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Effects of attentional focus on upper extremity motor performance in post stroke patients

A randomized pilot study

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Abstract

Introduction: To facilitate the command to the learner, therapist can use verbal cues for guidance: internal focus (own body) and external focus (consequence of movement in the environment).

Objective: To examine the effects of different attentional focus on upper limb motor performance in post-stroke.

Methods: Randomized controlled trial with 2 groups. Study realized at Integrated Clinic of the Faculty of Health Science at Trairi (Santa Cruz, Rio Grande do Norte, Brazil). Twelve participants allocated into 2 groups. Two motor tasks were used: task 1, reach-point; task 2, reach-grasp-fit, with the paretic extremity, using verbal commands directed by a trained therapist. In the first phase, Group 1 received commands with internal focus, while Group 2 was instructed with commands with external focus. After 1 week, the command type was changed between groups. The variables collected was movement time, velocity and number of peaks velocity

Results: Both attentional focus promoted significant differences in movement time and velocity, however, only Internal Focus provided significant results in both tasks of the same variables.

Discussion: The benefits of 1 attentional focus on the other are not fully confirmed. However, not receiving any kind of attention guidance compromises motor performance. The results support the hypothesis that the benefits of the External Focus are accentuated when preceded by the Internal Focus.

Clinical Trial Registration: Research Ethics Committee of the Faculty of Helth Science at Trairi (Facisa - UFRN)- Number CAAE 2.625.609, approved on April 13, 2018; Brazilian Registry of Clinical Trials - RBR-4995cr approved on July 4, 2019 retrospectively registered (http://www.ensaiosclinicos.gov.br/rg/RBR-4995cr/).

Abbreviations: EF = external focus, FMA-UE = Fugl–Meyer Upper Extremity Assessment, G1 = Group 1, G2 = Group 2, IF = internal focus, MMSE = mini mental state examination, R = repetitions, T1 = task 1, T2 = task 2, TDAI = temporal data acquisition instrument, UEs = upper extremities.

Keywords: motor skill, rehabilitation, stroke, upper extremity

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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1. Introduction

Motor activities performed by the upper extremities (UEs) are commonly affected in post-stroke patients.[1] Rehabilitation strategies are the basis of the treatment to facilitate motor function recovery and integration of the post-stroke patients into the society.[2] This process suffers several influences, which may be potentiating or dispersing in the final process of the task to be successful, being considered as learning variables.[3]

Studies have demonstrated that therapist guidance on how the task should be performed is a central and effective factor in the rehabilitation process.[4–6] This resource is an important mediator to promote the cognitive representation of the observed model and to guide the learner's attention to critical aspects of movement. Thus, verbal commands appear as an important role in motor learning.[4,5,7]

The therapist can provide commands to the patient using verbal cues. These verbal cues include the use of short, concise sentences to direct the attention of the patient performing the movements, remembering the essential motor components to perform the task.[3]

Attention focus can be categorized into 2 types. First, internal focus (IF), in which the performer's attention is directed to the structure and movement of the body.[8] For example, in javelin throwing, the attention is directed to the movement of the arm or opening the hand to release the javelin.[4,9,10] Second, external focus (EF), in which the attention is directed to the consequences of environmental movement. For example, in javelin throwing, the attention is directed to the trajectory of the javelin or the target.[4,8,11,12]

Several studies have reported that efficiency of motor learning and performance is highly dependent on attentional focus applied by the therapist.[3,4,11,13,14] Some studies have demonstrated that EF is superior to IF in terms of performance and learning of motor skills.[4,6,11,15,16] However, in the absence of adequate instructions regarding specific type of attentional focus, patients tend to use conscious mechanisms for task execution, generating difficulties and slowing information processing and task execution.[4,6,8,17]

Studies have demonstrated the advantages of EF in healthy individuals, including consistent improvements in movement effects (such as accuracy and reduction of reaction time), immediate beneficial effects on performance, and retention and transfer, all of which enable automated motor control, whereas IF has been demonstrated to promote more conscious movement.[4,8,16,18]

The benefits of EF and IF, as well as their relationship with the level of motor impairment or memory, are unclear in post-stroke patients. The knowledge of these factors could help choose the most appropriate attention focus to improve the motor performance of these patients.[9] Additionally, communication during therapy has a significant impact on the patient's performance and motor learning. However, the therapist often uses complex and large instructions during rehabilitation, which can be difficult to follow. Research on this aspect will help improve therapists' verbal commands during rehabilitation of this patient population.

