

# Relationships between body symmetry during weight-bearing and functional reach among chronic hemiparetic patients

Correlação entre simetria corporal na descarga de peso e alcance funcional em hemiparéticos crônicos

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## Abstract

**Background:** Postural control is often impaired in hemiparetic patients. During upright stance, hemiparetic subjects sway more than subjects with an unaffected hemibody, and they assume asymmetrical postures to place less weight on the affected side. **Objective:** To analyze functional reach and dependence on support devices among people with chronic hemiparesis and to investigate the relationships between displacements of functional reach and weight-bearing symmetry during upright stance. **Methods:** Fourteen participants with hemiparesis, classified as dependent on support devices or independent from them, were included in experimental procedures to record functional reach displacements and symmetry values. **Results:** No significant differences were found between the dependent and independent participants for any variable. However, when weight-bearing occurred on the unaffected side, the greatest displacements were significantly correlated with the most asymmetrical hemiparetic participants. **Conclusion:** Symmetry did not contribute to functional reach or independence from support devices among participants with hemiparesis.

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**Key words:** asymmetries; balance; weight-bearing; cane; stroke.

## Resumo

**Contextualização:** O controle postural está frequentemente prejudicado nas condições de hemiparesias. Quando na posição em pé, sujeitos hemiparéticos oscilam mais do que sujeitos sem hemicorpo afetado, adotando posturas assimétricas com maior descarga de peso na perna não afetada. **Objetivo:** Analisar o alcance funcional e a dependência por dispositivo de apoio em hemiparéticos crônicos, verificando correlações entre deslocamentos de alcance funcional e valores de simetria de descarga de peso durante a posição em pé. **Métodos:** Quatorze hemiparéticos classificados em dependentes ou independentes de dispositivo de apoio foram incluídos nos procedimentos experimentais para registro de deslocamento de alcance funcional e valores de simetria. **Resultados:** Nenhuma diferença significativa foi obtida entre os dependentes e os independentes de dispositivo de apoio para todas as variáveis. Porém, quando a descarga de peso ocorreu no lado não afetado, os mais altos deslocamentos foram significativamente correlacionados com os hemiparéticos mais assimétricos. **Conclusão:** A simetria não favorece o alcance funcional nem a independência de dispositivo de apoio em hemiparéticos.

Artigo registrado no Australian New Zealand Clinical Trials Registry sob o número ACTRN12609000267257.

**Palavras-chave:** assimetria; equilíbrio; suporte de carga; bengala; acidente vascular encefálico.

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## Introduction

In physical therapy practice, the treatment of chronic patients with hemiparesis who wish to regain body symmetry lost due to this impairment is commonly performed<sup>1-4</sup>. The search for symmetry is justified by the idea that compensatory patterns of body asymmetries caused by hemiparesis lead to deficit of equilibrium in the orthostatic position. This determines modification of the stability limits in which the affected limb is avoided and the non-affected limb is overloaded<sup>1,5-7</sup>. In the last decade, studies have described characteristics of body asymmetries of hemiparetic patients by investigating the relationships between symmetry parameters and motor performance during postural maintenance, in gait and in functional transfers<sup>6,8-18</sup>.

While healthy subjects maintain a symmetric position of weight distribution between the lower limbs, for the reaction forces to the ground, the muscles are able to perform are similar for both feet. This occurs due to strategies of postural control influenced by mechanisms around the hip and ankles<sup>19</sup>. This symmetry condition is strongly modified by neurological disorders that cause hemiparesis. In this case, one of the lower limbs is overloaded in response to a decreased efficiency of the hip and ankle strategies for postural adjustments<sup>17,19,20</sup>.

Once the investigation of the contribution of each lower limb to postural control of hemiparetic patients was performed, the range of motion, speed and regularity of the center of pressure in the non-affected side were observed as being greater than on the affected side. This indicates a larger contribution of the non-paretic side to postural control<sup>21</sup>. The analysis of the displacement of the center of pressure for each lower limb of the patients demonstrated patterns similar to those observed in healthy subjects when they intentionally placed more weight on one of their lower limbs. This relationship demonstrates that this characteristic is determined by the weight distributed asymmetrically on one limb<sup>7</sup>.

