



Review article

# Motor relearning program in patients with stroke sequelae: a systematic review

## Programa de reaprendizaje motor en pacientes con secuelas de ACV: una revisión sistemática

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### ABSTRACT

**Introduction:** 90% of the population with stroke suffer sequelae that disable the individual for their independence in the activities of daily life. **Objective:** to determine the effects of interventions in adults after stroke of the motor relearning program vs different physiotherapeutic treatments on functional independence. **Methods:** a systematic review of the literature was carried out in PubMed, PEDro, LILACS, Cochrane, Scopus and ScienceDirect databases, and a manual search, taking into account clinical trials, Spanish, English or Portuguese. The methodological quality was carried out using the PEDro scale and the risk of bias assessment was applied according to the Cochrane Manual. Eight studies out of a potential 984 were included. **Results:** a clinically significant improvement was found in the motor relearning groups and only in one study is this improvement significant compared to another intervention. **Conclusion:** there are significant clinical effects in the use of the motor relearning program.

**Keywords:** Rehabilitation; Exercise Therapy; Stroke; Activities of daily living.

### RESUMEN

**Introducción:** el 90% de la población con accidente cerebrovascular sufre secuelas que incapacitan al individuo para su independencia en las actividades de la vida diaria. **Objetivo:** determinar los efectos de las intervenciones del programa de reaprendizaje motor en personas adultas después del accidente cerebrovascular vs diferentes tratamientos fisioterapéuticos en la independencia funcional. **Método:** se realizó una revisión sistemática de la literatura en bases de datos

*PubMed*, *PEdro*, *LILACS*, *Cochrane*, *Scopus* y *ScienceDirect*, y una búsqueda manual, teniendo en cuenta ensayos clínicos, idioma español, inglés o portugués. La calidad metodológica se realizó por escala de *PEdro* y la evaluación del riesgo de sesgo fue aplicada según el Manual *Cochrane*. Se incluyeron 8 estudios de 984 potenciales. **Resultados:** se encontró una mejora clínicamente significativa en los grupos de reaprendizaje motor y solamente en un estudio esta mejora es significativa con respecto a otra intervención. **Conclusión:** existen efectos clínicos significativos en el uso del programa de reaprendizaje motor.

**Palabras clave:** rehabilitación; tratamiento por actividad física; accidente cerebrovascular; actividades de la vida diaria.

## INTRODUCTION

In Western countries, cerebrovascular accident (CVA) is the third cause of mortality after cardiovascular diseases and neoplasias, corresponding to approximately 10% of deaths<sup>1</sup>. In Colombia, in the year 2016, it was described that transient cerebral ischemia and cerebral infarction showed the highest prevalence (29 and 279 per 100,000, respectively); concerning mortality, it was reported that non-traumatic intracranial hemorrhage presented a rate of mortality of 15 per 100,000<sup>2</sup>.

Due to the advent of new medical treatments, mortality from stroke has decreased notably in recent years, leaving an increasing number of survivors with a greater number of sequelae and a probability of recurrence<sup>3</sup>. 90% of the population with stroke suffer alterations that, in 30% of cases, generate mobility disabilities that can compromise functional independence for the development of activities of daily living, generating a demand for care and a need for institutionalization with considerable health and social spending<sup>1</sup>. Approximately 85% of the stroke population presents with initial paresis in the arm, which is the most disabling consequence; this alteration persists in 55% to 75% of patients even after three to six months of the episode<sup>4,5</sup>; only 5% to 20% of patients show complete recovery of the hemiparetic arm<sup>6</sup>.

Preston *et al.*<sup>7</sup> reported that for initially non-ambulatory stroke patients managed in a rehabilitation unit, the probability of independent walking was 60% at three months, 65% at six months, and 91% at 12 months.

A retrospective analysis of data from 292 people after their first stroke indicated that 75% were dependent on activities of daily living (ADLs) at stroke onset, and only 57% of survivors remained dependent

at the time of stroke discharged from the hospital. The incidence of dependence on activities of daily living is highest immediately after a stroke and decreases significantly afterwards<sup>8</sup>. Wade *et al.*<sup>9</sup> found that the incidence of total dependence in ADLs decreased from 58% one week after the stroke to 9% six months after the stroke.

Rehabilitation has proven helpful in improving the patient since it increases autonomy<sup>10,11</sup>, the frequency of return to home, and reduces hospitalization<sup>12,13</sup>. Among the strategies developed to counteract the sequelae of this phenomenon are: Rood's sensorimotor approach, Brunnstrom's movement therapy, the neurodevelopmental approach (Bobath), and the proprioceptive neuromuscular facilitation (PNF) approach<sup>14</sup>.

