Research Article



# Virtual reality in thermal body symmetry and muscular force after stroke

## Abstract

The use of virtual reality (VR) in post-stroke patients can maximize praxic-motor skills. The aim of the present study is to investigate whether the use of this interface can improve upper limb muscle strength, balance, body symmetry and functionality. The research was longitudinal, quantitative, case-study with a patient diagnosed with stroke. The selected variables were muscle strength (Load Cell), Body Symmetry (Thermography). The platform of the Nintendo Wii Sports game was used in association with the rehabilitation protocol based on the Bobath concept, in weekly 60 minutes of duration. There was a significant improvement in the scores of the evaluations related to functionality, muscle strength, balance and body symmetry. VR is a biofeedback tool that provides the individual with an immediate return on performance, where body parameters are directly influenced and praxis-motor skills are maximized.

**Keywords:** rehabilitation, stroke, virtual reality exposure therapy

Volume 2 Issue 2 - 2018

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**Received:** February 15, 2018 | **Published:** March 07, 2018

## Introduction

Muscle strength is an important critical component for optimal functional performance after stroke. Muscle weakness is reflected by the inability to generate force at normal levels. Morphological studies of the skeletal muscles in hemiplegic patients have indicated that muscular atrophy happens due to disuse, loss of trophic effects, neurogenic atrophy, and excessive rest in the bed in the acute phase of the pathology. Between the 21st and 61st month after stroke, the number of functioning motor units declines by half, which considerably reduces isometric and isokinetic torque.[1] Another impaired body function from this clinical picture is body symmetry. The asymmetry consists of the inability of the subject to maintain the body weight distribution equally and similar activation levels in both dimids, this means that the uninfected body has hyperactivation while the affected one has a hypoactivation of its functions, this can be evaluated through amount of heat emitted by muscle work. The altered weight distribution on the paretic hemisphere causes a change in the center of gravity to maintain the support base.[2]

The choice of one or more treatment modalities is crucial for the results expected by the therapist and the patient. One of the types of intervention that has been gaining space between practice of rehabilitation is Virtual Reality (VR).[3] Exercises that are performed in a virtual environment allow the patient a constant body adjustment to match the demands of the activity.[4,5] Thus, the purpose of this study is to investigate whether the use of VR can maximize práxico-motor skills of muscle strength, body symmetry, balance and consequent improvement in the functionality of a stroke patient.

## Methodological procedures

### Kind of study

This is a single-case, quantitative and longitudinal case study. This study was approved by the Research Ethics Committee of the University Hospital of the Federal University of Sergipe. The participant signed the term of free and informed consent, according to resolution 466/12 of the National Health Council (NHC).

### Population and sample

In order to carry out this study, a person with a diagnosis of stroke participated voluntarily. The patient, P.M.S, male, 63 years old, goldsmith, married, with a high school diploma, had a 2-year stroke of the ischemic type in the region of the middle cerebral artery, and the right (dominant) body dimidio was affected.

### Torque peak

A load cell was used to electronically capture muscle strength, amplify and transmit in a general monitor for records in newtons of force. It was used for analysis of upper limb muscle strains.[6] The data of muscular strength were collected in kilograms/force, converted into Newton (unit of international force, obtained multiplying by 9.8 the value of the kg/force) and for the second time multiplied by the size of the lever arm (measured in cm the size of the arm of the patient who performed the force). The patient was instructed to perform the movement against the resistance of the apparatus, which is sensitive to changes in compression or stretching. The Kratos®

brand of equipment used was the digital indicator IK14 and load cell MM of the "S" type, for measuring forces in the traction/compression direction, as in universal test machines.

### Body symmetry

In order to evaluate the thermal symmetry, thermographic images were taken before and after clinical care according to the procedures recommended by the European Association of Thermology, performed in a properly prepared room without natural light, only in an artificial way with fluorescent lamps, with no airflow directed to the collection site, ambient temperature conditions maintained through an air conditioner and monitored by a thermometer (HM- 01), around 23°-24°C and relative humidity between 42-50%. The individual was instructed not to perform vigorous physical activity in the previous 24 hours, not to consume alcohol or caffeine, not to use any type of cream or lotions on the skin in the last 6 hours preceding the evaluation. The patient was instructed to stand and not make sudden movements, not cross your arms and do not scratch yourself for a minimum of ten minutes for acclimatization.[7,8] The images were obtained through the thermal imager C2 (Flir System, Estolcomo, Sweden), with a resolution of 80 x 60 pixels, at a distance of 1.5m, with emissivity set at 0.98. The images were then transferred to a computer and analyzed using Flir Tools software (Flir Systems, Stockholm, Sweden).[8] The selection of the Body Region of Interest (BRI) was based on the same ones used in studies by Marins et al.[8] The anatomical points were:

a. Hand: junction of the 3rd proximal phalanx of the metacarpal with the 3rd ulnar styloid process;
b. Forearm: ulnar fossa to the distal forearm;
c. Arm: cubital fossa up to axillary line;
d. Thigh: 5cm above the upper limit of the patella and inguinal line;
e. 5cm below the patella and 10cm above the malleolus. The corresponding anatomical points were also used in the posterior region.

