13]

Parameters related to balance

The evaluation of the parameters related to equilibrium was performed using *Balance Master System®* (NeuroCom's Balance Master® System). This instrument is used both to assess and the balance of post-stroke hemiparesis training.[14,15] It is composed of a computer system and a dual force platform with four force sensors capable of detecting the pressure exerted on the same. The instrument has demonstrated adequate psychometric properties when used in post-stroke individuals.[16]

For the present study, the sit-to-stand test were used which offering three parameters. The main component of this task, evaluated by Balance Master, includes the speed of anterior displacement of the center of gravity (CG). The parameters were evaluated and analyzed: (1) time to transfer weight (in seconds), which refers to the time required to move the CG earlier from a sitting position to a full transfer of weight to the lower limbs, (2) rate of increase in percentage of body weight, which reflects the amount of force exerted by the lower limbs during the ascent phase and (3) the oscillatory velocity of the CG, degrees/second, which indicates control of CG on the basis support during the ascent phase and after five seconds in the upright position.[17]

Statistical Analysis

Descriptive statistics and normality tests (Shapiro-Wilk test) were performed for all variables. Analyses of variance (ANOVA one-way) with post-hoc LSD were used to compare the values of selected among groups stratified by walk speed variables. It was considered a significance level of α <0.05 for all analyzes and the statistical package SPSS version 17.0 for Windows was used. (SPSS Inc, Chicago, IL).

RESULTS

The study included 86 subjects, mean age 56 ± 13 years, time post-injury 65 ± 54 months, with half of the sample (55%) was composed of men. Seven subjects had walk speed <0.4 m/s, 22 subjects between 0.4 m/s 0.8m/s and 57 subjects > 0.8 m/s. No statistically significant differences among the three groups of level of functional performance in relation to age and time elapsed post-stroke (0.15 <F <0.44; 0.39 <p <0.87, respectively) were observed. The data concerning the characteristics of the sample are summarized in Table 1.

Table 2 shows the comparison between the variables measured by the Balance Master among groups stratified according to the level of functional performance. Regarding the transfer time, we observed statistically significant differences between the household ambulation group and the other groups (p = 0.01; F = 4.42), whereas the group with better functional performance (limited and complete community ambulation) had shorter transfer time. No statistically significant differences between the groups limited community ambulation and complete community ambulation (p = 0.44; F = 0.32) were observed.

Similar findings were observed for the rate of climb, statistically significant differences were found between the household ambulation group and the other groups (p <0.01, F = 8.46), when compared to the limited and complete community ambulation groups. The group with worse functional performance showed a lower rate of increase in the other two groups. No statistically significant differences between the groups limited communi-

ty ambulation and complete community ambulation (p = 0.19; F = 0.81) were observed.

No differences were observed between the groups of functional performance compared to variable speed of oscillation of the CG (p = 0.13, F = 2.11).

DISCUSSION

The results of this study demonstrated that chronic hemiparetic subjects with different levels of functional performance showed differences in parameters related to the balance during the sit-to-stand movement assessed by the Balance Master. According to the observed data, individuals with household ambulation spent more time to transfer from sitting to standing position and held less weight transfer to the lower limbs while performing the movement, compared to individuals with limited and full community ambulation. However, no differences between the three groups of functional performance with respect to speed of oscillation of the CG were observed.

The findings that household ambulators (worst performance) spent more time to complete the transfer of the seated to standing compared to individuals with higher walk speed corroborate those reported by Chou et al.[18] who observed in a sample of 40 chronic hemiparetic exists correlation between the rate of rise in mo-

Table 1. Descriptive data for anthropometric, demographic and clinical variables of the participants.

Characteristics	n= 86
Age (years), mean ± SD, (variable)	56 ± 13 (24-86)
Gender, n male (%)	54 (55)
Side of paresis, n right (%)	58 (59)
Length after stroke (months), mean ± SD, (variable)	65 ± 54 (6-240)
Number of medicines, mean ± SD	3 ± 2
BMI (Kg/m²), mean ± SD, (variable)	26.2 ± 34.5 (15.2-36.5)

n=number; SD=Standard Deviation; BMI= Body Mass Index.