For a long time, asymmetric weight-bearing in hemiparetic patients has been discussed as a risk factor for falls<sup>9</sup>. Relevant improvements in symmetry parameters, however, were not observed after practicing a more symmetric body weight distribution by going from the sitting to the standing position<sup>10</sup>. A cross-sectional study developed after the acute phase to verify the recovery of balance in hemiparetic patients demonstrated that, even though the subjects consciously learned to put more weight on the affected limb, this weight distribution was not an automatic response. When distracted, they went back to overloading the non-affected limb<sup>11</sup>.

Conventional therapies and therapies with visual feedback which train body symmetry were not effective in altering overloads on the paretic limb. The knowledge about how the asymmetric distribution of weight in the standing position is related to balance control in hemiparetic patients is still not well established<sup>22</sup>.

Deficit in balance seemed to correlate with the levels of functional independence<sup>23</sup>, and such situations were present in patients who had just used assistive devices to help their maintenance of posture control<sup>5,13,24</sup>. Although assistive devices stimulate gait of hemiparetic subjects by providing them more safety, they are usually used as an additional support to the non-affected side, what favors asymmetric patterns by overloading the non-paretic limb<sup>5,25</sup>. Asymmetries in weight distributions in hemiparetic patients can be precisely analyzed by methods of posturography using strength platforms<sup>26</sup>. Simpler methods that use two digital scales are also described as being capable of estimating such asymmetries<sup>27,28</sup>.

It has been long known that posture imbalance is highly related to falls and can be easily be measured by the functional reach test<sup>29,30</sup>. The present study aimed to analyze the functional reach obtained by chronic hemiparetic patients who were dependent and independent of assistive devices. This was done by assessing the correlations between displacements achieved by this test and symmetry parameters in the standing, weight-bearing position.

## Methods

### Subjects

Fourteen subjects with spastic hemiparesis, with ages varying from 44 to 82 ( $65 \pm 10$  years, mean  $\pm$  standard deviation) and a post-injury period from two to 84 months ( $29 \pm 23$  months) participated in this study. Sampling was performed among the subjects with hemiparesis who attended the university's outpatient clinic.

To be included in the sample, the participants had to: (1) have had a post-brain injury period of over three months and (2) were able to maintain themselves in the orthostatic position during a period of time long enough to register the weight-bearing in this posture. All the participants who underwent any type of treatments, in addition to the one performed at the school clinic were excluded. All the participants signed a consent term approved by the Research Ethics Committee issued by the Faculty of Medicine of ABC, Santo André (SP), Brazil, with protocol number 088/2008.

## Procedures

A cross-sectional study was used and the measurements were performed in a single session and the variables and their patterns of distribution and association were described. Initially, the inclusion and exclusion criteria were verified among the hemiparetic patients attending the school clinic. Once included, the patients were divided, by visual inspection during their arrival at the interview, into dependent ( $n=5$ ) and independent groups ( $n=6$ ) according to the need of assistive devices to support gait. During the interviews, the age (in years), post-injury period (in months) and total body weight (in kilograms) of each participant were verified. Following the interviews, the assessments of functional reach and weight distribution symmetry in standing were performed.

## Functional reach

Functional reach was evaluated by the use of a ruler graduated in centimeters (cm) and fixated on the wall, which allowed the measurement of displacements up to 200 cm. Each participant was placed with the non-affected side of the body parallel to the ruler and guided to stabilize the upper limbs so that the tip of their fingers would be at the zero level of the ruler. Thereby, one upper limb would be supporting the other without touching any surface in the environment. The patients were guided so that the anterior displacements of the trunk were performed without rotations, avoiding, in this manner, compensatory strategies using the non-affected side. After the placing of the subject in the initial position, the patient was requested to move laterally as much as possible, until immediately before losing balance or compensating the movement with trunk rotations. The procedure was performed three times, always registering the obtained displacement. The mean of the three measurements was used in the analysis.

## Symmetry in weight-bearing during standing

The symmetry in weight-bearing during standing was evaluated by the ratios of the distributions of the weight supported by each lower limb between the affected and non-affected sides of the hemiparetic patients. The measurements of the weight supported on each side of the body were obtained with the use of two calibrated scales with a digital display (Iplenna®) with a maximum capacity of 150 kg. The subjects were placed bare-foot, with their feet aligned, each foot about 20 cm away from the other, without any type of support, and the limbs placed separately on each balance (Figure 1). The display indicated integral values in kilograms (kg) with two decimals.