In this study, we aimed to examine the effects of IF and EF on UE motor performance in post-stroke patients.

2. Methods

2.1. Participants

This quantitative, pilot study included 14 patients. The participants who had been admitted to the Integrated Clinic of the Faculty of Health Science at Trairi (FACISA, UFRN), Santa Cruz, Rio Grande do Norte, Brazil, from January to April 2019 were selected telephonically and then screened for inclusion. Voluntary informed consent was obtained from all the participants. The study was approved by the local ethics committee (CAAE 2.625.609) and Brazilian Registry of Clinical Trials (RBR 4995CR).

Patients were included if they had a single and unilateral stroke; performed flexor/extensor synergy movements related to subsection; had a Fugl–Meyer Upper Extremity Assessment (FMA-UE) score of 1 or 2; had no sensory alterations in UEs on the Nottingham scale; and scored 20 (illiterate participants) or 25 to 28 (educated participants) in the Mini Mental State Examination (MMSE).[20] Participants with aphasia or being absent at 1 of the study phases were excluded.

2.2. Procedures

The telephonically selected participants were enrolled if they met the inclusion criteria. A trained therapist applied the FMA-UE, Nottingham scale, and MMSE, which was completed in 40 to 50 minutes. Of the telephonically selected patients, 12 who met the inclusion criteria were enrolled for the study and 2 were excluded because of aphasia.

Signed, informed consent (Term of Knowledge) was obtained from the patients after being appraised of the study details. One of the study's researchers was responsible for generating sequence, hiding allocation and implementing randomization. Randomization was by ordinal sequence of subjects eligible for the protocol, following the order of groups (first elegible patient for Group 1 [G1], second patient for Group 2 [G2]). Each group was composed of 6 individuals, to minimize any bias.

The study was conducted in 2 phases, and each phase in a single day. The 2 phases were separated by a 1-week interval. Regardless of the group or the phase, the tasks performed were the same. The only difference was in terms of the verbal commands provided by the therapist. In the first phase (phase A), G1 received commands with IF and G2 with EF. After 1 week, in phase B, the type of attentional focus was switched between the groups: G1 received commands with EF and G2 with IF.

The participants performed the same tasks, irrespective of the group they belonged to and the study phase, according to the protocol of the Temporal Data Acquisition Instrument (TDAI).[21] Both tasks were performed with the patient sitting, with the back supported and the trunk without restrictions, facing an adjustable-height table, and the elbow positioned at 90° flexion, shoulder at 0°, and hands on the table (demarcated point). TDAI was positioned in front of the participant at a distance equivalent to 90% of the arm length (distance measured between the axillary line and the sternum styloid process) (Fig. 1A).

Two reach and grasp tasks with the paretic UE were performed: reach-pointing (task 1 [T1]) and reach-hold-fit (T2). In T1, the participants were instructed to reach and touch 3 targets arranged in an "L" shape. In T2, the participants were instructed to carry a glass between 2 distinct targets, spaced 15-cm apart. Sixteen repetitions of each task were performed, with an interval of 15 s between each repetition and 3 min between each type of task (Fig. 1B).[21]

2.3. Intervention

Before beginning each task, the therapist demonstrated only once the movements that had to be performed by the patient. The participant was asked to make 1 movement attempt. This moment was only for observation, during which the therapist verified the strategies used by the participant to reach the targets and the motor points that needed guidance. Subsequently, to perform the 16 repetitions, a simple verbal command (according to the group and phase) was directed to the patient. The list of verbal commands used for each attention focus is provided in Table 1. The verbal commands were construction on the basis of a previous study's protocol.[9]

Each repetition was preceded by a single simple verbal command (combined commands were used only in the last 5 repetitions, with a maximum of 2 commands for each repetition) and by sound trigger (from the data acquisition board), transmitted by the evaluator as a reference to the participant to initiate the movement and to synchronize all the files.

