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Systematic Review

The Effects of Robot-Assisted Gait Training on Functional Recovery After Subacute Stroke: A Systematic Review

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Abstract

Stroke frequently causes sensory deficits, decreased muscle strength, and impaired postural control, all of which contribute to reduced mobility and functional capacity, highlighting the need for effective rehabilitation strategies. Conventional rehabilitation methods do not always succeed in fully restoring mobility and functional independence. Robot-assisted gait training (RAGT) provides an innovative approach to improving motor recovery and enhancing the quality of life of stroke survivors. The integration of the robotic concept, using devices to assist gait training, offers significant therapeutic potential. RAGT has been introduced as a complementary approach to the rehabilitation process, encouraging repetitive practice and leveraging neuroplasticity to enhance motor recovery. Objective: The systematic review focused on analyzing the available findings regarding the applicability of RAGT in enhancing task-specific performance, mobility, and functional capacity in stroke survivors. Data sources/Methods: Available research on gait limitations caused by stroke was analyzed, and available therapeutic options were subsequently examined in detail. A systematic search was performed in three databases, namely PubMed on 2 August 2026, PEDro on 3 August 2026, and Scopus on 5 August 2026. The outcomes of studies investigating the integration of RAGT were reviewed. Randomized controlled trials (RCTs) evaluating RAGT in patients with stroke were included. The selection of studies, extraction of data, and methodological quality assessment were carried out according to predefined criteria. The Cochrane Risk of Bias 2 (RoB2) tool was used to determine the methodological quality and risk of bias of the selected studies. Overall, the risk of bias assessment indicated that 11 studies had some concerns, while 4 studies were rated as having a low risk and 5 as having a high risk of bias. The certainty of evidence for the main outcomes was assessed using the GRADE approach, considering risk of bias, inconsistency, indirectness, imprecision, and publication bias. Certainty was classified as high, moderate, low, or very low. GRADE indicated low-certainty evidence for functional ambulation, gait speed, balance, and activities of daily living, and very-low-certainty evidence for walking endurance. Main results: A total of 20 RCTs involving 851 participants met the inclusion criteria. The results showed that most reported significant improvements in walking performance, postural control, and dynamic balance. However, between-group differences were less consistent. Greater improvements were generally reported when RAGT was combined with conventional rehabilitation or other adjunctive interventions. Differences were observed between studies regarding research design, implemented intervention protocols, and the scales used to assess functional outcomes. Conclusions: RAGT may be a useful adjunct to conven-

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tional rehabilitation by increasing the amount and standardization of task-specific gait practice. However, the included RCTs did not demonstrate consistent superiority over conventional rehabilitation across functional outcomes. The certainty of evidence was low or very low, and the optimal device, training dose, patient profile, and durability of benefit remain uncertain.

Keywords: subacute stroke; robot-assisted gait training; robotic gait training; robot-assisted locomotor training; robotic technology; gait; walking; locomotion; ambulation

1. Introduction

Stroke represents a leading cause of disability among adults and is often accompanied by lower-limb motor dysfunction, resulting in substantial deficits in mobility, coordination, and balance that limit ADLs and social participation [1,2].

According to the Global Burden of Disease, the mortality rate following stroke is 42.56 per 100,000 individuals, with approximately 3.3 million deaths reported annually. Worldwide, one in four people over the age of 25 will experience a stroke during their lifetime. The incidence of this condition continues to rise annually, resulting in a global economic burden exceeding USD 891 billion [3,4].

Approximately 60% of patients lose or limit their ability to walk immediately after stroke, while nearly 20% continue to remain unable to bear weight one year later [5,6].

Following a stroke, patients continue to face a persistently high risk of cardiovascular morbidity, recurrent stroke, myocardial infarction, and cardiac-related mortality [7,8].

Balance and gait dysfunction are common complications in patients with stroke, with more than 50% of these individuals estimated to be at risk of falls and injury, which affects independence in ADLs. Gait is a complex process that requires dynamic balance, adequate motor control, and precise movement of the center of pressure for its normal execution [9,10].

Recent studies have also consistently demonstrated that unilateral muscle weakness contributes to gait asymmetry and that the rehabilitation process is particularly critical immediately after stroke [11,12].

Impaired gait patterns limit ADLs, walking distance, and exercise tolerance, while reduced or lost walking function leads to long-term disability [13–15].