Once the examiner observed stability in the indication of the integral values by the displays of each scale, the bilateral reading was obtained and registered. In sequence, the equivalence between the subject's total body weight and the sum of the values obtained for both scales was confirmed. In case the sum was inferior or superior in the amount of over 1 kg to the subject's total body weight, the reading was performed again. The values obtained for each limb were registered as weight-bearing values for the affected (Figure 1A) and non-affected sides (Figure 1B).

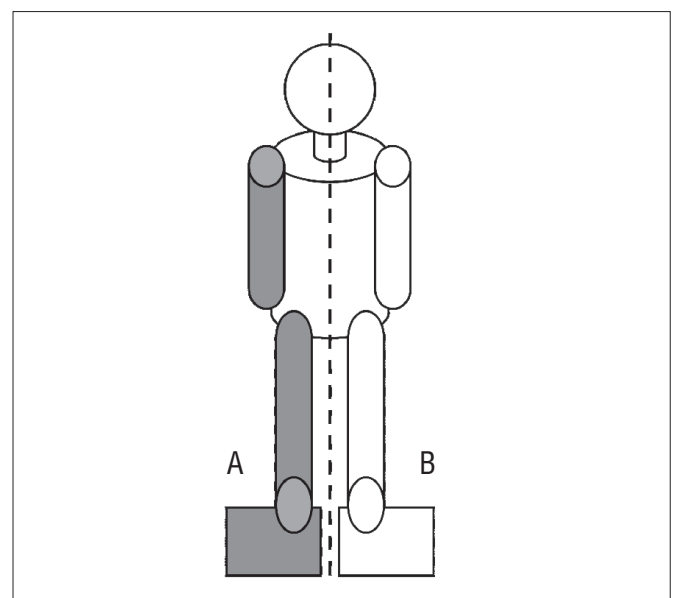
For the analyses, the symmetry ratios were calculated using the formula:

$$rs = \frac{a}{na},$$

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.

## Statistical analysis

All the variables applied in this study were submitted to the Kolmogorov-Smirnov test to verify whether they demonstrated the Gaussian distribution, which determined the use of parametric tests in this analysis. Pearson correlation test was used to verify the correlations indices ( $r^2$ ) between



**Figure 1.** Illustrative scheme of the utilized positions to verify weight bearing on the affected (A) and non affected (B) sides.

the variables. Positive indices would indicate direct correlations between the variables, in other words, as the value of one variable increased, an increase in the value of the other one was also observed. Inversely, negative indices indicated correlations in which an increase in the values of one variable would be accompanied by a decrease in the values of the other one.

Student *t* test was used to compare the means of weight-bearing on the affected side with the non-affected side. It was also used to compare the means of variables obtained with hemiparetic patients dependent and independent of assistive devices during gait. The significance level was established at  $\alpha=0.05$ .