Starting in 1980, new ways of approaching re-education in stroke patients were proposed, one of the most important being task-oriented motor relearning or motor relearning program (MRP); Then comes treadmill training with full weight support or partial weight suspension, movement therapy induced by restriction of the healthy side, muscle strengthening, and physical reconditioning programs, robot-assisted sensory-motor stimulation<sup>15,16</sup>, mental imagery, and virtual reality<sup>17-20</sup>.

The MRP aims to train or retrain the stroke patient to improve motor control when performing essential tasks or actions. In this way, relearning is promoted through the teaching of movement<sup>21</sup>, emphasizing the transfer of skills between corrective and functional tasks; in other words, the transfer of exercise skills learned in the training of the daily life of the patient improves the functional independence of these and can lead to a better physical capacity<sup>22</sup> compared with other interventions, concluding that this model is more effective than others in the treatment of stroke sequelae and. Therefore, it is recommended as a treatment for managing upper extremi-

ty deficiencies. However, some research also points to significant limitations that indicate that there is still not enough good-quality evidence to make definitive and conclusive recommendations on its implementation and that, although previous reviews, when addressing the upper extremity, describe results on the hand, they do not. There are studies that have studied the application of the MRP in functional independence<sup>23</sup>. Therefore, a systematic review of this topic is justified, considering that it allows the synthesis of the available evidence and its use in clinical decision-making in rehabilitating this type of patient.

The present systematic review aimed to determine the effects of motor relearning program interventions in adults after stroke vs. different physiotherapeutic treatments on functional independence.

## METHOD

### Design

This report is a systematic review of randomized clinical trials (RCT). Recommendations described in the PRISMA 2020 statement for Systematic Reviews of Interventions version 6.124 were followed. A meta-analysis was not performed due to the variability of the interventions.

### Search strategy

It was carried out between June and September 2020, with no time limit on the search. PubMed, PEDro, LILACS, the Cochrane Central Register of Controlled Trials, Scopus, and ScienceDirect, and hand searching and crawling through bibliographies were used; from the terms: («*Motor Relearning Program*»), («*Stroke*»), («*Activities of Daily Living*») and («*Functional Independence*»). Boolean connectors were considered to narrow the search for potentially eligible articles.

### Selection of studies

Study abstracts were taken from each database and imported into Rayyan management software. Initially, duplicate studies were eliminated; this process was done manually by supporting Rayyan's same function. Subsequently, two independent

reviewers (AC and AR) examined the titles and abstracts of potentially relevant articles; each one evaluated the articles' relevance in case of disagreement it was resolved through a third evaluator (OM). Full-text copies of the articles were then obtained for those that met the initial assessment and were reviewed in full text by two independent reviewers according to meeting the inclusion criteria as primary studies with randomized clinical trial designs, reported in English, Spanish, or Portuguese; whose participants were adults with stroke sequelae to whom the MRP was applied and whose evaluation measures were Functional Independence Measure (FIM), *Functional Gait Classification* (FAC), in English *Functional Ambulation Categories*), *Motor Assessment Scale* (MAS), Barthel Index (BI, *The Barthel Index*), *Chedoke Inventory* for arm and hand activity (CAHAI, for its acronym in English *Chedoke Arm and Hand Activity Inventory*) and *Wolf Motor Function Test* (WMFT, Wolf Motor Function Test) were excluded articles that were not found in full text.

### Data extraction

Each reviewer independently extracted the following information: Reference (author and year of publication), sample information (description of participants and location), intervention, description of the exercise (intervention and frequency), and outcomes of interest.

### Methodological quality and risk of bias

Two raters independently (AC and AR) assessed the methodological quality and mean risk of bias of the *PEDro (Physiotherapy Evidence Database)*<sup>25</sup>. A third evaluator (OM) resolved it in case of disagreement. And the *Cochrane Handbook of Systematic Reviews of Interventions* version 5.1.0<sup>24</sup>.

## RESULTS

### Resultados de la búsqueda

Nine hundred eighty-four articles were identified in databases (PubMed, PEDro, LILACS, the Cochrane Central Register of Controlled Trials, Scopus, and ScienceDirect). Additionally, a manual search was

performed. The first filter returned 79 duplicates, leaving 905 articles. Subsequently, 894 records were excluded when reading the title and abstract, leaving 11 articles for reading the full text; After their analysis according to the selection criteria, three reports were

excluded; among them: two did not report the functional results, one was a follow-up of another article and did not present an intervention protocol. Finally, eleven articles were chosen to meet all the criteria for this systematic review, all in English (Figure 1).

