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Mental practice is effective in upper limb recovery after stroke: a randomized single-blind cross-over study

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Aim. **The aim of this study was to investigate the role of mental practice (MP) in functional recovery of upper limbs in stroke patients.**

Methods. **Thirty-six hemiparetic stroke patients (15 females and 21 males) were enrolled in a randomized single blind cross-over study. Patients were randomly divided into two groups, (A and B) each comprising 18 patients. Patients in group A underwent the conventional neuro-rehabilitation protocol (therapeutic exercise and occupational therapy) for three weeks (3 hours a day, 5 days a week) and in the following 3 weeks, they received an additional 60 minutes of MP training. Patients in group B, instead, underwent, in the first 3 weeks, the rehabilitation program plus MP training and in the following 3 weeks, only the conventional neurorehabilitation program. All patients were evaluated at baseline (T0), at 3 weeks (T1) and at 6 weeks (T2) with the Motricity Index (MI) and the Arm Functional Test (AFT).**

Results. **At baseline (T0) there were no significant differences at MI and AFT between the two groups. At T1 the differences between the two groups became significant. At T2 the difference was once again minimal.**

Conclusion. **These results suggest that MP could be used to complement to the conventional neurorehabilitative treatments usually prescribed for post-stroke neuromotor recovery. However, there is still much to be tested and discussed regarding the role that MP might play in the treatment of neurological patients.**

Key words: Stroke - Upper extremity - Paresis.

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Stroke is the second cause of death worldwide and the third in Western countries, the most common being cardio-vascular diseases and cancer. It is also the first cause of disability with a huge impact on daily activities and social participation.[1-3] Approximately 50% of stroke survivors present significant limitations in activities of daily living (ADL). It has been calculated that in Italy over one million stroke patients require rehabilitation.[4]

Impairments related to stroke affect motor-sensory, cognitive and psychological functions. Among these, the most common is undoubtedly hemi-paresis. In the acute phase, more than 80% of patients present hemi-paresis, that persists chronically in over 40% of cases.

The Copenhagen Stroke Study, which evaluated 1 197 acute stroke patients over a period of 25 months, reported that neurological and global recovery could be obtained in a relatively short time span, with maximum recovery at three months.[5-7] Duncan *et al.* demonstrated that recovery of the upper limbs was generally obtained within the first thirty days and its level was related to the severity of initial motor impairment.[8] In a study of 55 patients, Higgins also demonstrated that functional recovery of motricity of the upper and lower limbs was 50% in a period of only four weeks.[9] Nakayama, in his paper on functional recovery of the upper limbs after stroke, stated that "if functional recovery has not occurred by the 11th week, further recovery of upper extremity function should not be expected".[6]

Upper limbs motor impairments can also affect global functional recovery. In order to overcome this obstacle, rehabilitation methods, which specifically address the recovery of upper limb function in stroke patients, have been introduced.

Mental practice (MP) is a technique by which physical skills can be cognitively rehearsed in a safe, repetitive manner.[10, 11] This has led to the hypothesis that MP may contribute to the activation of neural loops and movement patterns. It was initially used in sports training in order to improve specific athletic skills. Recently, MP has been introduced in a rehabilitative setting to increase motor skill learning and performance.[12] MP has also been proposed as part of stroke patient rehabilitation.[9, 13]

The objective of this study was to evaluate the role of MP in postacute rehabilitation training in order to improve functional outcome of the upper limb in stroke patients.

Materials and methods

A randomized single-blind study on stroke patients with paresis of the upper limb as a consequence of ischemic stroke was performed. Participants were recruited from stroke patients in an Intensive Neuro-Rehabilitation Care Unit. A physiatrist assessed potential participants to determine eligibility and to collect written informed consent.

From January to June 2008, 36 patients suffering from hemi-paresis after stroke were enrolled in the study (15 females, 21 males, mean age 60.11 years, mean onset 7.39 weeks). All subjects met the following inclusion criteria: 1) first episode of unilateral ischemic stroke with paresis of the upper limb; 2) onset between 1 to 3 months; 3) Motricity Index [14] of the upper extremity (MI-UE) ≥30; 4) ability to understand and follow simple verbal instructions and good cognitive level (Mini Mental State Examination [15] - MMSE ≥24); 5) age 18-75 years.

Patients were randomly divided into two groups, (A and B) each comprising 18 patients, using a computer-generated random number. Patients in group A underwent the conventional neuro-rehabilitation protocol (therapeutic exercise and occupational therapy) for three weeks (three hours a day, five days a week) and in the following three weeks, they received an additional 60 minutes of MP training. In this training, the patient was led to a comfortable, quite room, twice a day, where s/he could lie down and perform relaxing exercises before listening to an audio CD on which s/he was asked to imagine in detail some simple activities involving the upper limbs. The activities were those included in the Arm Functional Test (AFT) [16] (Table I). Patients in group B, instead, underwent the rehabilitation program plus MP training in the first three weeks and in the following three weeks the conventional neuro-rehabilitation program alone (Figure 1). The protocol was approved by the Institute Ethics Committee.