In addition to movement time and velocity data (obtained by TDAI), peak velocity data were obtained using a free cinematic software (CVMob version 4.0). Therefore, the whole experiment

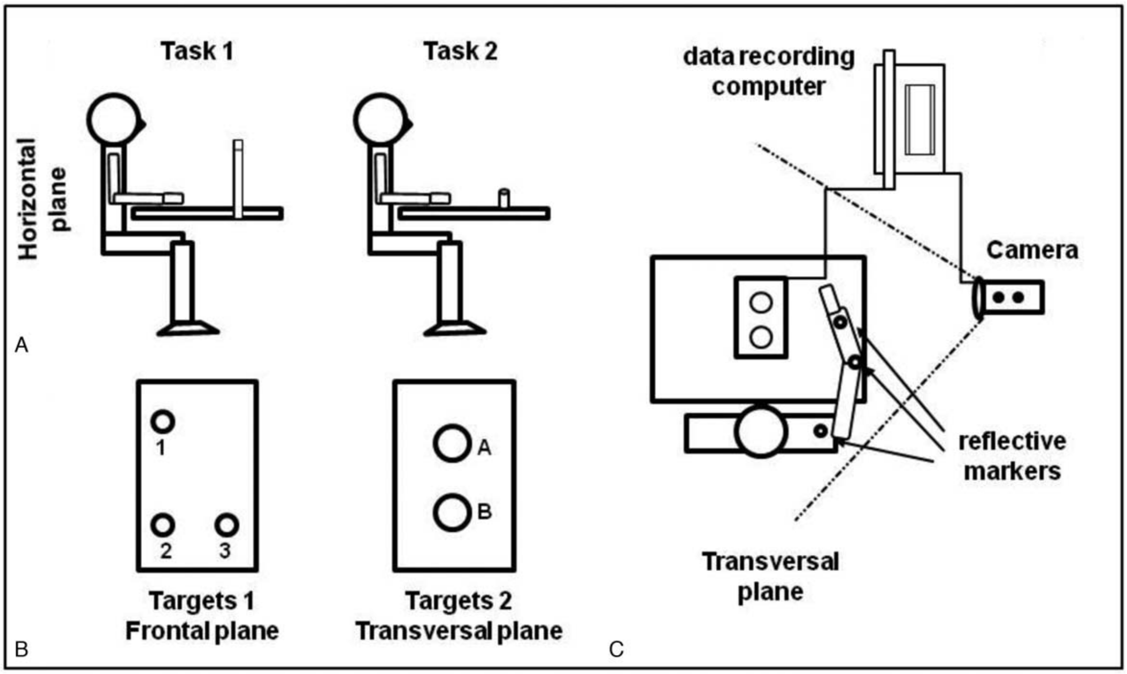

Figure 1. Participant positioning. (1A) The execution of both tasks was performed with the individual in the same position, the only changes were made only on the platform. (1B) For Task 1 it was placed vertically, with 3 targets arranged in “L” (left image), while for Task 2 the platform remained horizontally, the circumferences were arranged in line. The cup was positioned above the platform, in the target “A.” The participant should grab the glass and fit in the target “B” (right image). (1C) The camera was positioned in the sagittal plan and was connected to the data recording computer, as well as the TDAI and the synchronizer (which emitted sound and light). Reflective markers were also used at the upper extremity.

was filmed using a Canon Vixia R800 FullHd camera with a sampling frequency of 30 Hz (image consent form was signed by the participants). For this, reflective markers (1 cm in diameter) were used at the UEs (acromial process, lateral epicondyle, and styloid ulnar) (Fig. 1C).