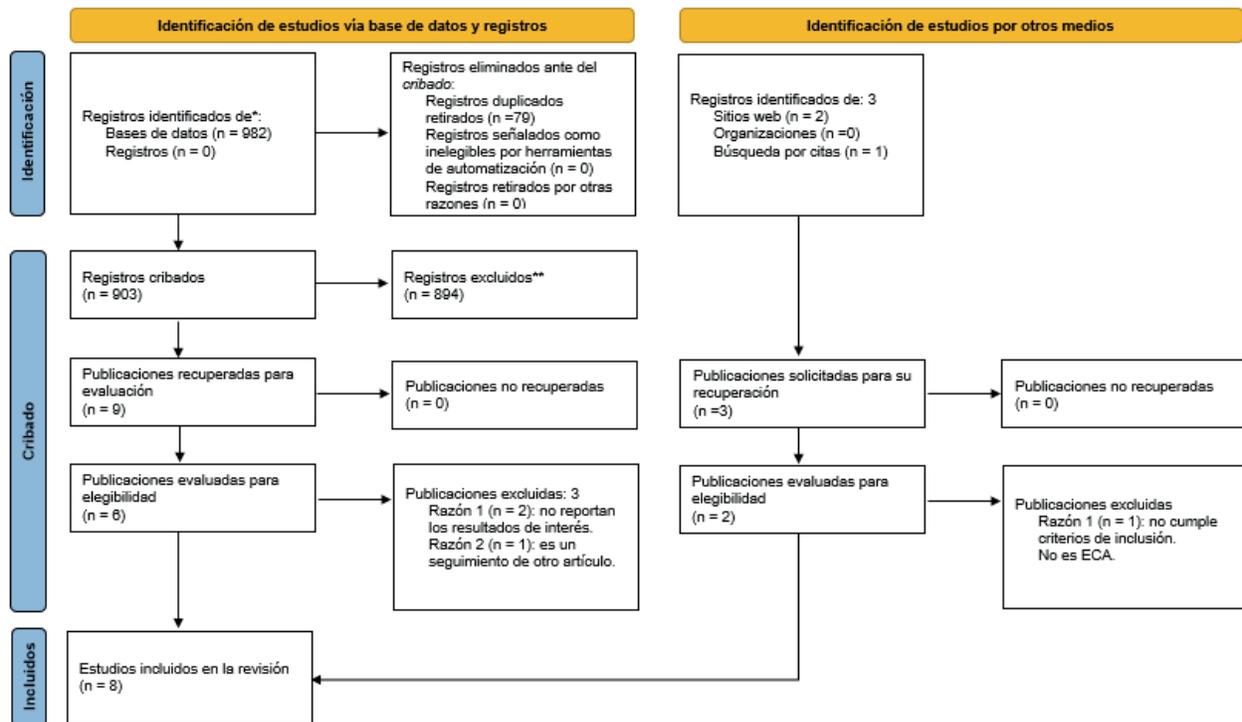


Figure 1. Document search and selection process.

## Location of studies and patient characteristics

Physical medicine and rehabilitation institutes in civil, rehabilitation, multispecialty, and university hospitals: four reports were developed in India<sup>26-29</sup> and one in Pakistan<sup>30</sup>, China<sup>31</sup>, Norway<sup>32</sup>, and Sweden<sup>33</sup>, respectively. The total number of subjects in these investigations was 379 participants, aged between 21 and 95 years; 56.6% were men; 46 losses were recorded for medical reasons, death, removals, voluntary withdrawal, absence, travel, or refusal to carry out the corresponding intervention. The total number of people who completed the interventions was 333 (Table 1).

## Description of the intervention

The MRP intervention programs found could be divided into two types: treatment based on the MRP

alone<sup>26,28-30,32</sup> and protocols where the MRP was applied combined with usual physiotherapy<sup>27,31,33</sup>. Interventions in the comparator groups included mirror therapy neurorehabilitation treatments, Constraint Induced Movement Therapy (CIMT), the Bobath concept, training program (body weight supported treadmill training), and conventional physiotherapy.