## Results

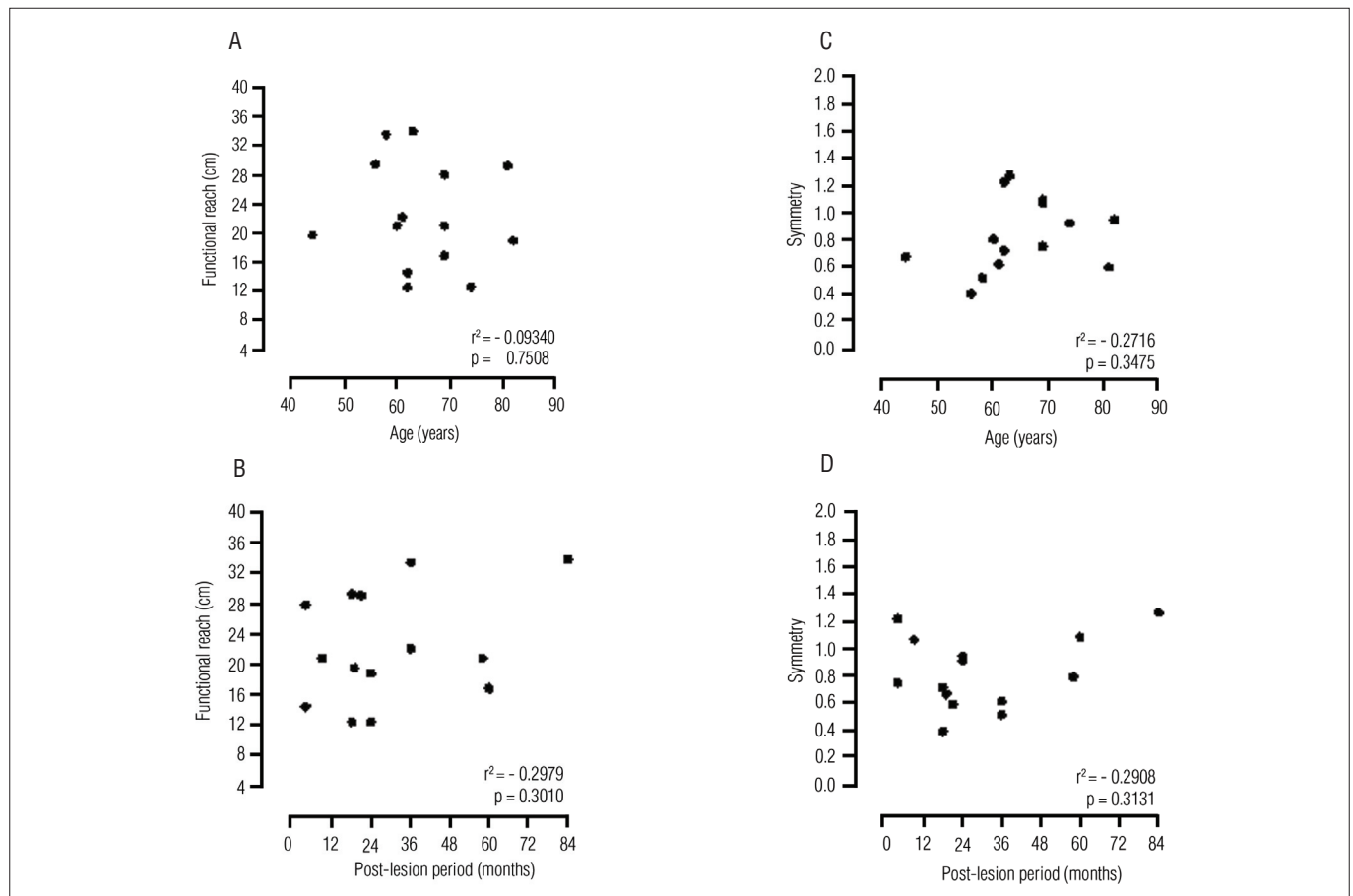
The results for functional reach varied between 12.6 and 34.0 cm ( $22.4\pm7.3$  cm). These results did not correlate significantly with age (Figure 2A) nor with the post-injury period (Figure 2B). The calculated symmetry ratios varied between

0.40 and 1.27 ( $0.83\pm0.26$ ). For the functional reach, the symmetry ratios values did not correlate significantly with age (Figure 2C) nor with the post-injury period (Figure 2D).

The participants had a total body weight of  $77.2\pm13.3$  kg. Forty-six percent of this weight was supported on the affected side ( $35.6\pm7.1$  kg) and fifty-four percent on the non-affected side ( $41.5\pm6.2$  kg). The differences in weight-bearing between these two sides were not significant, as indicated in Figure 3.

Individually, none of the hemiparetic patients demonstrated symmetric weight-bearing in the orthostatic position. Four subjects were observed with weight-bearing asymmetries towards the affected side and 10 subjects towards the non-affected side.

Significant correlations between the functional reach and the symmetry ratios were not observed for the total number of patients who participated in this study (Figure 4A). The same was concluded when the correlations were performed only for the subjects with weight-bearing asymmetries towards the affected side (Figure 4B). However, significant inverse correlations between the functional reach and the symmetry ratios were evidenced for weight-bearing asymmetries towards the non-affected side. This meant that the symmetry ratios became



**Figure 2.** Dispersion graph of the variables correlated by the Pearson correlation tests. The correlations between functional reach and age (A), functional reach and post-lesion periods (B), symmetry and age (C) and symmetry and the post-lesion periods (D) are indicated by the correlation indices ( $r^2$ ) and *p* value.