The camera was positioned in the sagittal plane, and TDAI and CVMob data were processed (using the) using Octave in version 4.2.1. The following variables were calculated: movement execution time (including time to reach each goal and total time), velocity, and peak velocity (Fig. 1C).

2.4. Statistical analysis

The BioEstat version 5.3 software was used for data analysis. Data normality was assessed using the Shapiro–Wilk test and nonparametric tests. The study population and clinical characteristics were defined using descriptive statistics. The Friedman test was used to compare the 16 repetitions of each task, in each phase, to determine the changes in motor performance.

The Mann–Whitney test was used for intergroup comparison and determination of differences between IF and EF (G1 Phase A - Internal Focus x G2 Phase A - External Focus; G1 Phase B -

Table 1

Internal and External commands.

Desired body movement	Internal Focus	External Focus
Trunk - extension	Try to stretch your arm instead of pushing your trunk forward	Try to get as close as possible to the target by keeping against the chair
Shoulder – flexion	Raise your arm higher	Go towards the target
Shoulder – extension	Try to keep your elbow close to your body.	See this sticker on the table? Try to follow it
Elbow – extension	Stretch your elbow more	Get closer to the target
Wrist	As you move your arm forward, try to bend your hand	As you get close to the target, try to bring that target toward
Fingers – task 1	Look at your fingers, straighten your index finger	Touch targets in number order
Fingers – task 2 (to open)	Look at your fingers, push them apart	Try to open as time as you encompass the glass
Fingers – task 2 (to close)	Bend all fingers, closing your hand	Encompass the glass fuly to make more secure
Thumb	Spread your thumb away from the rest of your fingers	See this tape? Take the sticker closer to you (blue sticker placed on the subject's thumb before the protocol begins)
Grasping	Close your hand, bringing your fingers firmly together.	Grab the glass and take it toward the ceiling away from the table.
Fitting	Bring it closer to your body and snap it	Bring the glass closer to the table to fit the target
Velocity	This time, try moving your arm faster	This time try to touch the targets / grab the glass faster
Coordination	As you stretch your arm open your hand. Try to make both movements together.	As you approach the target, prepare to grab the glass.