Regarding the dosage of the interventions, it was found that the weekly frequency parameter was distributed as follows: four reports performed six sessions per week<sup>27-30</sup>, in three articles, they reported a frequency of 5 times per week<sup>26,32,33</sup>, while only one reported a frequency of three times per week<sup>31</sup>. The duration of each treatment session ranged between 30 and 120 minutes per session; two articles reported 120 minutes<sup>30,31</sup>; four, 60 minutes<sup>26-29</sup>; one, 40 minutes<sup>32</sup>; and finally, another with 30 minutes<sup>33</sup>. The duration of the intervention protocol varied between 3 and 19 weeks. The interventions were generally carried out by physiotherapists<sup>26-30,32,33</sup>;

however, occupational therapists<sup>31,32</sup> and physicians participated in the studies<sup>32</sup>.

### Synthesis of the effects of MRP

Eight studies were included in the systematic review, and significant improvements were reported between the baseline and the final evaluation<sup>26-33</sup>. When comparing the different interventions, it was found that in five, the MRP had greater efficacy<sup>26,28,29,31,32</sup>; in two, no significant differences were found<sup>27,33</sup>, and only one reported a better result in the comparison treatment<sup>30</sup>.

In the reports by Chan *et al.*<sup>31</sup> and Kumar Immadi *et al.*<sup>26</sup>, the MRP was shown to be superior compared to conventional therapy; in the first<sup>31</sup>, better results were reported in balance functions, performance in

self-care, and instrumental activities of daily living and community integration, while in the second<sup>26</sup> better results were found in functional recovery. Along the same lines, Langhammer *et al.*<sup>32</sup> reported that the women treated with the MRP presented more significant improvements in the execution of ADLs compared to those treated with Bobath; in turn, Bhalerao *et al.*<sup>28,29</sup> indicates that physiotherapy treatment using MRP is more effective than the Bobath approach and shows early improvement in ADLs, ambulation and functional independence in stroke rehabilitation measured at every other initial six-week training interval and rehabilitation. In contrast, Batool *et al.*<sup>30</sup> reported that the CIMT intervention was superior in improving motor function compared to MRP. Finally, mirror therapy<sup>27</sup>, and weight-bearing treadmill training<sup>33</sup> were not superior to MRP in hand function<sup>27</sup> and functional gait<sup>33</sup>.

**Table 1.** Characteristics of the studies.

Author	Population characteristics	Intervention with motor relearning program	Comparator	Intervention time	Results
Batool <i>et al</i> <sup>30</sup>	28 men and 14 women between 35 and 60 years old. subacute stroke	Exercises of reaching, signaling, weight-bearing, and different manual tasks in different positions with both extremities	ITAC	Six sessions per week lasting 2 hours each, over three weeks	The CIMT group showed an improvement in motor function and self-care performance of the hemiplegic upper extremity compared to the MRP group
Chan <i>et al</i> <sup>31</sup>	28 men and 24 women, mean age of 54.1 years, with a single vascular event	Identifying missing performance components; recovery exercises; training with functional task components; transfer of skills to task performance. Twenty-four recovery tasks and ten functional tasks to cover deficits in sitting and standing balance. Physiotherapy: exercises to strengthen the lower limbs and trunk balance	Conventional therapy	Three sessions per week lasting 2 hours each, over six weeks	The MRP group presented improved functional recovery than the conventional therapy group in balance functions, performance in self-care and instrumental activities of daily living, and integration into the community.
Kumar Immadi <i>et al</i> <sup>26</sup>	31 male participants, and 29 female participants, mean age of 51 years, with a single vascular event	Stimulate muscle activity and train motor control for reaching and pointing and for manipulation of wrist extension; train palmar abduction and thumb rotation (opposition); train opposition of the radial and ulnar sides of the hand; train object manipulations; improve the use of holding objects	Conventional therapy	Five sessions per week lasting 1 hour each, over eight weeks	Patients in the MRP performed better on self-care and ADL tasks
Langhammer <i>et al</i> <sup>32</sup>	36 male participants, and 25 female participants, mean age of 78 years, with a single vascular event	Manual with MRP procedures to apply to patients during hospitalization. After discharge, the patients received physiotherapy with an individual treatment program and instructions from the physiotherapist.	Bobath Concept	Five sessions per week lasting 40 minutes each, throughout the hospitalization time	Patients in the MRP group had a shorter hospital stay and improved motor function more than those treated, according to the Bobath concept.
Nilsson <i>et al</i> <sup>33</sup>	40 male participants, 33 female participants, younger than 70 years with a single vascular event	Walking, standing exercises to allow weight bearing on the hemiparetic leg, and training to maintain proper segmental alignment for balance Physiotherapy treatment: improving motor control and strengthening functionally weak muscles through transfers and range of motion exercises, as well as techniques to improve motor function on the paretic side	Weight-bearing treadmill training conventional therapy	Five sessions per week lasting 30 minutes each, for between 3 and 19 weeks	Both groups improved to an equal extent after treatment for these variables. However, no differences were found in walking ability, balance, or sensorimotor performance.

