Review Paper

Cerebellar Infarction: Physiotherapeutic Approach an Overview of Existing Studies

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Citation Lykou PM, Kyriakatis GM, Besios T. Cerebellar Infarction: Physiotherapeutic Approach an Overview of Existing Studies. Iranian Rehabilitation Journal. 2023; 21(3):389-398. http://dx.doi.org/10.32598/irj.21.3.1982.1

http://dx.doi.org/10.32598/irj.21.3.1982.1

Article info:
Received: 22 Dec 2022
Accepted: 11 Jan 2023
Available Online: 01 Sep 2023

Keywords:
Cerebellum, Rehabilitation, Stroke, Infarct, Physical therapy, Neurological rehabilitation

ABSTRACT

Objectives: Cerebellar infarction is an ischemic or hemorrhagic type episode involving the three main cerebellar arteries. An infarction in each of these arteries causes different but common symptoms, requiring a particularly important contribution of physiotherapy to its treatment. This overview aimed to investigate the effectiveness of physiotherapy programs on the symptoms of patients with cerebellar infarction.

Methods: A literature search was performed using eight databases and the keywords, including physiotherapy, physical therapy, rehabilitation, therapeutic exercise, exercise, cerebellar infarct, cerebellar infarction, and cerebellar blockage. The selection process of the final studies was carried out after setting inclusion and exclusion criteria and separately by two reviewers.

Results: Out of 1477 initial records, six studies met the inclusion criteria for this overview. Interventions focused on a balance training program and walking training, as opposed to a treadmill training program, seem to improve symptoms in these patients. Also, task-oriented approach was a promising method of rehabilitation.

Discussion: Physiotherapy has a beneficial effect on the symptoms of patients with cerebellar infarction and should be considered for the overall recovery of the patient. However, future research is needed due to the small number of studies and to find therapeutically proven forms of intervention.

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Highlights

- Cerebellar infarcts account for 2-3% of all strokes.
- Balance exercises and gait training reduce the symptoms of these patients.
- The task-oriented approach can also be effective.

Plain Language Summary

The cerebellum is located inside the skull and behind the brain. It is mainly responsible for the balance and normal movement of the human body. It is also vascularized by the three main arteries that are blocked; thus, the blockage of blood flow inside the vessel is called a cerebellar infarction. The main treatment options are medical operations and drug therapy. However, physical therapy can help these patients function, and this review examines the effectiveness of physical therapy programs on the symptoms of these patients. More specifically, a program based on progressive balance exercises and specific muscle exercises was found to reduce patients' symptoms, as opposed to a treadmill exercise program. In addition, an individual program with the correct use of the principles and techniques of physiotherapy, depending on the severity of the injury and functional level, leads to the improvement of the patient's condition. This overview of existing studies is extremely important as it summarizes for the first time all the research data available on the subject, providing the necessary information for the management of these patients.

Introduction

The cerebellum occupies most of the posterior brain and, more specifically, the posterior cranial fossa [1]. The functional role of the cerebellum is quite important in humans as it is responsible for posture control and body balance, muscle tone, eye movement, motor planning, motor control, as well as motor learning [1]. The cerebellar vasculature consists of three main arteries, the superior cerebellar artery (SCA), the anterior inferior cerebellar artery (AICA), and the posterior inferior cerebellar artery (PICA) [2].

Cerebellar infarction is to ischemic or hemorrhagic type episode affecting the posterior cranial fossa region and in particular, the cerebellum [3]. In the US, 800,000 vascular strokes are recorded every year where 87% belong to the ischemic stroke category [4]. More specifically, cerebellar infarcts account for 2-3% of all strokes. The gender ratio of cerebellar infarction is 2/3 for men, with an average age of 65 years. The mortality rate is reaching 23%, but in recent years this rate has decreased dramatically due to the evolution of healthcare with magnetic resonance imaging and computed tomography making a significant contribution to the early management of such an episode [3, 5].

Cerebellar infarction can be caused by arterial occlusion, mechanical compression, or vasoconstriction. The source of blockage can be created either through the circulation of the heart, called the thromboembolic phenomenon, or through the cerebellar vessel itself, known as the thrombotic effect, due to various vascular diseases and atherosclerosis [3].

There are many factors that can contribute to the formation of a cerebellar infarct with the most common causes being atherosclerosis, atrial fibrillation, paradoxical embolism, cardiomyopathy, and heart failure [3, 5].