Programs that emphasize functional mobility and the ability to perform ADLs are essential for improving the quality of life of stroke survivors. The feasibility of maintaining these programs is important for preserving the progress achieved [16–18].

To restore walking capacity, modern rehabilitation concepts emphasize task-specific repetitive training, and high-intensity practice has demonstrated significant outcomes [19,20].

The repetitive nature of training, closely resembling physiological gait, together with continuous proprioceptive and exteroceptive feedback, provides favorable conditions for motor relearning [21,22].

Rehabilitation alternatives for motor dysfunction are based on motor relearning principles aimed at promoting motor neural network plasticity. Accordingly, RAGT integrates intensive, repetitive, and structured task-oriented practice, which is fundamental for motor relearning and has been shown to contribute to targeted motor improvement in individuals after stroke [23–25].

RAGT reduces the workload of physiotherapists while ensuring task-specific gait practice. Studies have shown that RAGT optimizes movement patterns and muscle activation of the affected lower limb during walking compared with conventional rehabilitation [26–28].

The interactive component of RAGT, combined with virtual reality or therapeutic games, increases active patient participation [29,30].

The primary objective of RAGT is to deliver structured, high-intensity, repetitive, and task-specific training [31,32].

In accordance with the fundamental principles of neurorehabilitation, enhancing neuroplasticity through motivation, multisensory stimulation, early initiation, and the application of appropriately timed therapy with progressive intensity is essential for effective gait training. In this context, effective methods that support the standard neurorehabilitation process for gait and mobility disorders in post-stroke patients are continuously being developed and investigated, involving assistive robotic technologies, virtual reality, and biofeedback [33,34].

The integration of robotic systems for gait training aims to promote nervous system activation, encourage active participation, stabilize balance control, and enhance muscle activation [35].

During robotic-locomotion-based therapy, the patient is secured in a body-weight support harness, and the robotic exoskeleton is attached to the lower limbs. The exoskeleton applies guiding forces throughout movement, enabling patients to engage in repetitive gait practice at near-normal speeds. RAGT provides intensive, repetitive, and task-specific practice that may support motor relearning; however, the included clinical trials did not directly assess neural reorganization [36].

Clinical guidelines emphasize the significance of intensive, repetitive, and task-oriented training to stimulate neuroplasticity, taking into account both visual feedback and motor input. RAGT has demonstrated positive effects on balance. The concept of rehabilitation has undergone a significant change with the development of robotic technologies, representing a fundamental perspective in addressing conventional methods. The use of targeted, intensive, and engaging rehabilitation strategies based on RAGT outlines an innovative approach in the recovery process [37–45].

Patients with severe mobility impairments can practice movements resembling physiological gait at near-normal speeds, performing prolonged, regular training independent of the manual efforts of physiotherapists, compared with conventional rehabilitation [46].

Technology-assisted gait rehabilitation emphasizes repetitive, intensive, and task-specific practice, helping stroke survivors with both mild and severe motor impairments regain motor coordination [47].

RAGT has a positive impact on the psychological condition of patients by increasing active participation, attention, and motivation. The interactive component, together with real-time feedback, stimulates patients and encourages them to achieve the proposed objective. This psychological impact is important because it influences their adherence to the rehabilitation program [48,49].

Compared with conventional rehabilitation, integrating robotic gait rehabilitation intervention is cost-effective, as therapy sessions can be longer, gait patterns are more symmetrical, the intervention can be conducted by a single physiotherapist, and energy expenditure is reduced [50].

Recent studies have reported that RAGT supports a more symmetrical muscle activity pattern compared with conventional rehabilitation [51].

A systematic review of the effectiveness of robotic therapy in patients with neurological disorders reported statistically significant improvements in gait speed, functional abilities, and motor function following treatment [52].

The exploration of the effectiveness of robotic systems, including end-effector robots, fixed and wearable exoskeletons, as well as their combinations, has opened new perspectives for targeted gait and balance rehabilitation. Robotic systems provide distinct benefits in the field of functional recovery. Gait re-education through the use of an exoskeleton contributes to the development of a gait pattern similar to the physiological one, both in temporal

and spatial terms. In addition, it supports postural control during walking through active patient involvement. Besides facilitating gait re-education, robotic systems also contribute to reducing the secondary consequences of immobilization [53–55].