Autor	Características de la población	Intervención con programa de reaprendizaje motor	Comparador	Tiempo de intervención	Resultados
Rehani <i>et al</i> <sup>27</sup>	12 patients patients with a mean age of 54.9 years with a single vascular event	Wrist extensor training, object holding, forearm supination, thumb opposition, hand cupping, and object manipulation training. Physiotherapy treatment: moist heat, stretching of the wrist flexors with a 30-second hold, and electrical stimulation of the wrist extensors	Mirror therapy Conventional therapy	Six sessions per week lasting 1 hour each, over four weeks	Improvement in hand function in both groups separately. It was concluded that there was no difference between the two therapeutic approaches regarding hand function.
Bhalerao <i>et al</i> <sup>28</sup>	22 patients patients with a mean age of 52.9 years with their first, middle cerebral artery cerebrovascular event.	Activities of daily living (sitting from supine decubitus, sitting, standing, sitting to standing, walking, and upper extremity function), and followed the steps described by Carr and Sheperd (task analysis, missing components practice, complete task practice and training transfer)	Bobath Concept	Both groups received physiotherapy for 1 hour a day, six days a week for six weeks, for 36 hours.	Functional gains in acute rehabilitation using MRP, with improvement in functional mobility and activities of daily living compared to the Bobath approach. Subjects in the MRP group showed early independence and improved walking.
Bhalerao <i>et al</i> <sup>29</sup>	32 patients 19 male participants, and 13 female participants, mean age of 54 years with the first cerebrovascular event	Evaluation and training in seven different tasks of daily life: a) Upper limb function. b) Orofacial function. c) Sitting supine. d) Sitting. e) Standing and sitting. e) Standing. g) Walking. Four steps of the MRP were followed: 1) Task analysis. 2) Practice missing components. 3) Practice the task. 4) Transfer of learning.	Bobath Concept	Both groups received physiotherapy for 1 hour a day, six days a week for six weeks, for 36 hours.	MRP showed better improvement than the Bobath approach in the Barthel index, the measure of functional independence, and the functional ambulation category in the second, fourth, and sixth weeks, and in the dynamic gait index, it was shown only in the sixth week.

MRP: Motor Relearning; CIMT: healthy side restriction therapy; ADL: Activities of Daily Living

## The methodological quality of the articles

Performed using the PEDro Scale<sup>25</sup>, it ranged from 3 to 7 with a mean score of 5. All the articles presented adequate randomization of the subjects<sup>26-33</sup>, 37.5% reported hidden allocation<sup>30,31,33</sup> in the 87.5% of the studies, the groups were similar at the beginning about the most critical prognostic indicators<sup>27-33</sup>,

there was no blinding of the subjects and therapists who administered the intervention, 37.5% of the studies had blinded evaluators<sup>31-33</sup>, 50% maintained many participants greater than 85% of the total population<sup>30,32,33</sup>, in none of the studies was an intention-to-treat analysis performed, in 100% of the articles the results of comparisons Between-group statistics were reported and 87.5% of studies provided point and variability measures<sup>26-28,30-33</sup> (Table 2).

**Table 2.** The methodological quality of the selected studies.

Study	Pedro Score	1	2	3	4	5	6	7	8	9	10	11
Batool <i>et al</i> <sup>30</sup>	6/10	Y	Y	Y	Y	N	N	N	Y	N	Y	Y
Bhalerao <i>et al</i> <sup>28</sup>	5/10	Y	Y	N	Y	N	N	N	Y	N	Y	Y
Bhalerao <i>et al</i> <sup>29</sup>	3/10	N	Y	N	Y	N	N	N	N	N	Y	N
Chan <i>et al</i> <sup>31</sup>	6/10	Y	Y	Y	Y	N	N	Y	N	N	Y	Y
Kumar Immadi <i>et al</i> <sup>26</sup>	3/10	Y	Y	N	N	N	N	N	N	N	Y	Y
Langhammer & Stanghelle <sup>32</sup>	6/10	Y	Y	N	Y	N	N	Y	Y	N	Y	Y
Nilsson <i>et al</i> <sup>33</sup>	7/10	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y
Rehani <i>et al</i> <sup>27</sup>	4/10	N	Y	N	Y	N	N	N	N	N	Y	Y

**Nota:** **N:** No. **Y:** Yes. **(1)** Eligibility criteria; **(2)** Random assignment; **(3)** Hidden assignment; **(4)** Comparability of the baseline; **(5)** Blind subjects; **(6)** Blind therapists; **(7)** Blind raters; **(8)** Adequate follow-up; **(9)** Intention-to-treat analysis; **(10)** Comparisons between groups; **(11)** Point estimates and variability.