In the first hours that the patient experiences the infarct, he or she will experience severe headache, vomiting, sleepiness, and changes in psychology [3]. Depending on the damaged artery, there will be different symptomatology. Thus, damage to the PICA, which is the most common, involves the development of two possible syndromes, Wallenberg syndrome, or Horner syndrome [1]. Some of the symptoms are ataxia, nystagmus, vertigo, myesis, and loss of sensation in line with and opposite side of the lesion [5].

For infarction in the SCA, the symptoms are more severe due to the greater distribution of the artery in the cerebellum [5]. Indicatively, severe ataxia in limbs and gait, dysarthria, dysmetria, paresis, loss of sensation of the opposite side of the body, and visual-motor nystagmus are observed [3].

Finally, common symptoms of AICA strokes as the rarest posterior circulation strokes are vertigo, nystagmus, falling to the side of the lesion, associated tinnitus and deafness, dysarthria, and dysphagia [1].

For the assessment of a patient with a cerebellar infarct, the head impulse test, Nystagmus, test of skew exam (HINTS) is mainly used as a preliminary and rapid screening tool for the diagnosis of central (cerebellar infarction) or peripheral (vestibular neuritis) vertigo. It is performed in patients with continuous, for hours or days, symptoms of vertigo and sudden nystagmus and consists of the head impulse test, the nystagmus test, and the skew test [3].

Several assessment scales can be used to evaluate the severity of symptoms in these patients, with interest focusing on two ataxia assessment scales. Firstly, the scale for the assessment and rating of Ataxia (SARA) through eight different parts assessing gait, posture, sitting, speech disorders, the index finger–index test, the index finger–nose test, the fast palm alternation test (pronation–supination), and the heel–shin test [6]. It is worth mentioning that the SARA has been found to have a very good correlation with the patient's gait and independence level in the activities of daily living (ADL) [7]. Finally, the international cooperative ataxia rating scale (ICARS) assesses the patient through four subscales of postural and gait disorders, limb ataxia, speech disorders, and oculomotor disorders [8].

The treatment of these patients is mainly focused on surgery and drug therapy. Some of the most common surgical operations used are decompressive hemicraniectomy, sub-occipital craniectomy, extraventricular drainage, and ventriculostomy [3, 5, 9]. Regarding pharmacological treatment, the most commonly used drugs are aspirin, clopidogrel, atorvastatin, mannitol, and heparin [9-12]. Also, since this is a neurovascular episode, the contribution of the rehabilitation team in general, and physiotherapy in particular, is extremely important, always aiming at the functional independence of the patient. Using individualized physical therapy programs, appropriate exercises, as well as appropriate equipment that only a qualified physical therapist knows how to use, it is possible to improve the performance of patients with cerebellar infarction, as shown by other cerebrovascular diseases, such as stroke [13]. In addition, similar research has been conducted on the effectiveness of physiotherapy and therapeutic exercise programs in cerebellar dysfunction and cerebellar ataxia, showing very good results for disease severity and balance, always suggesting further study in this field [14, 15]. This overview of existing studies aimed to investigate the effectiveness of physiotherapy programs on the symptoms of patients with cerebellar infarction.

Materials and Methods

A literature search was performed using PubMed (MEDLINE), Scopus (Elsevier), CENTRAL (cochrane central register of controlled trials), Web of Science, SPORTDiscus (EBSCO), and ResearchGate databases on September 4, 2022. An additional search of PubMed Central and Google Scholar databases was performed on September 8, 2022. To conduct the review, the databases were searched using defined keywords and certain eligibility criteria. The following keywords were used for the search: physiotherapy, physical therapy, rehabilitation, therapeutic exercise, exercise, cerebellar infarct, cerebellar infarction, and cerebellar blockage. The search strategies in the databases are given in Table 1.

The inclusion criteria were: a) Randomized, pilot or case studies, b) Studies published exclusively in the English language, c) The age of the subjects being over 18 years, d) Studying subjects diagnosed with cerebellar infarction, e) Physiotherapy, therapeutic exercise, rehabilitation, or exercise in general as an intervention, and f) Evaluation of any parameter that may be affected as a symptom in this group of patients and evaluated with the relevant evaluation tool. In contrast, the exclusion criterion was studies that followed vestibular or cognitive rehabilitation as the type of intervention.

The eligibility of studies was assessed by two separate reviewers and there was the possibility of a third-party consensus in case of disagreement, which was only needed in a study where the main reviewers were not confident enough about its inclusion in the qualitative synthesis of the overview [16].