TABLE I.—*Arm Functional Test.*

	Arm Functional Test
1	Place the forearm on the table
2	Extend the elbow to the maximum possible degree
3	Flex the elbow in order to approach the hand to the lips
4	Bring back the elbow in maximum extension pushing with the back of the hand a glass full of water across the table
5	Flex the elbow pushing with the palm of the hand the glass towards the person
6	Lift the glass and bring it close to lips
7	Grasp one straw between index and inch and put it in the glass
8	Make a tower with three wooden cubes
9	Flip three game cards
10	Fold a napkin twice to form a triangle
11	Take a small basket full of fruits from the chair in front of you and put it on the table
12	Turn the key in lock to open and close the door

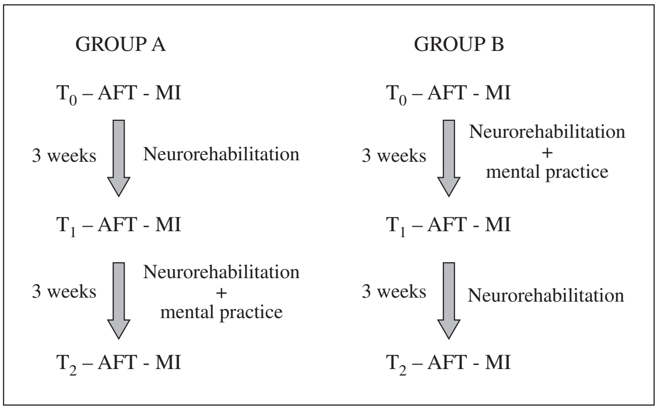

Figure 1.

All patients were evaluated at baseline (T0), at three weeks (T1) and at six weeks (T2). In order to assess motor strength and ability we used the following scales: 1) the subtest for the upper limb of the Motricity Index and 2) the Arm Functional Test. This latter, derived from Wolf Motor Function Test,[17] provides information about two parameters – performance quality, measured by the Functional Ability Scale – FAS,[17] and speed of execution measured in hundredths of seconds.

All assessments were carried out by a physiatrist who did not know to which group the patient belonged.

Statistical analysis

Data were analysed using SPSS for Windows. Groups were compared at baseline using the Student's t-test for independent samples for the continuous variables and Fisher exact test for categorical data. To test between-group differences in changes score for strength and upper limb functioning the Mann-Whitney Test was used. To analyse patient progress in the three evaluation times the Wilcoxon Test was used. Significance was set at 0.05.

Results

Demographic and clinical characteristics of the two groups are presented in Table II. Baseline comparisons showed that age, sex and time since stroke of the subjects enrolled did not differ between the groups (P>0.05).

Table III shows median values (confidence interval) for ordinal data (MI-UE; AFT-FAS) and mean values ± standard deviation for continuous data (AFT-T) of both groups. At baseline (T0) there were no significant differences between the two groups. After three weeks of treatment (T1), however, the difference became statistically significant. At six weeks (T2) the median MI-UE score in group A (who had undergone only the conventional treatment) was 52.00 (CI: 52.64; 63.25),

Table II.—*Demographic characteristics of the two groups and baseline measurements.*

Characteristic	Group A	Group B	P*
No. of patients	18	18	
Age (y)	60.17±11.69 (34-75)	60.06±11.68 (32-75)	0.80°
Female/Male	7/11	8/10	1°°
Time since stroke (weeks)	7.33±2.38 (4-12)	7.44±2.41 (4-12)	0.63°
Motricity Index (UE)	56.22±10.81	56.72±11.14	0.85°°°

NOTE. Values are n or mean ± standard deviation (SD). Ranges in parentheses are provided for continuous variables.
Abbreviation: MI-UE, motricity index upper extremity; AFT-FAS, Arm Functional Test-Functional Ability Scale; AFT-T, Arm Functional Test-Time.
*P value of difference at baseline.
°Student t test.
°°Fisher exact test.
°°° Mann Witney Test.