## Risk of bias

The risk of bias in the articles included in this systematic review was assessed using the Cochrane Collaboration tool for determining bias in randomized clinical trials<sup>24</sup>.

## Selection

**Adequate sequence generation:** Five of eight ar-

ticles had a low risk of bias<sup>27-31</sup>, and the other three had an unclear risk of bias<sup>26,32,33</sup>. The most common methods used for proper sequence generation were: computer-generated random numbers<sup>27,28,30</sup> and block randomization<sup>29,31</sup>.

**Allocation concealment:** Three articles presented a low risk of bias<sup>30,31,33</sup>; the method used was sealed envelopes. In five articles, it needed to be described or was insufficiently described, presenting uncertain or unclear risk<sup>26-29,32</sup>.

**Realization**

**Blinding of participants and personnel:** One study presented blinding of the participants and personnel, obtaining a low risk of bias<sup>32</sup>. No masking was performed in four articles<sup>28,29,31</sup>, or it was incomplete<sup>33</sup>. In three articles, insufficient information was provided, considering an unclear risk of bias<sup>26,27,30</sup>.

**Detection**

**Blinding of outcome assessors:** Two articles reported the blinding of the evaluators of the results, qualifying them as low risk of bias<sup>31,32</sup>; on the other hand, four articles were classified as unclear risk of bias because they did not provide sufficient information on the blinding of the evaluators or this result was not addressed in the study<sup>26,27,30,33</sup>; in two articles there was no blinding of the evaluators<sup>28,29</sup>.

**Wear**

**Incomplete results data:** a total of three articles presented low risk since they met one of these two items<sup>28,30,32</sup>, three articles presented high risk since they did not meet any of the items<sup>27,31,33</sup> and two studies they did not provide sufficient data on losses or exclusions, considering the unclear risk of bias<sup>26,29</sup>.

**Notification**

**Selective reporting of results:** seven articles included in this review described the intervention protocol, and all prespecified study outcomes of interest to the review were fully described, obtaining a low risk of bias<sup>26-28,30-33</sup>; only one article<sup>29</sup> did not meet this criterion, being evaluated as high risk (Table 3).

**Table 3.** Assessment of bias according to Cochrane.

Authors	Selection bias		Performance bias	Detection bias	Attrition bias	Reporting bias
	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessors	Incomplete outcome data	Selective reporting of results
Batool <i>et al</i> <sup>30</sup>	+	+	?	?	+	+
Bhalerao <i>et al</i> <sup>28</sup>	+	?	-	-	+	+
Bhalerao <i>et al</i> <sup>29</sup>	+	?	-	-	?	-
Chan <i>et al</i> <sup>31</sup>	+	+	-	+	-	+
Kumar Immadi <i>et al</i> <sup>26</sup>	?	?	?	?	?	+
Langhammer <i>et al</i> <sup>32</sup>	?	?	+	+	+	+
Nilsson <i>et al</i> <sup>33</sup>	?	+	-	?	-	+
Rehani <i>et al</i> <sup>27</sup>	+	?	?	?	-	+

Note. The symbol + represents “low risk,” - represents “high risk,” and ? “uncertain risk.”

## DISCUSSION

Optimal functional recovery is the primary objective in rehabilitation, especially in neurology<sup>34,35</sup>. Due to the frequent changes and the more significant development of procedures<sup>36</sup>, it is necessary to redefine these approaches, expanding the possibilities of rehabilitation treatments that consider the new knowledge and concepts of neuroscience and neuropsychology for neurorehabilitation<sup>37</sup>. Task-oriented motor relearning or MRP emerges as a rehabilitation option based on neuroscience research that includes the practice of tasks with the possibility of stimulating the neuroplasticity potential in the individual from the fractionation and direction in phases of the practice of activities, movement learning, and feedback mechanisms given by repetition are used<sup>21</sup>.