Results

The number of initial records searching the six main databases was 155. After removing the duplicate studies, 97 cases remained, and after removing the articles by title, six studies remained to read their abstracts. It should be mentioned that Microsoft Excel was used to remove duplicate studies by deleting duplicate variables, but the reviewers also manually deleted duplicate studies. After reading the abstracts, five studies were removed and finally, only one study met the criteria. In addition, a second search of two databases was performed, in which the records screened were 1322. After reading the titles of the studies, the abstract, and the full text of some of them, we concluded that five studies met the inclusion criteria of this overview. Thus, the total number of articles included in the overview was six. The process of selecting studies was also presented graphically based on the PRISMA 2020 (preferred reporting items for systematic reviews and meta-analyses) flowchart in Figure 1 [17].

Table 1. Search strategies using the selected databases

Database	Search Strategy
PubMed	(“physical therapy modalities”[MeSH Terms] OR (“physical”[All Fields] AND “therapy”[All Fields] AND “modalities”[All Fields]) OR “physical therapy modalities”[All Fields] OR “physiotherapies”[All Fields] OR “physiotherapy”[All Fields] OR “physical therapy”[All Fields] OR (“rehabilitant”[All Fields] OR “rehabilitants”[All Fields] OR “rehabilitate”[All Fields] OR “rehabilitated”[All Fields] OR “rehabilitates”[All Fields] OR “rehabilitating”[All Fields] OR “rehabilitation”[MeSH Terms] OR “rehabilitation”[All Fields] OR “rehabilitations”[All Fields] OR “rehabilitative”[All Fields] OR “rehabilitation”[MeSH Subheading] OR “rehabilitation s”[All Fields] OR “rehabilitational”[All Fields] OR “rehabilitator”[All Fields] OR “rehabilitators”[All Fields]) OR “therapeutic exercise”[All Fields] OR (“exercise”[MeSH Terms] OR “exercise”[All Fields] OR “exercises”[All Fields] OR “exercise therapy”[MeSH Terms] OR (“exercise”[All Fields] AND “therapy”[All Fields]) OR “exercise therapy”[All Fields] OR “exercise s”[All Fields] OR “exercised”[All Fields] OR “exerciser”[All Fields] OR “exercisers”[All Fields] OR “exercising”[All Fields])) AND (“cerebellar infarct”[All Fields] OR “cerebellar infarction”[All Fields] OR ((“cerebellum”[MeSH Terms] OR “cerebellum”[All Fields] OR “cerebellar”[All Fields]) AND (“blockage”[All Fields] OR “blockages”[All Fields]))))
Scopus, CENTRAL, Web of Science, SPORTDiscus, ResearchGate, PubMed Central, Google Scholar	(((((physiotherapy) OR (“physical therapy”)) OR (rehabilitation)) OR (“therapeutic exercise”)) OR (exercise)) AND (((“cerebellar infarct”) OR (“cerebellar infarction”)) OR (“cerebellar blockage”))

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Of the 1477 initial records, only six studies met the entry criteria, of which two cases were research studies with more than one participant and the remaining four were case studies. Of the included studies, two cases were conducted in the United Kingdom and one study each was conducted in Japan, Germany, Egypt, and the US. Also, the total sample of participants in these studies was 38, with the majority of them being female. The interventions of the studies involved a program of balance and active exercises for the trunk, hips, and knees with emphasis on extensors, a treadmill exercise