Table III.—*Between-group differences in changes score for strength and upper limb functioning.*

Parameter		Group A	Group B	P*
MI-UE	T0	50.50 (50.85; 61.60)	51.50 (51.19; 62.26)	0.849
	T1	52.00 (52.64; 63.25)	60.00 (62.31; 73.69)	0.020
	T2	61.50 (63.67; 75.00)	64.50 (64.42; 75.35)	0.740
AFT-FAS	T0	37.00 (33.74; 40.37)	36.00 (33.03; 39.53)	0.657
	T1	39.00 (35.36; 41.97)	47.50 (44.34; 49.21)	0.001
	T2	51.50 (46.69; 52.20)	50.50 (47.24; 52.10)	0.899
AFT-T	T0	48.94 ± 13.30	49.22 ± 13.13	0.874
	T1	48.24 ± 13.34	34.61 ± 8.99	0.002
	T2	34.13 ± 9.03	33.78 ± 8.89	0.692

NOTE. Values are median (confidence interval) for ordinal data (MI-UE; AFT-FAS) and mean ± standard deviation for continuous data (AFT-T).
Abbreviation: MI-UE, motricity index upper extremity; AFT-FAS, Arm Functional Test-Functional Ability Scale; AFT-T, Arm Functional Test-Time.
*Mann Whitney Test.

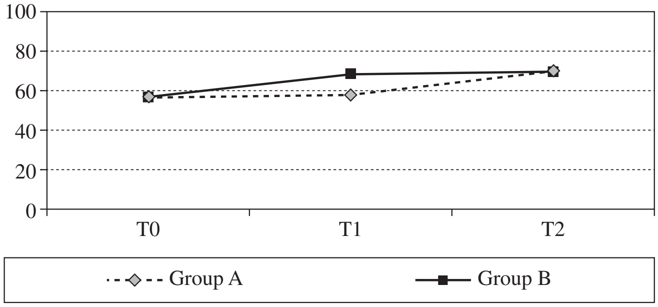

Figure 2.

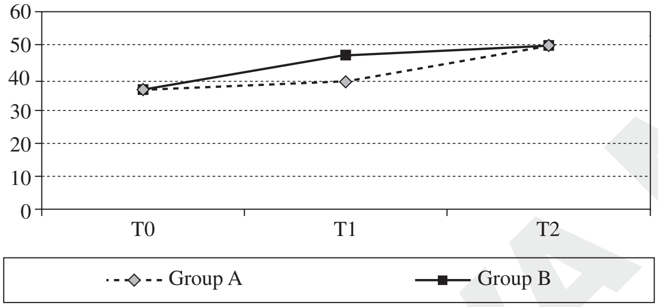

Figure 3.

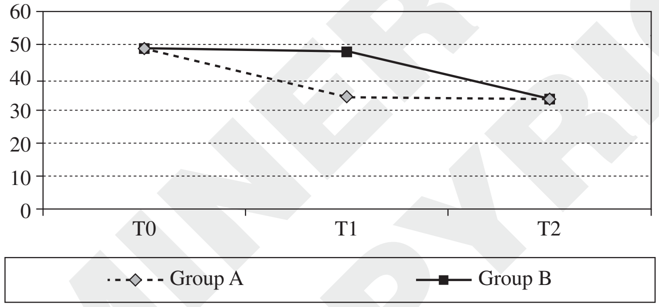

Figure 4.

whereas the median MI-UE value of group B (who had also undergone the Mental Practice training) was 60.00 (CI: 62.31; 73.69) with a P=0.02 (Figure 2). In the Arm Functional Test at T1, the quality of execution measured by FAS, achieved a median score of 39.00 (CI: 35.36; 41.97) in group A and a median score of 47.50 (CI: 44.34; 49.21) in group B (P=0.001) (Figure 3). At T1 the AFT results relating to the speed of execution of the test showed a mean of 48.24 in group A and 34.61 in group B with a difference in means of 13.63 (P=0.002) (Figure 4).

Table IV shows intra-group median (MI-UE; AFT-FAS) and mean (AFT-T) differences at the three evaluation times. The table shows an improvement in terms of strength (MI-UE), quality of gesture (AFT-FAS) and speed of execution (AFT-T) that was more evident between T1 and T2 in group A and between T0 and T1 in group B, which were the periods during which patients were also following the MP protocol.

Discussion

Modern neuro-rehabilitative approaches focus on the recovery of not only basic motor control, but moreover on the use of the limb in activities of daily living, and, particularly, on upper limb dexterity.[18] MP has been proposed as a viable tool in improving motor learning and performance in rehabilitative settings.[19-22]

The results of the present study confirm that a three-week training of MP, added to the conventional neuro-rehabilitation in a postacute setting, can significantly contribute to the recovery of motor performance of upper limbs in stroke patients.