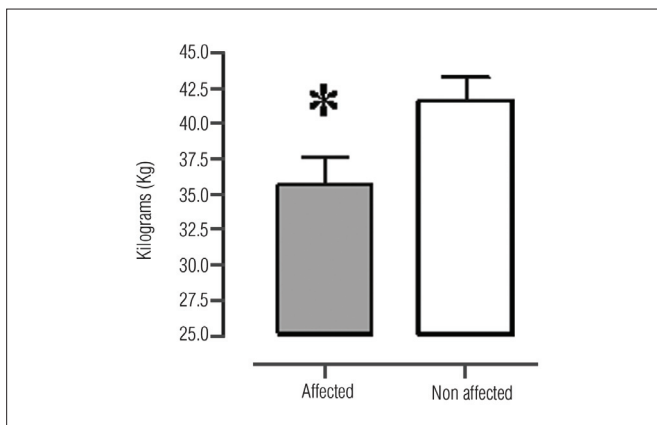
progressively smaller than as functional reach became progressively larger (Figure 4C). When separating hemiparetic patients who were dependent and independent of assistive devices, no differences were observed between age (Figure 5A), post-injury period (Figure 5B), functional reach (Figure 5C), nor symmetry ratios (Figure 5D) for these subjects.

## Discussion

The present study demonstrated that this sample of hemiparetic patients reached about 10 cm less than the elders evaluated by the functional reach test described in another study<sup>31</sup>. Among the elderly population, the risk of falls is increasing, and the decreases in functional reach are intimately related to falls<sup>29-32</sup>. In this manner, as the subjects of this sample demonstrated lower reach values than the elderly population, a higher risk of fall occurrence could be inferred.

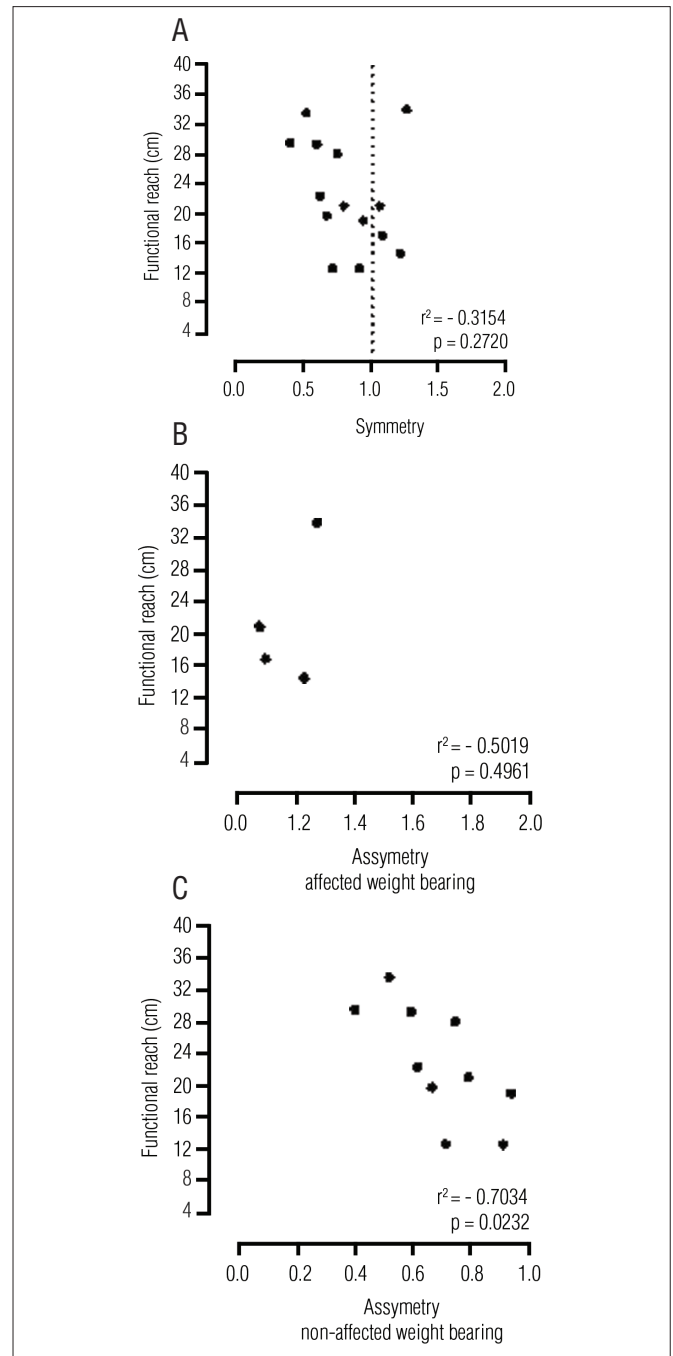
A heterogeneous age group (65±10 years) and varied chronicity (29±23 months) were observed among the participants. However, both the functional reach and the symmetry ratios did not correlate with age and the post-injury period (Figure 2). This indicated that age and chronicity did not determine advantages or disadvantages that could derail any analyses of correlations between functional reach and symmetry ratios.