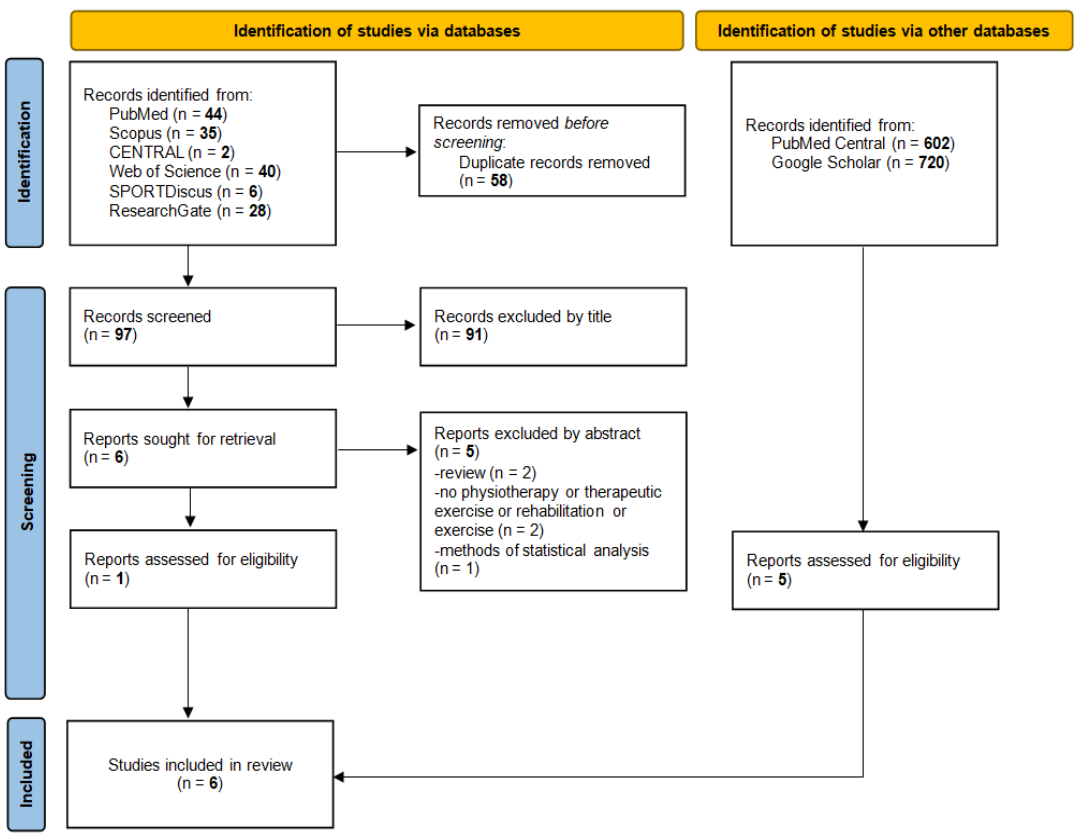

Figure 1. Diagram showing the search process and selection of the final studies

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Table 2. Sample, assessment characteristics, intervention, and results of each article

Articles					
Study	**Sample**	**Sample Data**	**Assessment**	**Methods**	**Results**
ElWishy & Rashad (2007) [18]*	24: Group 1 (n=12) Group 2 (n=12)	Female > Male, 52–67 years old, ID: 7–11 months	Functional standing balance scale: Balance without movement component (static balance test), Biodex stability system (dynamic balance test) Before and after the physiotherapy training program (six weeks).	Group 1: Graduated-according to initial patient's evaluation grades of static and dynamic standing balance-exercises with shifting the head forward, backward, right, and left rotation. Also, raising both arms gradually upwards till the maximum range, followed by moving the trunk forwards, backward, and sideward to the right and to the left. Then, the patient was pushed in different directions from stride position and then, from walking and standing on one foot, alternatively. Finally, balance board training was performed. Group 2: The same program as Group 1, and graduated active exercises for the abdominal and back muscles in the sagittal plane as well as hip and knee extensors. Both groups: Each exercise 20 times with a rest period of 1 minute every ten repetitions. The program was performed three days a week for six weeks.	Static balance: A statistically significant improvement in both groups (P<0.01), with statistically significant difference in Group 2 compared to Group 1 (P<0.05). Dynamic balance: A statistically significant improvement in both groups (P<0.01), with no significant difference between them.
Bultmann et al. (2014) [19]*	10: Treadmill-trained group (n=5) Control group (n=5)	Female < Male, 43–82 years old, PICA > SCA, right side >left side, ID: 12.4±11.7 days	ICARS (the total score and its subscores for gait, posture, and lower limb) Before the program, at the end of the study (two weeks), and after three months.	Treadmill-trained group: 2-week treadmill training carried out by an experienced therapist and lasted 30 min per day. The velocity of the training was varied and progressively increased based on patients' abilities.	No significant difference was detected between groups in the total ICARS score (P=0.59) and in the ICARS subscores (P>0.35).

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Abbreviations: N: Sample number; ID: Infarct duration; PICA: Postrerior inferior cerebellar artery; SCA: Superior cerebellar artery; ICARS: International cooperative ataxia rating scale.

*Approximate sample data.

program, a task-oriented approach, a metronome-based walking program, a program based on general physiotherapy principles and tools from the intensive care unit (ICU) to outpatient, and finally, a program based on virtual reality. The duration of interventions ranged from two to 57 weeks, and the assessment tools used in the studies were varying, assessing ataxia, gait, balance, function, etc.

