

# Could heart rate variability be associated with weight-bearing asymmetries in cerebrovascular diseases?

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## ABSTRACT

**Introduction:** Cerebrovascular diseases result in sensory-motor deficits disturbing postural control that is observed by weight-bearing asymmetries commonly named as hemiparesis. Besides hemiparetic impairments, first observed after stroke, many studies have pointed cardiac failure and risk of sudden death as the main factors responsible for death of stroke survivors. This case series characterized weight-bearing asymmetries and heart rate variability, and describes relationships between these parameters in hemiparesis. **Case Series:** Five Brazilian male subjects with chronic hemiparesis acquired after ischemic stroke in the middle cerebral artery were selected to study heart rate variability obtained by Root

Mean Square Successive Difference. Also, weight-bearing asymmetries were measured by Symmetry Ratio calculated by weight-bearing recorded between each foot. The Symmetry Ratio was  $1.1 \pm 0.43$  for all cases presenting a symmetry case ( $n = 1$ ) and different types of asymmetries cases ( $n = 4$ ) during upright position. Root Mean Square Successive Difference was  $9.9 \pm 3.4$ , presenting strong and significant ( $p < 0.05$ ) positive correlation with age and a strong but not significant ( $0.05 < p < 0.10$ ) negative correlation with hemiparesis chronicity. A strong but not significant negative correlation was observed between the Root Mean Square Successive Difference and the Symmetry Rate values. **Conclusion:** A characteristic pattern of heart rate variability for patients with cerebrovascular disease was observed in these cases, associated significantly with age. Still, this behavior seems to be influenced by chronicity and by different types of asymmetries in the distribution of weight bearing that could be investigated in more appropriate clinical research designs.

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## INTRODUCTION

Cerebrovascular diseases (CVD) damaging one of the cerebral hemispheres commonly results in movement deficits in the opposite hemi-body promoting weight-bearing asymmetries commonly observed as hemiparesis [1-2]. Besides sensory-motor impairments, first observed after stroke, cardiovascular dysfunctions have also been reported for this population and many studies have pointed cardiac failure and sudden death risk as the main factors responsible for death of stroke survivors [3-6].

Cardiovascular dysfunction is present because the stroke can also damage brain areas related with autonomic control modifying sympathetic-vagal balance [6-8]. A lot of evidences show that autonomic dysfunction can be identified by heart rate variability [4-6, 9-13] and specific heart rate profiles have been described as a predictor of sudden death [14-15].

It has already been reported in literature during past decades that abnormal reduction of the heart rate variability reflects autonomic dysfunction and risk of sudden death, and that heart rate variability could be correlated with motor impairments in stroke survivors, there is no evidence to show if heart rate variability could be associated with weight-bearing asymmetries in cerebrovascular diseases.

This case series aimed to characterize weight-bearing asymmetries and heart rate variability, describing the relationships between these measurements in cases of hemiparesis.

## CASE SERIES

A multiple-case descriptive-exploratory research design was selected for this study with measurements performed in a single session. We describe five Brazilian male subjects with chronic hemiparesis acquired after ischemic stroke in the middle cerebral artery were identified in the available records on files at the Ceilandia Regional Hospital. All cases had eligibility criteria to be submitted to procedures analysis to calculate parameter of heart rate variability [3-5, 13]. To be included in the study the participants had to: 1) have had a post-brain (CVD) injury period of over six months, 2) have spastic hemiparesis, 3) be able to maintain themselves in an upright stance posture long enough to register weight-bearing on the digital scales, and 4) be able to walk themselves without assistance or support device. Study excluded, the participants who: 1) were smokers and/or alcoholic; 2) were on beta-blocker medication, and 3) were presenting other types of disability in addition to hemiparesis. All of them signed a consent form approved by the Research Ethics Committee issued by the Faculty of Health Science of the University of Brasília (protocol number 034/2009).

Heart rate was monitored during 6-minutes walk test and the heart rate variability was obtained by comparisons between adjacent RR intervals and

calculated by Root Mean Square Successive Difference (RMSSD) [13].

Weight-bearing distribution was evaluated by the ratios of the weight supported by each lower limb between the affected and non-affected hemibodies. The measurements of the weight supported under each lower limb of the body were obtained with the use of two parallel calibrated scales with a digital display (Plenna®) with a maximum capacity of 150 kg. The subjects were placed barefoot, with their feet free and aligned on the scales with each foot about 20 cm away from the other, without any type of additional support, and the limbs placed separately on each scale. All subjects were instructed to maintain an upright position as comfortable as possible, always looking forward to a fixed point on the wall at a distance of three meters.

The display of each scale indicated integer values in kilograms (kg) with one decimal value representing tenths of a kg. Despite instability of the decimal value, once the examiner observed stability in the integer value indication of the displays of each scale, the bilateral reading was obtained and recorded (in integer values). In sequence, the equivalence between the total body weight and the sum of the values obtained for both scales was confirmed. In case the sum had been inferior or superior (> or <1 kg) to the total body weight, the reading would be performed again. The values obtained for each limb were registered as weight-bearing values for the affected and non-affected hemibodies.