A mean of 54% of weight support towards the non-affected side was observed. This value was similar, though inferior to the value of about 60% described in the literature<sup>26</sup>. The values of weight-bearing asymmetries towards the non-affected side were influenced by the values of weight-bearing asymmetries of four subjects who, contrary to the majority of the sample, overloaded the affected side. Although it is less common, hemiparetic patients with Pusher Syndrome adopt a postural

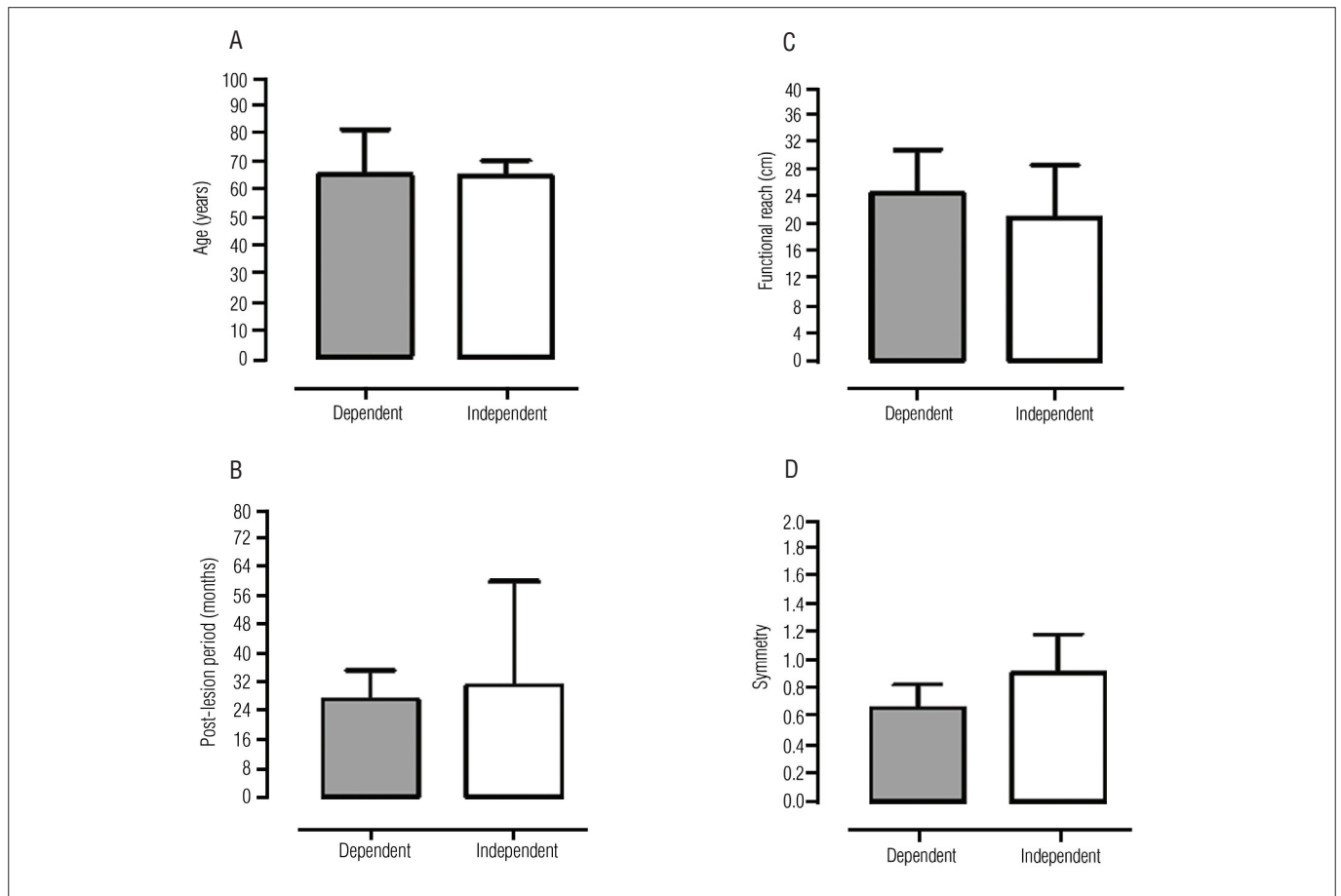


**Figure 3.** Bar graphs indicating average and pattern deviations of the weight bearing values recorded in kilograms (kg) on the affected and non-affected sides of the hemiparetics. The asterisk (\*) indicates significant differences ( $p < 0.05$ ) obtained by Student *t* test.

pattern that pushes them towards the affected side<sup>33-36</sup>. Because of this, a separate analysis of weight-bearing symmetries in terms of predominance of this load towards the affected and non-affected side becomes necessary.



**Figure 4.** Dispersion graph of the variables correlated by the Pearson correlation tests. The correlations between functional reach with symmetry ratio values for the total number of hemiparetics (A), for the hemiparetics with asymmetries of weight bearing predominating on the affected side (B), and for the hemiparetics with asymmetries of weight bearing predominating in the non affected side (C), were indicated by the correlation indices ( $r^2$ ) and  $p$  values. The dotted line in graph A indicates the positions where the values of the symmetry ratios would be equal to 1 (total symmetry).



**Figure 5.** Bar graphs comparing the averages of dependent (gray) and independent (white) support devices of subjects for the variables: age (A), post-lesion period (B), functional reach (C) and symmetry ratio values (D). Non-significant differences were obtained by the Student *t* test between dependent and independent subjects ( $p > 0.05$ ).

The results demonstrated that no significant correlations between functional reach and variations of asymmetry values were evidenced when considering the total number of subjects. However, when separately analyzed by the predominance of overload, inverse correlations were obtained between functional reach and weight-bearing asymmetric values towards the non-affected side (Figure 