Details of the sample, design, intervention, evaluation, and effectiveness of each study are presented in Tables 2 and 3. It should be noted that in two research studies, the sample was divided into groups based on a randomization method. In addition, in these two studies, one did not correctly report the number of participants by gender compared to their sample size, as well as information on infarct location, and the second study did not report the characteristics of the participants who finally carried out the intervention. Thus, in Table 2. the sample characteristics described are approximate for these two studies [18, 19].

According to the results of the analyzed studies, a program of balance and active exercises on the trunk, hips, and knees with emphasis on the extensors showed that it helped the static balance of the participants who followed the program, as opposed to the dynamic balance of those who only did a balance exercise program, which showed no difference in effectiveness compared to the group who also did extensor exercises. In contrast, a treadmill exercise program showed no differences between groups in ataxia symptoms, with one group receiving an intervention and the other not.

Table 3. Sample, assessment characteristics, intervention, and results of each case study

Case Studies				
Study	**Participants' Data**	**Assessment**	**Methods**	**Results**
Derks (2015) [20]	78-year-old female subjects with right PICA stroke, after three weeks the 2nd episode was associated with ataxic gait, lower extremity weakness, decreased sensation and cognition, impaired balance and coordination, and functional mobility deficits.	BBS, MMT, FIM, MAS, deep tendon reflexes, heel-to-knee test, discriminative touch, proprioception test, and functional and gait analysis. From admission to discharge every week (4-5 weeks).	Acute rehabilitation setting: Task-oriented approach with re-training of bed mobility, transfers, gait, and wheelchair mobility. Neuromuscular re-education, therapeutic exercise, and motor learning. Visual and tactile cues (blue parallel lines) during gait. Progressed lower extremity strengthening and balance exercises. Right ankle foot orthotic to assist gait training at week three. Every day (morning and afternoon), 30-60 minutes/day, 60 sessions for 4-5 weeks.	↑ of endurance, walking distance with the ambulatory, and independent movement with the wheelchair. [FIM ↓ by 28 points, BBS ↓ by 8 points]
Wright et al. (2016) [16]	81-year-old female samples with left PICA stroke, slight dysmetria, tired of walking, falls, atrial fibrillation, and ICARS score (gait and posture)=11 .	15-camera Vicon system: Gait variability for the temporal and spatial gait parameters for the left and right sides, sagittal hip, knee, and ankle angles. Three standard gait trials and three gait trials with an auditory metronome.	1st, she performed three gait trials at her comfortable pace. Her average cadence was used for the metronome. Then, a 5-min familiarization period to the metronome and then, three gait trials were performed with metronome cueing. The first and last three steps of each walking trial were discarded for acceleration and deceleration.	↓ in variability for step length & time, stance time, double support time, and joint angle measures (except right hip flexion).
Wilson et al. (2017) [21]	51-year-old female subjects with left PICA stroke with obstructive hydrocephalus, vertical diplopia, dysphagia, dizziness, headache, impaired coordination, and ataxic gait.	CARE, MMT, PASS, PSFS, and TUG. During the study from week one to week 57.	ICU: Passive and active exercises, stretching, and a sitting position for 30 minutes each time for six weeks. IRP: Lower limb active exercises, open and closed kinetic chain exercises in all planes (standing position), short sits with lightweight application on the ankle joints, upright position on toes and heels, trunk stabilization exercises (supine position), on-site steps for ten weeks. ORP: Static and dynamic balance exercises from sitting and standing positions, lower limb lunges with weight transfer and balance disturbance, torso exercises from a quadruped position, treadmill, transfer from a supine to a kneeling position, mini push-ups, and family training for 41 weeks.	The patient was able to return home and be independent in modified and instrumental ADLs.

Case Studies				
Study	**Participants' Data**	**Assessment**	**Methods**	**Results**
Takimoto et al. (2021) [22]	40-year-old male subjects with right cerebellar/brain-stem infarct, ataxic gait, requiring supervision for transferring and moving.	SARA, FBS, mini-BEST, and FIM. Before the intervention and after three, five, and seven weeks.	IRP: Balance and gait exercises for three weeks. VR: Balance re-training, the patient sat and tried to catch the balls that appeared in front of him with both upper limbs and with the controllers that he was holding. There are two colored balls, matching the two upper limbs that have to fend them off. Speed, position, and number of balls can be modified according to the patient. The patient is trained and learns to shift his body weight smoothly. Five days a week for 20 minutes in two sets for two weeks.	↓ of ataxia, ↑ of balance and he functionally returned to work.