After analysis, the body temperature delta was calculated by subtracting the body temperature pre/post intervention and between the two limbs, being that the asymmetry attention level below 0.4°C is considered as the normal asymmetry rate; 0.5 to 0.7°C- requires monitoring; 0.8 to 1.0°C - requires prevention; 1.1 to 1.5°C- gravity alarm; greater than 1.6°C-high severity.[8]

### Virtual reality

The virtual reality protocol was drawn from literature data and after analysis only one game was used: Boxing of Nitendo Wii Sports with an equipment called kinect that serves as interface between player and machine. The game happened with the patient standing with the kinects in both hands, during the game, cross-movements of the midline with both arms and alternating body weight on the support base. There were 30 sessions that took place during 7 months, each session lasting 60 minutes, executing selected virtual games to favor bilateral and symmetrical movements. Principles of the Bobath Concept were incorporated during the games: stretching and mobilization of upper and lower limb muscle groups; inhibition of spasticity; use of resources to promote balance (balance foam, Swiss ball and balance board); activation of the function and isometry of both upper and lower limbs; distribution of body weight in a symmetrical way, aiming at bilateral muscular activation; perceptual training stimuli of the body environment; alignment and postural control.

## Statistical analysis

For the analysis of the results, we used descriptive statistics with delta and percentage measures to evaluate the patient in the pre and post intervention. Statistical Package for Social Sciences (SPSS), version 20® software was used.

## Results

Peak torque results showed improvement over 50% in right elbow extensors (4.19 vs 10.90, Δ= 6.71, 61.56%), right shoulder adductors (2.57 vs 7.19, Δ=4.62, 64.26%) and right shoulder flexors (3.70 vs 10.95, Δ=7.25, 66.22%). The graphical representation of the data can be observed in Figure 1. Body asymmetry assessed by thermography showed improvement in the BRI arm (NAA monitor 0.6 vs normal 0.4) and posterior hand (NAA monitor 0.6 for normal 0.4) (Table 1) (Figure 2).

**Table 1** Result of the body asymmetry evaluated by thermography through the body temperature delta

| BRI | Δ Tp (°C) PRÉ | ALA | Δ Tp (°C) PÓST | ALA |
|---|---|---|---|---|
| Previous arm | 0.2 | Normal | 0 | Normal |
| Rear arm | 0.6 | Requires monitoring | 0.4 | Normal* |
| Forearm | 0.4 | Normal | 0 | Normal |
| Posterior forearm | 0.7 | Requires monitoring | 0.7 | Requires monitoring |
| Previous hand | 0 | Normal | 0.3 | Normal |
| Posterior hand | 0.6 | Requires monitoring | 0.2 | Normal* |

BRI, body region of interest; ΔTP, body temperature delta; ALA, attention level of asymmetry; below 0.4°C, normal; 0.5 to 0.7°C, requires monitoring; 0.8 to 1.0°C, requires prevention; 1.1 to 1.5°C, gravity alarm; greater than 1.6°C, high severity; *decrease in the asymmetry rate; **increased asymmetry rate.

**Citation:** Paixão MC, Santos KMB, Junior HA, et al. Virtual reality in thermal body symmetry and muscular force after stroke. *MOJ Sports Med.* 2018;2(2):60–63. DOI: 10.15406/mojsm.2018.02.00047