Although previous systematic reviews and meta-analyses have evaluated robot-assisted and electromechanical gait rehabilitation after stroke, uncertainty remains regarding the additional clinical benefit of RAGT specifically during the subacute phase, when spontaneous neurological recovery and intensive conventional rehabilitation may substantially influence functional outcomes. Previous evidence has also frequently combined heterogeneous stroke stages, robotic technologies, and outcome domains. The present review updates the evidence through 2026 and focuses specifically on randomized controlled trials involving adults within 6 months after stroke. In addition, it distinguishes within-group improvements from between-group treatment effects and evaluates functional ambulation, gait speed, walking endurance, balance, and activities of daily living using both RoB2 and GRADE. This approach aims to clarify the additional contribution of RAGT beyond conventional rehabilitation and to identify areas in which the certainty of evidence remains limited.

Gait rehabilitation is a major component of clinical practice for patients with stroke. Robotic technologies designed for RAGT have gained significant popularity due to their potential to provide repeated, controlled, and intensive walking practice.

1. To what extent does RAGT improve functional walking ability in patients with stroke compared with conventional rehabilitation?
2. How does the level of active patient participation during RAGT influence rehabilitation outcomes?
3. Are the improvements gained through RAGT transferred to real-life walking situations and maintained over time?

These three questions are important for understanding the effectiveness of RAGT in stroke rehabilitation, as they not only assess functional improvements in walking but also investigate the role of active patient engagement and the extent to which the results transfer to real-life situations, thereby providing a comprehensive view of the clinical and practical potential of robotic technology.

2. Materials and Methods

2.1. Selection Criteria

The systematic review was conducted by identifying studies in the PubMed, PEDro, and Scopus databases, focusing on studies published between 2011 and 2026. Only studies published in English were considered eligible. No language filters were applied during the searches in PubMed and PEDro, but in the Scopus database, the search was restricted to articles in English by using the "Language: Limited to English" filter. Additionally, the "Document Type: Limited to Article" filter was applied. The included studies involved adult patients (≥18 years) post-stroke, regardless of stroke type (ischemic or hemorrhagic) and post-stroke stage (subacute, <6 months post-stroke), reporting at least one of the relevant outcomes.

Eligible study designs included RCTs that evaluated the effects of RAGT in patients with stroke. The information selected for the Introduction was drawn from the existing literature and previous studies solely for contextual purposes and did not influence the data extraction or analysis of the results.

A systematic literature search was conducted in three electronic databases: PubMed, PEDro, and Scopus. The PubMed search was performed on 2 August 2026, the PEDro search on 3 August 2026, and the Scopus search on 5 August 2026.

The search strategy was adapted for each database according to its specific indexing and search syntax.

In PubMed, MeSH terms and free-text terms were searched using the All Fields option. ("subacute stroke" OR "post-stroke") AND ("robot-assisted gait training" OR "robotic gait training" OR "robot-assisted locomotor training") AND (gait OR walking OR locomotion OR ambulation). In PEDro, simplified free-text searches were performed in the Abstract and Title fields, as the database does not support complex Boolean combinations in the same way as bibliographic databases. The search terms "subacute stroke" AND "robot-assisted gait training" were used to identify potentially eligible studies. In Scopus, the search was performed in the article title, abstract, and keywords fields using the following search strategy: ("subacute stroke" AND ("robot-assisted gait training" OR "robotic technology")).

The search strategy was intentionally focused on terminology explicitly describing task-specific robot-assisted gait training, rather than the broader category of electromechanical lower-limb rehabilitation technologies, in order to preserve the predefined intervention scope of the review.

2.2. Inclusion and Exclusion Criteria

For the purpose of conducting this systematic review, the inclusion and exclusion criteria were clearly established to select the most relevant studies, thereby ensuring the methodological coherence of the material.

Studies published between 2011 and 2026 were considered, focusing on the integration and use of robotic systems for gait rehabilitation in post-stroke patients and examining solutions supported by empirical data. Studies were excluded if they lacked empirical data, did not specifically investigate RAGT in patients after stroke, or did not include human participants. Eligible studies were published in English and included adult participants (≥18 years) with ischemic or hemorrhagic stroke in the subacute post-stroke phase, defined as less than 6 months from stroke onset to participant enrollment. The time from stroke onset to participant enrollment is summarized in Table 1.