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Abbreviations: PICA: Postrerior inferior cerebellar artery; BBS: Berg Balance Scale; MMT: Manual muscle testing; FIM: Functional independence measure; MAS: Modified Asworth Scale; ↑: Improvement; ↓: Reduction; ICARS: International cooperative ataxia rating scale; CARE: Continuity Assessment record and evaluation; PASS: Postural assessment for stroke scale; PSFS: Patient-specific functional scale; ICU: Intensive care unit; IRP: Inpatient rehabilitation program; ORP: Outpatient rehabilitation program; ADL: Activities of daily living; VR: Virtual reality, TUG: Timed up and go; SARA: Scale for the assessment and rating of ataxia; FBS: Functional balance scale; Mini-BEST test: Mini-balance evaluation systems test.

Regarding the case studies, the effect of the task-oriented approach showed an improvement in both the gait and functional independence of the patient in a relatively short period (4-5 weeks). Improvement in gait parameters was also found in the study using the metronome, although no safe long-term conclusions can be drawn due to the very short duration of the intervention. Furthermore, a well-structured physiotherapy program based on general physiotherapy principles and tools, from the ICU to outpatient, with a duration of 57 weeks, was found to have very good results for the patient's full independence in ADLs. Finally, a virtual reality program based on balance and weight shifting showed beneficial effects on the patient's ataxia symptoms, balance, and return to work (Table 3).

Discussion

This overview of the available studies is the only one that exists in this field and considers it necessary for the clinical and scientific field of physiotherapists in the management of such cases. With no time limit for finding literature and including any type of study from eight databases, the research gaps for the management of patients with cerebellar infarction emerge, and as can be seen, there are no similar studies to compare with those mentioned above, as all those that were relevant to the selected topic.

As it seems from the research studies where the sample size was larger, a personalized program of balance and strengthening exercises of the body's extensor muscles is very helpful in stabilizing the patient's body to cope with daily functional demands and probably creating the patient's security and confidence to perform activities that require balance. Perhaps the treadmill exercise program was not as successful, even though it targeted the patient's functional gait, due to the patient's failure to be demarcated into specific rehabilitation frameworks based on symptoms. Also, the task-oriented approach program that was used in a case study showed very positive results for gait and balance in stroke patients [23]. Overall, in combination with the case studies, gait and balance exercise programs improve a patient's functionality, thereby achieving his/her independence in ADLs and reducing his/her symptoms. Finally, the results of this overview are in line with the findings of systematic reviews and meta-analyses that studied cerebellar ataxia and cerebellar dysfunction as they found the positive response of physiotherapy and therapeutic exercise programs mainly on the balance of these patients [14, 15].

The outcome of patients after cerebellar infarction is that they will have better hand mobility and walking ability in the ADLs than patients with cerebral stroke [24]. The process of the patient's recovery and the outcome depend on the severity of the damage and the initial functional level. There is an improvement in the mean functional independence measure (FIM) scale score after recovery from infarction, but the patient's pre-existing comorbidities and functional status at the time of discharge from acute hospitalization are also important [25]. Finally, in the study using functional magnetic resonance imaging (fMRI), recovery after infarction was based on cerebellar reorganization on the infarct side and activation of cerebellocortical loop connections with ipsilateral cerebrum and contralateral cerebellum movement control [26].

Conclusion

It seems that the physical therapy approach of the patient with cerebellar infarction is focused on a program of balance exercises and walking exercises, which always aims at the functional independence of the patient. Individual research in this field is extremely necessary in order to provide properly structured and clinically proven forms of physiotherapy intervention for these patients.

This overview of existing studies is an incentive to conduct more studies on cerebellar infarction, especially studies with a larger number of participants or even randomized controlled trials with a control group for safer, valid, and reliable conclusions. Also, future research can target the selection of interventions for patients with infarct in a specific cerebellar artery, giving appropriate conclusions for the respective symptomatology. In addition, it is considered important to emphasize the long-term outcomes of the studies, since only a few discussed studies had long durations of both intervention and follow-up.

Regarding the limitations of the present overview, initially, due to the variety of intervention programs, no safe conclusion can be drawn about the most effective form of intervention in general for the symptoms of patients with cerebral infarction. Furthermore, safe conclusions cannot come up due to not assessing the quality of the included studies. Also, the long-term effects of each intervention cannot be known as very few studies have re-evaluated their sample. Finally, the conclusions do not address treatment guidelines for patients with infarction in a specific cerebellar artery but provide general guidance.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflicts of interests.

Acknowledgments

The authors would like to thank Besios Thomas for helpful comments and discussion and everyone else who took part in this review article.

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