There is a large number of publications that study the application of the MRP in the rehabilitation of people with stroke sequelae<sup>38-40</sup>. However, very few studies focus specifically on the recovery of functional independence; therefore, this study aimed to determine the effects of the intervention of the motor relearning program in adults with stroke sequelae compared to another type of intervention by reviewing and evaluating the available literature on its application in the rehabilitation of functional independence, finding six articles as a result of a systematic search for evidence.

Among the outcome measures described in the analysis of each of the articles included in this review, it was evidenced that the measure of functional independence was the most used<sup>28-31,33</sup>. In addition, measures were found for the functionality of the upper limb and hand, motor function, functional ambulation, and activities of daily living. With these outcome measures, through a critical analysis of the evidence, there are indications that the application of the motor relearning program could have clinical effects in treating functional independence<sup>26-33</sup>.

Motor recovery can be characterized as a “relearning” process that responds to the demands of daily life<sup>37</sup> and is based on the premise that training after brain injury improves motor performance in acquiring new skills and adaptation or refinement of previously acquired skills<sup>41</sup>. Despite these findings, motor learning research has only just begun

to have an impact on rehabilitation practice<sup>21</sup>. Some authors have described that research related to functional recovery from brain injury has been based on: the benefits of early interventions since this minimizes the severity of the initial damage and reduces functional loss<sup>42</sup>; and brain reorganization in restoration and compensation of altered functions<sup>37</sup>. It is essential to highlight that early intervention in acute stroke rehabilitation plays a transcendental role in restoring function and reducing the degree of disability<sup>28</sup>.

The clinical data strongly favor early mobilization and training, but no study has shown to what extent the beneficial effect is due to specific rehabilitation strategies. A study conducted by Nilsson *et al.*<sup>33</sup>, where walking training on a treadmill with body weight support was compared with walking training on the ground based on the MRP, showed a significant improvement between admission and discharge (ten weeks) for the FIM (56.1 and 76.4 respectively) and FAC (at admission 19 (51%) patients could not walk independently, at discharge the number decreased to three (9%)), in the MRP group. It also improved significantly from admission to 10-month follow-up, but no significant difference existed between treatment groups. Therefore, it was concluded that both methods are similar options at an early stage in stroke patients. The functional results regarding gait rehabilitation coincide with the study by Richards *et al.*<sup>9</sup>, which reports that the vast majority of clinical studies have described recovery as occurring primarily in the first three months after stroke with a plateau at approximately six months after stroke.

On the other hand, several investigations report that the MRP improves restoring the function of the upper extremity<sup>43</sup>. This is in line with the study carried out by Batool *et al.*<sup>30</sup>, who evaluated motor function in the hemiplegic upper limb in subacute stroke patients, concluding in their research that the outcome measures increased significantly in all items of the MAS and all items of the FIM after applying the MRP. However, no significant differences were found in advanced manual activities, grooming activities, and upper limb dressing. The study compares the effectiveness of Constraint-Induced Movement Therapy (CIMT) versus MRP and concludes that CIMT is a more statistically significant and clinically effective intervention compared to this program among 35- and 60-year-old patients in terms of muscle recovery motor function and self-

care performance of upper extremity. The results of this review further support the view that functional recovery after a stroke can occur after three months up to at least six months.

Different clinical trials suggest that task-oriented relearning is more effective than traditional therapies and that the effect is specific to the retrained activity<sup>15</sup>. Kumar Immadi<sup>26</sup> evaluated the efficacy of the relearning motor model compared to conventional therapy to promote upper extremity function after stroke. The results showed an improvement in upper extremity function in both groups; however, patients in the MRP were found to perform significantly better on self-care tasks and activities of daily living. The results of this clinical trial corroborate that “role-based” task-oriented training is equally important in improving the functional recovery of patients after stroke.

Motor tasks involving arm and hand movement are highly complex combinations of muscle action. As soon as the isolated muscle action is elicited, it should be practiced and extended to a meaningful task<sup>44</sup>. Rehani *et al.*<sup>27</sup>, in an evaluation of the efficacy of two therapeutic approaches (MRP and mirror therapy) that can be used to improve hand function in stroke, concluded that there was no statistically significant difference between the two therapeutic approaches in terms of hand function and found that the results were not significant in the comparison between the scores before and after the intervention in both groups. Despite this, clinically, an improvement in hand function was observed in terms of CAHAI. Similar results were reported by French *et al.*<sup>45</sup>; they found no evidence of a significant benefit from repetitive training on functional activity of the upper extremity. However, it is important to highlight that several factors could have influenced the results of this study, including the sample size and the time that elapsed between the stroke and rehabilitation, which varied between 1 and 6. This last point is crucial since it has been described that performance improvement is related to the early start of treatment<sup>46</sup>.