Weight-bearing asymmetries were calculated and classified by the Symmetry Ratio (SR), as described by Pereira and collaborators [1], SR was calculated using the formula:  $SR = a/na$ , in which RS is the dimensionless value of the symmetry ratios calculated by the division of the weight-bearing values of the affected (a) by the non-affected side (na). As such, the values of  $RS = 1$  would represent the total weight-bearing symmetry in the orthostatic position. Values of  $RS > 1$  would represent weight-bearing asymmetries towards the affected side and values of  $RS < 1$  towards the non-affected side.

We used descriptive statistical (mean  $\pm$  standard deviation) and Spearman correlation test once the Kolmogorov-Smirnov test did not confirm Gaussian distribution. The significance level for all analyses was established at  $p < 0.05$ .

They had an average age of  $58.6 \pm 14.03$  years with an average chronicity of  $17.4 \pm 15.85$  months. The RMSSD and RS were  $9.9 \pm 3.4$  and  $1.1 \pm 0.43$  respectively and the values for each case are presented in the table 1.

The RS identifies three types of weight-bearing distribution classified as symmetric ( $n = 1$  and  $RS = 1$ ) and asymmetric with overweight toward affected side ( $n = 2$  and  $RS > 1$ ) or non-affected side ( $n = 2$  and  $RS < 1$ ).

The relationships between variables are presented by scatter graphs in the figures 1, 2 and 3. Strong and significant positive correlation was found between RMSSD and years old, showing that the oldest patients obtained the highest RMSSD (figure 1). Moreover, strong but not significant negative correlation between RMSSD and chronicity suggests that patients surviving

Table 1: Description of the variables recorded for each case (n=5).

Case	Age	Chronicity	SR	RMSSD
1	37	15	1.5	5.5
2	55	45	1.6	7.3
3	59	13	1.0	10.3
4	71	8	0.7	12.9
5	71	6	0.7	13.5
Mean	58.6	17.4	1.1	9.9
SD	14.0	15.9	0.4	3.5
SEM	6.3	7.1	0.2	1.6

Abbreviations: Age in years old, Chronicity in months post-stroke, Symmetry Ratio (RS) and Root Mean Square Successive Difference (RMSSD). Values were detailed for each case in the first five rows and the last three rows describe Mean, Standard Deviation (SD) and Standard Error of Mean (SEM).

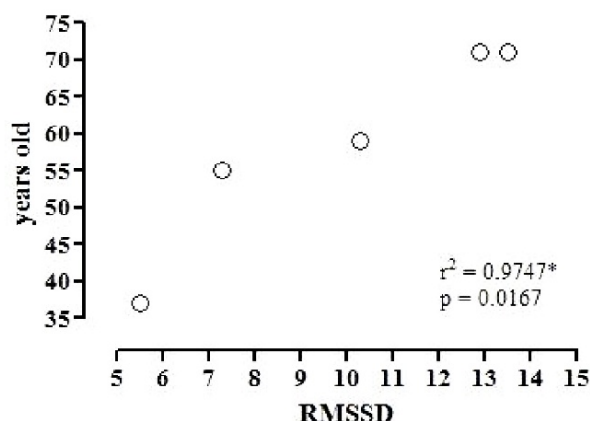


Figure 1: Dispersion graph of the variables correlated by the Spearman correlation tests. The level of correlation between root mean square successive difference (RMSSD) and age (years old) are indicated by the correlation indices ( $r^2$ ) and the significance is indicated by the p value. Asterisk indicates strong correlation ( $p < 0.05$ ).

post-stroke for long time have the lowest RMSSD (figure 2).

Strong but not significant negative correlation also was found between RMSSD and RS suggesting that the  $RS > 1$  are associated with the lowest RMSSD and the  $RS < 1$  with the highest RMSSD (figure 3).

## DISCUSSION

The values of SR and the RMSSD in the five cases were within the values commonly reported for

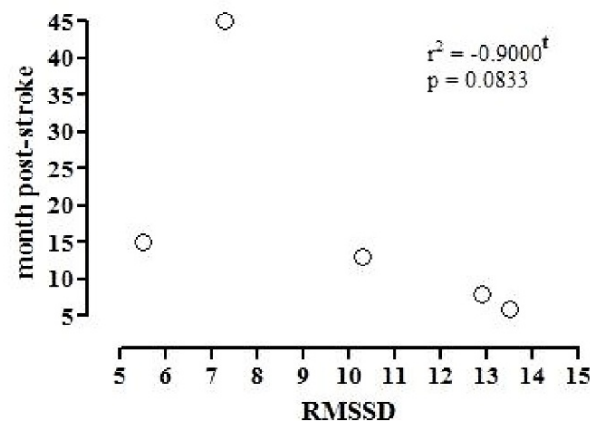


Figure 2: Dispersion graph of the variables correlated by the Spearman correlation tests. The level of correlation between root mean square successive difference (RMSSD) and chronicity (months post-stroke) are indicated by the correlation indices ( $r^2$ ) and the significance is indicated by the p value. The letter t indicates strong tendency to correlate ( $0.1 > p > 0.05$ ).