4C). Initially, the fact that more asymmetric hemiparetic patients achieved a greater functional reach could cause some surprise. Even greater surprises would occur by the extrapolation of the observations of elders to infer that greater displacements would indicate lower risks of falls<sup>31</sup>. These inferences could be due to the considerations that more asymmetric subjects would fall less if these asymmetries were towards the non-affected side.

As significant differences between participants that were dependent or independent of assistive devices were not observed for values of symmetry ratios or displacements obtained in functional reach, one could not speculate on this matter. However, in the present study, it was evident that patients with weight-bearing asymmetries towards the non-

affected side seemed to use this strategy as a compensatory mechanism to obtain greater reach and, consequently, better balance. Further information could clarify this issue in a research design in which the symmetry measures were obtained during the functional reach test. In this way, the behaviors of the weight distribution between the limbs could be verified in a more dynamic manner, while the subjects attempted their maximum reach.

Roerdink et al.<sup>21</sup> described that hemiparetic patients with severe motor impairments develop an effective compensatory strategy based upon weight-bearing asymmetries and lateral control when performing their duties. In addition, such strategies seems to be influenced by the levels of attention and uncertainty of the patient<sup>8,11,21,24</sup>. This evidence is useful for directing the treatment strategies planned for chronic hemiparetic patients. Paradoxically, therapeutic programs are usually adopted to reinforce patterns of body symmetry<sup>1-3</sup>.

The present study demonstrated that, in this sample, the asymmetries contributed to the functional reach. However, the clinical meaning of these correlations could not be clarified due to the limitations related to size and the lack

of analyses, as determined by the vascular syndromes, which would have to be further investigated. It was concluded that, in the present study, symmetric weight bearing did not contribute to improved functional reach or independence from supportive devices in patients with hemiparesis.

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