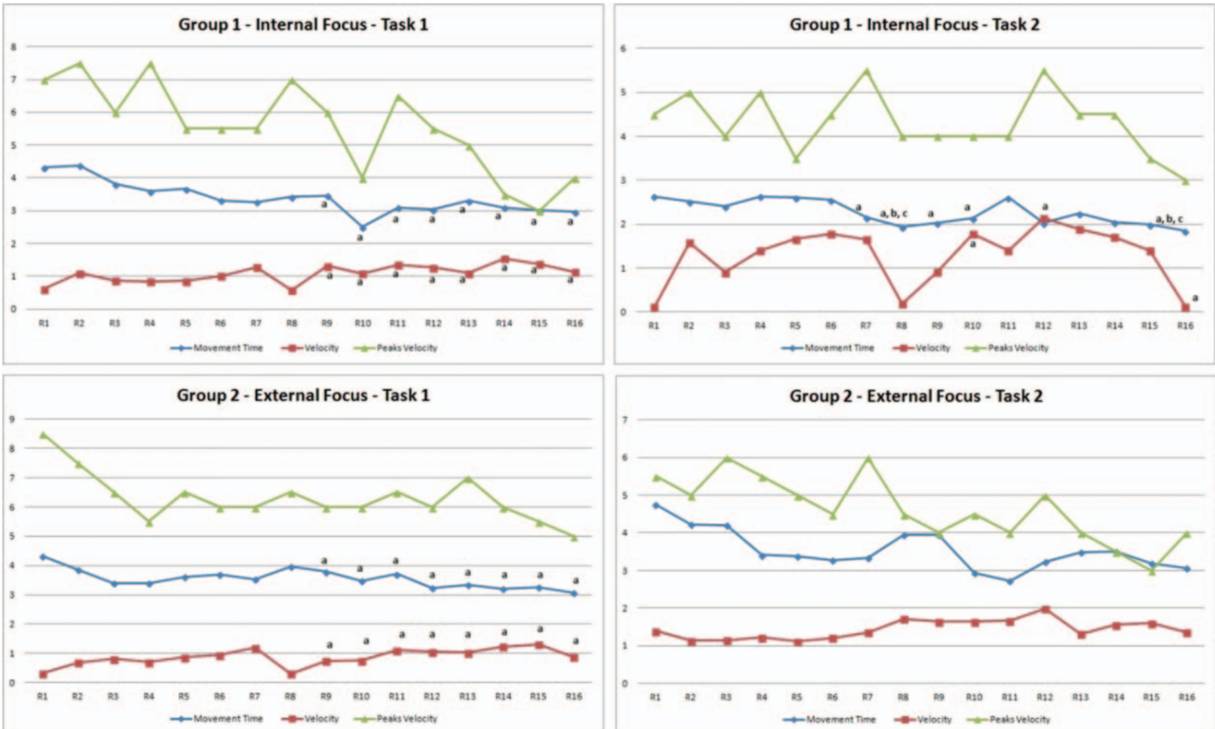

Figure 2. Motor behavior along the 16 repetitions of Phase A. The 2 images above represent the variables of movement time (in seconds), velocity (in centimeters per second) and the peaks velocity for group 1 - phase A (with attention focused to internal focus), where in both tasks were observed significant values in total time and average velocity. In the 2 lower images are represented the temporal variables of group 2 - phase A (external focus), which in turn presented significant values only in task 1. The Friedman Test was used ($P < .05$). [a]statistically significant when compared to 1R; [b]statistically significant when compared to 2R; [c]statistically significant when compared to 3R.

External Focus x G2 Phase B - Internal Focus). For Mann–Whitney test, the averages of the first 3 repetitions (initial averages) and the average of the last 3 repetitions (final averages) of each task were considered.

The Wilcoxon test was used for intragroup comparison and establishing whether the order in which different types of attention provided to the patients affected the motor performance (G1 Phase A x G1 Phase B; G2 Phase A x G2 Phase B) For the test, the first 3 repetitions and the last 3 repetitions of each task were considered.

3. Results

The groups were similar in the number of individuals (n=6), male-to-female proportion (2:4; women, 33.4%; men, 66.6%), median age (G1: 64 [52.2–70.2] years; G2: 66 [52.2–70.2] years), dominant hand (right-handed), chronicity of the disease (injury time: G1: >6 years; G2: >3 years).

In G1, the FMA-UE; Nottingham sensorial test; and MMSE scores were 54.5 (median: first quartile/third quartile: 49.5/55.7); 152 (143.7/153); and 21.0 (20.5/21.0) and 28.0 (26.0/29.0) (respectively, for the 3 illiterate and 3 educated participants), respectively. The respective values in G2 were 53 (49/54.7); 143.5 (137.5/148); and 21 and 24.0 (24.0/26/0) (1 illiterate and 5 educated participants, respectively).

Motor behavior (movement time, velocity, and peak velocity) was analyzed in each group for the 16 repetitions (R). In G1 and G2 (phase A; T1), statistically significant differences were found between 1R and from 9R to 16R for movement time and velocity variables (Fig. 2).