Table 1. Summary of the key characteristics of studies included in the review, published from 2011 to 2026.

Author (Year)	Time Since Stroke	Study Design	Sample Size	Group Distribution	Intervention
Kim et al., 2025 [56]	Experimental group: 3.60 ± 2.67 Control group: 4.06 ± 2.69 (months)	RCT	Randomized: 70 Final analysis: 60	Experimental: 30 Control: 30	Angel Legs M + conventional rehabilitation
Huang et al., 2026 [57]	Experimental group: 1.88 ± 0.54 Control group: 1.95 ± 0.80 Placebo group: 2.00 ± 0.51 (months)	RCT	Randomized: 51 Final analysis: 48	Experimental: 16 Control: 17 Placebo: 15	Flexbot + conventional rehabilitation
Lin et al., 2022 [58]	Experimental group: 25.8 ± 26.5 Control group: 34.7 ± 25.5 (days)	RCT	Randomized: 40 Final analysis: 40	Experimental: 20 Control: 20	MRG-P100 + conventional rehabilitation

Table 1. *Cont.*

Author (Year)	Time Since Stroke	Study Design	Sample Size	Group Distribution	Intervention
Li et al., 2021 [59]	Experimental group: 2.53 (1.33) Control group: 3.38 (1.19) (months)	RCT	Randomized: 36 Final analysis: 32	Experimental: 17 Control: 15	BEAR-H1 + conventional rehabilitation
Chang et al., 2025 [60]	Experimental group: 33.0 ± 24.0 Control group: 28.4 ± 21.5 (days)	RCT	Randomized: 93 Final analysis: 75	Experimental: 35 Control: 40	Angel Legs M20 + conventional rehabilitation
Lee et al., 2023 [61]	Experimental group: 0.93 ± 0.69 Control group: 0.91 ± 0.71 (months)	RCT	Randomized: 55 Final analysis: 49	Experimental: 26 Control: 23	Morning Walk + conventional rehabilitation
Han et al., 2016 [62]	Experimental group: 21.56 ± 7.98 Control group: 18.10 ± 9.78 (days)	RCT	Randomized: 60 Final analysis: 56	Experimental: 30 Control: 26	Lokomat + conventional rehabilitation
Bergmann et al., 2018 [63]	Experimental group: 7.5 ± 2.6 Control group: 8.0 ± 3.8 (weeks)	RCT	Randomized: 38 Final analysis: 30	Experimental group: 15 Control group: 15	Lokomat + conventional rehabilitation
Thimabut et al., 2022 [64]	Experimental group: 56.15 ± 23.71 Control group: 72.54 ± 20.12 (days)	RCT	Randomized: 26 Final analysis: 26	Experimental: 13 Control: 13	Welwalk + conventional rehabilitation
Tang et al., 2026 [65]	Experimental group: 11.8 (6.7) Control group: 11.2 (6.7) (weeks)	RCT	Final analysis: 60	Experimental: 30 Control: 30	UGO220 + conventional rehabilitation
Chang et al., 2012 [66]	Experimental group: 16.1 (4.9) Control group: 18.2 (5.0) (days)	RCT	Randomized: 48 Final analysis: 37	Experimental: 20 Control: 17	Lokomat + conventional rehabilitation
Han et al., 2026 [67]	Experimental group: 21.53 ± 9.35 Control group: 26.13 ± 11.48 (days)	RCT	Randomized: 36 Final analysis: 30	Experimental: 15 Control: 15	R-BoT Plus + conventional rehabilitation
Gorsler et al., 2025 [68]	GT group: 36.5 (19.5) ST group: 44.8 (21.3) (days)	RCT	Randomized: 43 Final analysis: 43	GT group: 25 ST group: 18	THERA-Trainer balo, THERA-Trainer Lyra