In order to evaluate global motor function of the upper limbs we used the specific subtest of Motricity

Table IV.—*Strength and upper extremity functioning of the 2 groups at T0, T1 and T2.*

Parameter	Group	T0-T1 (P*)	T1-T2 (P*)	T0-T2 (P*)
MI-UE	A	-1.72 (0.001)	-11.39 (0.000)	-13.11 (0.000)
	B	-11.28 (0.000)	-1.89 (0.007)	-13.17 (0.000)
AFT-FAS	A	-1.61 (0.044)	-10.78 (0.000)	-12.39 (0.000)
	B	-10.50 (0.000)	-2.89 (0.000)	-13.39 (0.000)
AFT-T	A	0.70 (0.004)	14.10 (0.000)	14.81 (0.000)
	B	14.61 (0.000)	0.83 (0.000)	15.44 (0.000)

Values are mean differences
MI-UE: Motricity Index Upper Extremity; AFT-FAS: Arm Functional Test-Functional Ability Scale; AFT-T: Arm Functional Test-Time
*Wilcoxon Test

Index. These results show a statistically significant improvement in MI scores after neurorehabilitative treatment and an even greater improvement when associated with the MP training.

The Arm Functional Test evaluated dexterity in the execution of simple ADL. The results obtained in the AFT show that, when the groups were treated with neurorehabilitation plus MP, the improvements were greater than when the groups underwent only neurorehabilitation. In fact, after the first three weeks, group B AFT scores, both AFT-FAS and AFT-T, were significantly greater than the ones in group A; while the situation was inverted when group A underwent neurorehabilitation plus MP.

These results suggest that MP could be used to complement the conventional neurorehabilitative treatments usually prescribed for poststroke neuromotor recovery. It could, in fact, improve and speed up the functional recovery process and the recovery of upper limb dexterity in particular.

Recently, a single-blind multicenter randomized control trial confirmed the cost-effectiveness of a MP based training in improving arm function and daily activity performance in stroke patients.[20]

There is still much to be tested and discussed regarding the role that MP might play in the treatment of the neurological patient.

Ravey [23] suggests a difference between "motor image", which is the process of imagining a movement once or repeatedly (Mental Imagery), and the act of mentally repeating the motor action with the aim of learning or bettering it (MP).[24-31]

It must be remembered that individual's capacity to imagine varies greatly. This is why some authors have used evaluation scales designed to assess this ability.[32-35] In fact, it is suggested that before considering the application of MP methods patient's "imaginative capacity" should be analysed. A great deal of psychophysical, physiological, neuro-anatomical details can be gathered to evaluate motor imaginative capacity.

Decety *et al.* demonstrated that patients with unilateral cerebral lesions took longer to imagine a movement with the affected limb than with the unaffected one.[36] Motor imagery is a process that most probably depends on the integrity of motor-related anatomical structures. Patients with a brain lesion affecting the motor system (*e.g.*, stroke) are likely to be able to imagine movements but their performance, either physical or imagined, could be similarly compromised. Functional similarities between executed and imagined movements have been confirmed by several studies that have shown an increase in the heart and respiration rates of subjects engaged in the motor imagery of effortful actions.[37-40] In mental imagery, autonomic reactions are greater than expected, considering no actual movement is produced. Functional brain imaging studies (functional resonance imaging, electroencephalography, and magnetoencephalography) give evidence of the correspondence between imagined and executed movements in healthy subjects.[41-44]

In stroke patients' hemiparesis it is possible to keep motor circuits active through the repetition of movement through motor imagination, thus facilitating and stimulating future execution of specific movements. According to Jackson, MP would also work on the declarative conscience and on a subconscious learning level, augmenting both movement pattern retention and use of the neuron networks involved in this movement. When the patient has already achieved partial motor recovery or the damage is not complete and he is required to learn new abilities (*i.e.*, walking with a cane), the use of MP associated with physical exercise promotes learning through additional reinforcement processes at a subconscious level. The feedback obtained through the execution of task movements during neurorehabilitation would help to produce more realistic and efficient motor images, thus increasing MP potential and speeding up recovery.

More recently Page *et al.* demonstrated, in a clinical trial using fMRI, that premotor area and primary motor cortex ipsilaterally and contralaterally to the paretic arm, and the ipsilateral superior parietal cortex were activated after a 30 minutes repetitive task-specific practice session followed by 30 minutes of MP training, concluding that MP seems to improve movement favouring a cortical reorganization in chronic stroke patients.

We do not know how much of the improvement related to MP training is due to the method itself, or to the additional time spent in the rehabilitation process. In our opinion MP could be used to augment the frequency of repetition of movement at a cerebral level, with no increase in the physical demand for the patient. It could also be useful in maintaining the results achieved. We believe that the main issue is no longer whether MP can help in the rehabilitation of stroke patients, but rather, establishing the best way to implement this cost-efficient technique into current practice.

Conclusions

MP is a useful tool in improving motor learning and performance in rehabilitative settings. Stroke diagnosis and functional recovery of the upper limb are the ideal context in which to apply this new method. This experimental study demonstrates that, through the application of MP, a significant improvement in functional recovery can be obtained.

Although the potential of MP has been ascertained, guidelines which specify timing, quantity and modality in the introduction of this method to the rehabilitation process are necessary. Furthermore, it is also important to solve the issue on the selection of patients who would most benefit from MP.

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