In G1 (phase A; T2), significant differences were found in movement time between 1R (median: 2.62 s; quartiles: 2.32/3.31) and 7R (2.15 s; 2.06/2.52) to 10R (2.14 s; 1.87/2.91), as well as 12R (2.05 s; 1.94/ 3.28), 14R (2.05 s; 1.97/2.82), and 16R (1.96 s; 1.59/2.75). In addition, significant differences were found between 8R (2.06 s; 1.79/2.78) and 16R when compared with 2R (2.52 s; 2.32/2.66) and 3R (2.40 s; 2.08/2.66). Regarding velocity, a significant difference was noted between 10R (1.0 cm/s; 0.94/1.26) and 15R (1.15 cm/s; 1.00/1.43) when compared with 1R (0.06 cm/s; 0.04/0.08). Regarding peak velocity for both tasks in G1 (phase A), no significant differences were noted. In G2 (phase A; T2), no changes in motor performance were found in any of the variables studied (Fig. 2).

In phase B (T1), statistically significant differences were found between 1R and 9R in movement time in G1 (EF). However, significant differences were found only in movement time from 9R to 16R when compared with 1R. In phase B (T2), no significant differences were found in both groups (Fig. 3).

Intragroup and intergroup comparisons were performed for attention focus. In the intragroup comparison, IF and EF were compared (G1 - Phase A x G2 - Phase A; and also G1 Phase B x G2 Phase B) using the average value of the first 3 repetitions (initial averages: 1R; 2R; and 3R) and the average value of the last 3 repetitions (final averages: 14R; 15R; and 16R) of each task. In the intergroup comparison, the initial means and final means (Initial Averages Phase A x Final Averages Phase A; Final