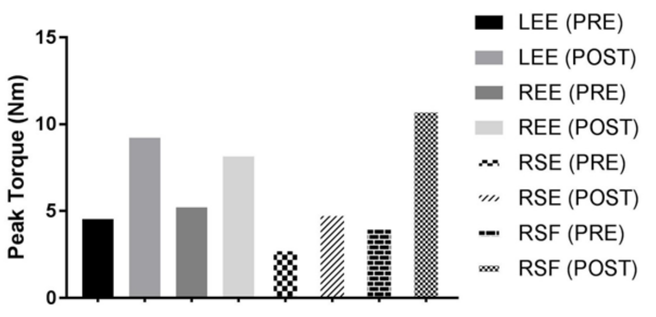
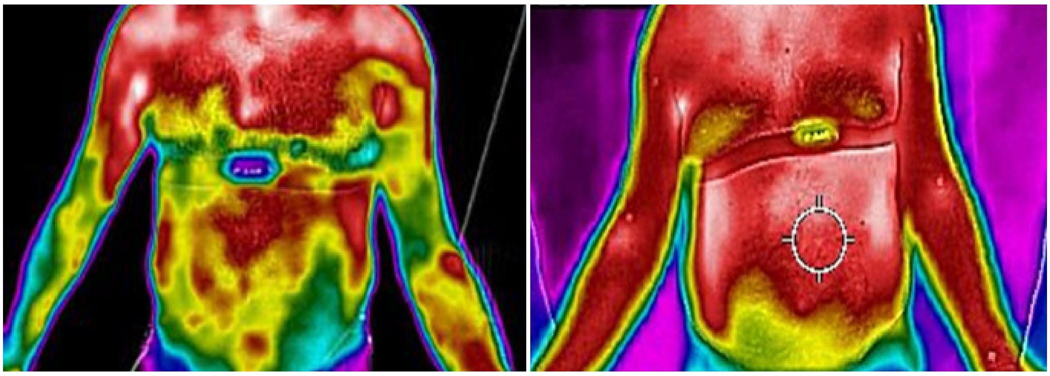



**Figure 1** Results of the muscle strength component evaluated by the load cell.
LEE, left elbow extensors; REE, right elbow extensors; RSE, right shoulder elbows; RSF, right shoulder flexors; PRE, pre intervention; POST, post intervention.



A B

**Figure 2** Thermograms of the upper limbs pre (A) and post intervention (B), respectively.

## Discussion

Muscle strength of the upper limbs showed improvement of more than 60% in some muscle groups (shoulder flexors and elbow extensors of the right upper limb), indicating that the isometry and isotonic contraction performed to sustain and move controls and segments against gravity activated the contraction of muscle fibers. Although the resistance movement has been minimal, for this population the ability to move the limbs against gravity is an activity considered arduous because of low levels of muscle strength and movement control. Increased strength in elbow extensors decreased the synergistic flexor pattern due to stroke. From this data it can be inferred that the use of VR contributes to increase muscle strength, activation and function of the paretic upper limb, rebalancing the use of both upper limbs, which also contributes to the improvement of body symmetry. In the study by Mouawad et al.[9] patients undergoing VR had significant improvements in the executive functions of the upper limb, thus corroborating our results. Also on the function and activation of the upper limb, it is possible to identify in the thermogram that the right upper limb presented low activation represented by cold colors such as blue and green (Figure 2A), while the unaffected left upper limb showed signs of increased activation represented by predominantly red and yellow colors. After the intervention, similar activation was noted in both upper limbs (Figure 2B), indicating that through VR it was possible to modulate the functions of the arms and hands through forced use during the game of boxing. After the interventions it was possible to perceive improvement not only in the upper limbs, but in the general body symmetry.

In the arm and hand (posterior) and posterior thigh body regions, it was possible to identify the decrease in the asymmetry rate, thus changing the monitoring classification to normal rates of asymmetry, thus improving the appendicle symmetry throughout the dorsal region of the limb superior and proximal region of the lower limb.

In the anterior and posterior leg BRI, there was an increase in the asymmetry rate after the intervention. This fact can be explained due to the patient's difficulty in effectively coordinating all the demands of the activity with the required skills. As the game required focusing on the upper limb it may have occurred that the patient had selected attention only for the upper movements, despite the therapist's constant commands to transfer weight equally to the lower limbs. Another hypothesis is that the patient also presented hypertonia/spasticity in the sural triceps in the right lower limb that caused hyperextension of the knee, so each time the patient transferred weight to this segment there were reports of pain. Muscular mobilizations were performed before the game in order to inhibit spasticity, however due to the important degree of spasticity the techniques employed were not sufficient to reduce this condition.

Taking into account the exposure, it is well known that VR promoted a significant improvement in upper limb muscle strength, body symmetry, balance and functionality of the post-stroke patient. Thus, this interface may be indicated for treatment as a therapeutic option because it is an approach that maximizes conventional therapy and can provide motivation for patients. It is suggested that more studies be performed with a larger number of patients, in addition to different statistical tests, since these points were considered as limitation of the present article.

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## Acknowledgements

None.

## Conflict of interest

Authors declare that there is no conflict of interest.

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