Chan *et al.*<sup>31</sup> inquired about the efficacy of MRP in promoting function and performance in people after stroke, applying for the program in comparison with conventional therapy, finding significant changes specifically for balance functions in performing functional activities after six weeks, instruments of daily life, personal care, and integra-

tion into the community, these authors emphasize that this must be a sequential treatment to reach the expected results. In the same way, Pinzón *et al.*<sup>8</sup>, in a non-randomized clinical trial, were able to conclude that the intervention program based on motor relearning is more effective than a conventional physiotherapeutic program to improve antigravity postural control and the quality of selective lower limb patterns in adults with hemiparesis.

Bhalerao *et al.*<sup>28,29</sup> and Langhammer *et al.*<sup>32</sup> conducted randomized controlled trials that compared the Bobath approach and the MRP in stroke rehabilitation. The results showed that both groups improved, but the improvement in motor function was significantly more significant in the MRP group. From their study of the population in the acute phase of this condition, the authors conclude that, despite not finding statistically significant differences between the groups based on the measurement of performance in activities of daily living through the Barthel index, Given the comprehensiveness of the MRP approach, they recommend its use in the first stage of the rehabilitation of people with stroke<sup>32</sup>. The same authors further conducted a follow-up study to investigate whether the initial physiotherapy approach has long-term effects on mortality, motor function, postural control, activities of daily living, quality of life, and patient follow-up community services. Their data suggested that the initial physiotherapy approach did not significantly influence the long-term functional capacity of the subjects. However, they did find a rapid deterioration in basic activities of daily living and increased reliance on family members<sup>47</sup>. These results agree with Krutulyte *et al.*<sup>48</sup>, who have studied the efficacy of physiotherapy methods (Bobath and MRP) in the rehabilitation of patients with stroke; in their study, the activities of daily living were also evaluated using the Barthel index, concluding that physiotherapy with strategies oriented to tasks represented by MRP is preferable to physical therapy with facilitation/inhibition strategies, such as the Bobath program in the rehabilitation of stroke patients.

Although there is evidence that early and intense rehabilitation is associated with a decrease in associated morbidity and mortality and improves functional outcomes, it is not entirely clear which of the proposed therapeutic methods is the best since none has been definitively shown to be superior

to the others; It can be deduced that no technique is effective by itself. For its part, the environment also plays a vital role in rehabilitating stroke patients<sup>27</sup>.

The MRP approach forces patients to focus on missing performance components in their daily tasks, which may help them learn to cope with post-stroke limitations more quickly and positively affect their overall social participation<sup>21</sup>. Second, considerable evidence shows that lack of physical activity and functional impairment may contribute to restrictions in social participation<sup>49</sup>. Motor relearning emphasizes the transfer of skills between corrective and functional tasks; in other words, the transfer of exercise skills learned in training to the patient's daily life. This improves patients' functional independence and can lead to a better physical ability to reintegrate into society. However, it is still being determined whether these effects can diminish after more extended periods due to the lack of long-term follow-up in the included MRP studies<sup>50</sup>.

Taking into account the above, the vast majority of the outcome measures described in the present investigation demonstrate clinically significant differences that indicate more tremendous advantages of the use of the MRP in the rehabilitation of functional independence, upper limb functionality, motor function, walking, and carrying out activities of daily living. It is worth mentioning that the research found in this systematic review shows a great variety of outcome measures and various instruments used to evaluate the same construct, which created difficulties when establishing comparisons and providing irrefutable results. Lastly, no risk or adverse events were reported in developing interventions with motor relearning program training in any of the articles.

The outcome measures included in this systematic review suggest that the motor relearning program generates clinically significant differences between the pre and post-intervention evaluations in the recovery of functional independence in patients with stroke sequelae such as stroke-developed AVD, balance, and self-care functions showing a trend toward improvement after applying this type of training. However, little research with adequate methodological quality evaluates these effects, so it is recommended that these conclusions be taken with caution.

## DECLARATION ON CONFLICT OF INTEREST

The authors state that there is no conflict of interest.

## AUTHORS' CONTRIBUTION

**Oscar Eduardo Mateus Arias:** participated in conceptualization, research, methodology, and writing.

**Angela Camperos Toro:** participated in research, methodology, and writing.

**Ashley Rangel Silva:** participated in research, methodology, and writing.

**Sonia Mantilla Toloza:** participated in supervision and writing.

**Javier Martínez Torres:** participated in supervision and writing.

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