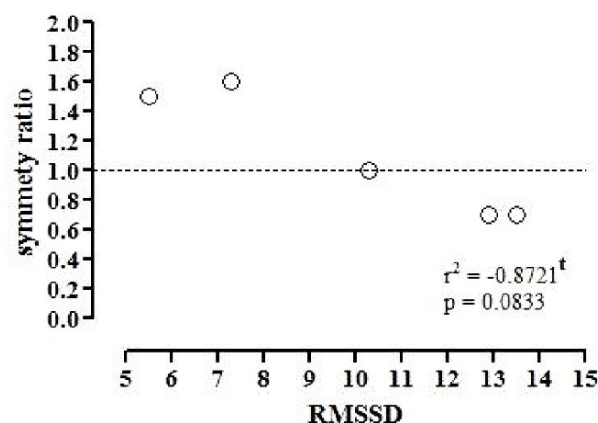


Figure 3: Dispersion graph of the variables correlated by the Spearman correlation tests. The level of correlation between root mean square successive difference (RMSSD) and symmetry ratio (SR) are indicated by the correlation indices ( $r^2$ ) and the significance is indicated by the p value. The letter t indicates strong tendency to correlate ( $0.1 > p > 0.05$ ). Discontinuous line indicates subjects with weight-bearing symmetrically distributed ( $SR = 1$ ) separating subjects with asymmetries toward affected hemibody ( $SR > 1$ ) of those with asymmetries toward non-affected hemibody ( $SR < 1$ ).

hemiparetic population [1, 3, 16]. As explained by Marães [13], the highest values of the RMSSD among them could indicate subjects with better cardiovascular adjustments by autonomic nervous system.

In this study, cases in which the subjects had more advanced ages were those where the highest values were obtained from RMSSD (figure 1), disagreeing with McLaren and collaborators [4]. However, Tulppo et al. [17] reported that the low values of RMSSD were observed in elderly during rest and as described the RMSSD was recorded during six minutes walk test.

Moreover, the vagal modulation of heart rate during exercise is also affected by physical fitness [17]. However, we did not record the level of physical fitness of the subjects, so it is incorrect to state that our results disagree with McLaren et al. [4]. This is a limitation of this study.

In the five cases, chronicity seems to contribute to a loss of effectiveness of autonomic adjustment. Other researches investigating heart rate variability in stroke survivors during acute [3, 6] and chronic [4] phases found similar relationship, however, still no definite arguments to support a clear association between chronicity and heart rate variability is present.

It was interesting to note that subjects overweighting on the non-affected side had the highest RMDSS values and those overweighting to the affected side had the lowest RMDSS values, suggesting that the compensatory strategy of overweighting non-affected side seems to favor a better autonomic adjustment.

However, the present descriptive-exploratory study describes five patients with which is a small number of patients for drawing conclusions from statistical analysis. The results are not sufficient for generalizations that the asymmetric strategy toward the non-affected side was responsible for increased heart rate variability, a drawback of this study, however it pointed towards evidences that could be investigated by others research designs.

More appropriate designs are necessary to confirm the findings described here, since the sample was small and the information previously collected were not sufficient to disregard the influences of other variables. Except the limitations outlined here, this study has generated new questions about the influences of postural asymmetry in heart rate variability.

## CONCLUSION

It was concluded that a characteristic pattern of heart rate variability for patients with cerebrovascular disease was observed in these cases, associated strongly and significantly with age. Still, this behavior seems to be influenced by chronicity and by different types of asymmetries in the distribution of weight bearing that could be investigated in more appropriate clinical research designs.

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## Author Contributions

Rogério Batista Balthazar – Acquisition of data, Analysis and interpretation of all data, Drafting the article, Final approval of the version to be published

Pedro Henrique Côrtes de Sousa – Acquisition of data and Analysis of weight-bearing data, Final approval of the version to be published

Paulo Henrique Ferreira de Araujo Barbosa – Acquisition of data and Analysis of weight-bearing data, Final approval of the version to be published

Lidiane Teles de Menezes – Acquisition of data and Analysis of weight-bearing data, Final approval of the version to be published

Abraão Souza Costa – Acquisition of data and Analysis of weight-bearing data, Final approval of the version to be published

Danilo Veloso Alves Carneiro – Acquisition of data and Analysis of heart rate variability data, Final approval of the version to be published

Vera Regina Fernandes da Silva Marães – Acquisition, Analysis and interpretation of heart rate variability data, Critical revision of the article, Final approval of the version to be published

Emerson Fachin Martins – Conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Critical revision of the article, Final approval of the version to be published

## Guarantor

The corresponding author is the guarantor of Submission.

## Conflict of Interest

The authors declare no conflict of interest.

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