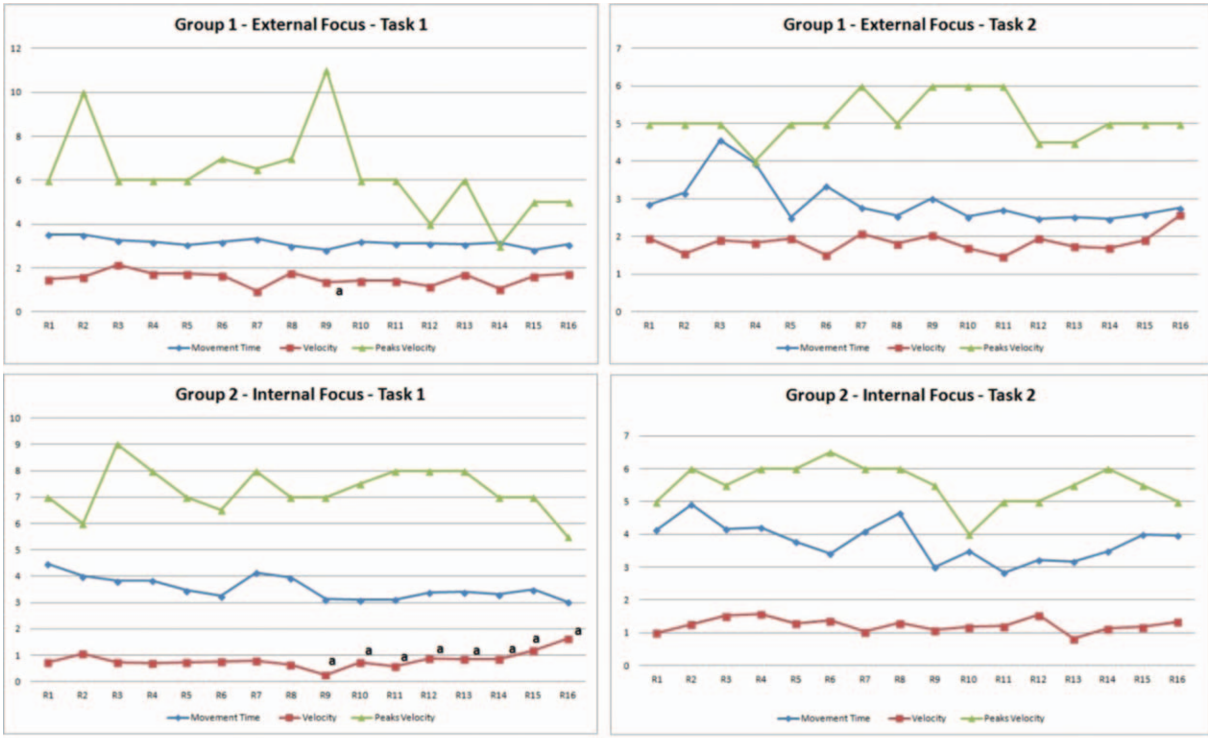

Figure 3. Motor behavior along the 16 repetitions, in both tasks, of Phase B. The two images above represent the temporal for group 1 - phase B (external focus). In this phase, the variables of total time number of peaks of velocity presented significant values (task 1). In the two lower images are represented group 2 – phase B (internal focus), that only total time had significant values, also in task 1. Task 2, in both groups, did not show significant changes in motor behavior during repetitions. Friedman Test was used ($P < .05$). [a]statistically significant when compared to 1R.

Averages Phase A x Initial Averages Phase B; Initial Averages Phase B x Final Averages Phase B) were compared separately for both groups (Table 2).

4. Discussion

Both attentional focus, EF and IF, provided similar motor enhancements, offering positive effects on total time of execution and mean velocity variables. The only difference found from 1 type of focus from another was that IF provided significant differences in both the selected tasks and EF only in the first task.

Therapists often invest considerable talk time during rehabilitation, where instruction and feedback are constantly given. Therefore, it is necessary for the therapist to recognize the importance of attention focus (coming from communicating with the learners/practitioners during therapy) on the performance

Table 2

Intragroup and intergroup analysis during Task 1, in both phases.

	Phase A			
	Internal Focus (G1)		External Focus (G2)	
	Initial Averages	Final Averages	Initial Averages	Final Averages
Movement Time (s)	3.8 (3.1/4.2)*	3.1 (2.3/3.7)*	3.7 (3.3/4.2)*	3.2 (2.7/3.4)*
Velocity (cm/s)	0.87 (0.84/0.99)*	1.2 (1.1/1.4)*	0.8 (0.6/1.3)	1.6 (1.0/1.9)
Peaks Velocity (n)	6.5 (5.2/7.7)†	4.5 (4.0/8.0)	7.5 (6.2/8.7)†	5.5 (2.7/6.0)
	Phase B			
	External Focus (G1)		**Internal Focus (G2)**	
	Initial Averages	**Final Averages**	**Initial Averages**	**Final Averages**
Movement Time (s)	3.3 (3.0/3.5)*,†	3.0 (2.7/3.1)*	4.2 (3.5/4.9)*,†	3.9 (3.0/4.7)*
Velocity (cm/s)	1.6 (1.3/1.6)	1.5 (1.2/1.7)	1.5 (0.4/1.8)	1.9 (0.9/1.7)
Peaks Velocity (n)	6.0 (6.0/6.0)†	5.0 (5.0/6.5)	6.0 (4.2/7.0)†	5.5 (5.0/6.0)

Values in: median (first quartile / third quartile)
G1 = Group 1; G2 = Group 2; Q = quarter; s = seconds; cm/s = centimeters per seconds; n = number
* significant difference between Phase A x Phase B (intragroup).
† significant difference between G1 x G2 (intergroup); The data related to intragroup analyzes, obtained through the Wilcoxon Test, and those related to intergroup analyses through the Mann Whitney Test ($P < 0.05$)

and motor learning of their patients.[14] Moreover, the therapist can regulate and manipulate motor learning process-related variable throughout the treatment period, potentiating the desired results.

Post-stroke patients appear to respond differently to the types of attentional focus when compared to healthy individuals. Studies on the effects of EF and IF on this patient population are limited. Moreover, this being a broad heterogeneous group may present different responses on the basis of the individual's level of commitment.[9,14,22,23,24]

However, not receiving any kind of attention guidance, either IF or EF, may result in patients adopting their own strategies, generating greater attention/memory demand and compromising the automated motor functioning.[8] In this study, both types of attention focus caused significant positive changes in execution time and mean velocity when the first repetitions were compared with the final repetitions (only for T1).