Table 2. Comparison of variables between groups: Household ambulation (n=7), Limited community ambulation (n=22) and Complete community ambulation (n=57).

Variable	Household ambulation	Limited community ambulation	Complete community ambulation	F (p)
Age	55.6 ± 11.7[a]	57.7 ± 12.1[a]	54.9 ± 13.6[a]	0.16 (0.83)
Length after stroke (months)	68.5 ± 50.1[a]	62.6 ± 42.3[a]	63.8 ± 52.3[a]	0.47 (0.62)
Transfer time (s)	1.96 ± 1.58[a] [0.29-3.7]	1.02 ± 0.71[b] [0.24-2.2]	0.84 ± 0.93[b] [0.58-1.08]	4.42 (0.01)
Index of climb (%)	6 ± 4.8[a] [2-16]	19 ± 11.4[b] [8-61]	22 ± 9.8[b] [4-47]	8.46 (<0.01)
Oscillation speed of the center of gravity. (º/s)	3.4 ± 1.8[a] [1.9-6.1]	4.5 ± 1.9[a] [2.4-12]	4.7 ± 1.4[a] [1.6-8.1]	2.11 (0.13)

CG= center of gravity. Data are reported as mean ± standard deviation, minimum and maximum values. For each row, different letters indicate significant differences between groups (p <0.05).

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ving from sitting to standing with walk variables such as speed, stride length and cadence. Similarly, Boyne et al.[19] found an increase in walk speed after a training program moving from sit-to-stand with the focus on the transfer time in chronic hemiparesis. So, the velocity reached during the movement of passing from sitting to standing appears to be closely related to gait performance.

No significant difference was found between the groups with higher functional levels, ie, with limited and complete community ambulation for all the variables investigated. This result can be partially explained by the large variability of the study participants, which can be evidenced by the high values of standard deviation. High variability in functional parameters and engine seems to be a common finding in hemiparetic subjects.[20,21]

During transfer from a sitting to a standing position, is changing the base of support for two of three points, which requires a high demand of muscular trunk and lower limbs.[22] The findings of the present study demonstrated that individuals with functional index higher (limited and complete community ambulation), compared to those with household ambulation, unloaded a higher percentage of weight in the lower limbs during the movement sitting to standing, requiring greater force demand to the lower limbs. However, related to lower limb muscle strength variables were not evaluated in this study.

Although no statistically significant differences among the three groups with respect to the speed of oscillation of CG have been observed, it is reported that the control of CG position is crucial to control the upward movement, as well as the maintenance of postural stability.[23] If the CG is not moved sufficiently forward or moves excessively, the individual risks of suffering a fall. Additionally, the lateral stability while performing the activity is dependent on the symmetrical distribution of power between both legs, which most often is not obser-

ved in post-stroke individuals.[17,24] Despite being described in the literature that hemiparesis have marked postural oscillation (mainly medial-lateral), (7.18) according to the results of the present study, the rate of oscillation of the CG was not related to functional levels. Therefore, this variable cannot be qualified to evaluate and treat the balance from a functional perspective. However, this result may have been influenced by the small sample size of the group of household ambulation.

This study has some limitations. It is known that the relations of cause and effect cannot be determined due to the methodology and design used in this study. Additionally, the data collected were not equally distributed among the different levels of functional performance, which may have influenced the findings. This fact can be justified by individuals with reduced walk speed of the greater difficulty in getting to the location of data collection. Finally, the results of this study reflect characteristics related to chronic hemiparesis, and thus cannot be generalized to populations in acute and sub--acute phases after stroke.

CONCLUSION

The results of this study demonstrated that chronic hemiparetic subjects with poorer functional performance (Household ambulation) spent more time to complete the transfer from sitting to standing with a smaller weight transfer to lower limbs while performing the movement, when compared to individuals with limited and complete community ambulation. No differences were observed between the three groups of functional performance compared to the speed of oscillation of the CG. Therefore, the results of this study suggest that the clinical context in which balance training is conducted with the aim of improving mobility and gait performance of individuals with household ambulation, transfer time and rate of climb must be prioritized.

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