Studies demonstrated that healthy individuals who received EF had a tendency to focus on the task's end goal, promoting shorter motor reaction and control times, whereas those who received IF related instructions focused on the movement of the body and how to consciously control it, leading to superficial muscle activity and impaired task performance.[4,8,11,12,16,24]

EF is associated with less memory processing, which can be beneficial to post-stroke patients.[23,25,26] However, a small sample (n = 10) study reported that IF was superior to EF in execution of dynamic balance activities.[19]

Few studies have investigated the effects of directing attention in post-stroke individuals, and most of them have explored exclusively its immediate effects on the motor performance.[9,27,28] In this study, the immediate effects of different types of attention focus were investigated. Motor performance measures were observed in 3 different ways: first, over 16 repetitions of 2 tasks, where the changes in each group were analyzed separately.

On first analysis, both EF and IF appeared to promote significant differences in time of execution and mean velocity (only in T1). However, we observed that verbal commands with attention directed to IF promoted a greater amount of significant alterations in the mentioned variables, being observed in both tasks, whereas in the EF results were found only in T1.

The literature is unclear regarding the benefits of 1 type of attention focus over the other, as well as the relationship between the level of the motor impairment or of the memory as factors that may influence the use of the type of focus.[9,24]

To investigate the differences that may exist between the types of focus and their effects on post-stroke motor performance, we performed a second analysis. In the second analysis, intergroup comparison in both the phases was performed. That is, G1 Phase A (IF) was compared with G2 phase A (EF), and G1 Phase B (EF) was compared with G2 phase B (IF). No significant differences were found in the means of the final repetitions between the groups that received IF or EF in both phases. These results are in accordance with those of the previous studies, in which both types of attentional focus provided similar improvements.[24,29] Observational studies suggest that, during rehabilitation, post-stroke patients should first receive IF.[9,14,27]

Post-stroke patients tend to instinctively use IF to control movement over time.[30] This fact may compromise the automation of movement in these individuals, a phenomenon called "constrained action hypothesis".[4,9,28]

Considering this aspect, we performed a third analysis to verify if the order of receipt of verbal commands (IF followed by EF [G1] or EF then IF [G2]) significantly affects motor performance. The results suggest that the benefits of EF are accentuated when preceded by IF, because G1 (IF followed by EF) demonstrated significant values in total time and mean velocity variables and G2 (EF followed by IF) presented significant values only in time.

This result corroborates with those of previous studies, suggesting the importance of providing patients with information about their own movement first, to guide them in the following sessions about the effect of movement on the environment, which improves the motor performance of individuals.[9]

The limitation of this study was the small sample. The limitation of this study was the small sample. We believe that the small sample size is due to the fact that 1 of the inclusion criteria was post-stroke individuals who had a high functional level, which excluded a large part of the studied population. We emphasize that the study was carried out with an innovative experimental protocol, using a kinematic analysis equipment developed by the authors. Thus, our study presents an innovative experimental design and an important reflection based on how the verbal command of the therapist can influence the motor performance of post-stroke individuals during treatment. As it is a pilot study and with a small number of participants, we understand that the results found cannot be extrapolated to the general population or to those individuals affected by stroke in other locations, considering that there are socioeconomic and cultural variables that also influence results found.

We therefore, suggest new studies, using a larger sample size, where the use of our experimental protocol can be useful to observe the difference between the types of verbal command in motor performance.

5. Conclusion

In conclusion, the results support the hypothesis of better use of verbal guidance, provided by the therapist to post-stroke patients, when commands directed to EF are preceded by IF. It is pertinent that the therapist is aware of the importance of verbal commands while providing rehabilitation therapy, because the motor learning variable can be easily manipulated to obtain the expected results. Moreover, it enables the therapist to observe the particularities of each individual to choose verbal instructions that are concise and simple to understand but significant enough to improve post-stroke motor performance.

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