Table 1. *Cont.*

Author (Year)	Time Since Stroke	Study Design	Sample Size	Group Distribution	Intervention
Alingh et al., 2021 [69]	Experimental group: 5.4 ± 1.8 Control group: 5.9 ± 2.1 (weeks)	RCT	Randomized: 34 Final analysis: 27	Experimental: 13 Control: 14	LOPES II combined with MOOG BV
Xie et al., 2026 [70]	Assistive training group: 96 (41–139.5) Passive training group: 42 (31–86) Control group: 95 (51.25–166.5) (days)	RCT	Randomized: 48 Final analysis: 48	Assistive training group: 16 Passive training group: 16 Control group: 16	AiWalker + conventional rehabilitation
Zhang et al., 2024 [71]	Experimental group: 49.71 ± 36.054 Control group: 43.63 ± 42.164 (days)	RCT	Randomized: 60 Final analysis: 55	Experimental: 28 Control: 27	A3 + conventional rehabilitation
Ochi et al., 2015 [72]	Experimental group: 22.9 ± 7.4 Control group: 26.1 ± 8.0 (days)	RCT	Randomized: 26 Final analysis: 26	Experimental: 13 Control: 13	GAR + conventional rehabilitation
Fiedorova et al., 2026 [73]	Experimental group: 13 (12–17) Control group: 12 (12–16) (days)	RCT	Randomized: 42 Final analysis: 36	Experimental: 17 Control: 19	Lokomat + conventional rehabilitation
Huo et al., 2024 [74]	Experimental group: 68.07 ± 35.67 Control group: 74.00 ± 33.29 (days)	RCT	Randomized: 40 Final analysis: 30	Experimental: 14 Control: 16	LiteStepper + conventional rehabilitation
Hesse et al., 2012 [44]	Experimental group: 5.7 ± 2.3 Control group: 5.1 ± 1.6 (weeks)	RCT	Final analysis: 29	Experimental: 15 Control: 14	G-EO + conventional rehabilitation

RCT: randomized controlled trial; GT: Gait training; ST: Standing training. Devices manufacturers and locations: Angel Legs M (ANGEL ROBOTICS Co., Ltd., Seoul, Republic of Korea); Flexbot (Multi-Position Intelligent Rehabilitation Robot, Shanghai, China); MRG-P100 (HIWIN Technologies Corporation, Taichung, Taiwan); BEAR-H1 (Milebot Robotics Co., Ltd, Shenzhen, China); Morning Walk (CUREXO, Seoul, Republic of Korea); Lokomat (Hocoma AG, Volketswil, Switzerland); Welwalk (Toyota Motor Corporation, Toyota City, Japan); UGO220 (RoboCT Co., Ltd., Hangzhou, China); R-BoT Plus (CoTras, Daegu, Republic of Korea); THERA-Trainer balo and THERA-Trainer Lyra (medica Medizintechnik GmbH, Hochdorf, Germany); LOPES II (University of Twente, Enschede, The Netherlands); AiWalker (Beijing Intelligent DaAi Robot Technology Co., Ltd., Beijing, China); A3 (RAGATS-A3, NX Robotics, Shanghai, China); GAR (Toyota Motor Corporation, Toyota City, Japan); LiteStepper (Angelexo Scientific Co., Ltd, China); G-EO (Reha Technology AG, Olten, Switzerland).

Studies evaluating RAGT alone or in combination with conventional rehabilitation therapy or other adjunctive interventions, such as functional electrical stimulation (FES), were considered eligible.

Studies were required to report at least one relevant outcome related to balance, gait, functional mobility, or ADLs. Studies were excluded if they did not specifically investigate RAGT in post-stroke patients, lacked empirical data, did not include human participants, or were published in languages other than English. Observational studies, studies with incomplete or insufficient data, review articles, meta-analyses, and studies involving patients in the acute or chronic post-stroke phase, pediatric populations, or patients with other concomitant neurological conditions were also excluded.

2.3. Literature Selection Process

The literature selection process was carried out in multiple stages, in accordance with recommendations for conducting review articles and the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

Initially, a systematic search was performed in relevant scientific databases, using keywords and combinations of terms specific to the field of RAGT and post-stroke rehabilitation. After duplicates were removed, the titles and abstracts of the identified studies were screened to assess their eligibility in relation to the study objectives. Articles that did not meet the inclusion criteria or that did not directly address the research topic were excluded at this stage.

The full texts of relevant studies were reviewed, and only those reporting outcomes on gait, balance, and functional recovery in post-stroke patients were included. Literature selection was performed in several stages, including title/abstract screening and full-text assessment, by two independent reviewers (G.M. and D.P.S.).

Any discrepancies that arose during the study selection or data extraction process were resolved by discussion and consensus or, when necessary, by consultation with a third senior reviewer (D.V.M.). The study selection process was documented and presented according to a PRISMA (Figure 1) flow diagram, ensuring transparency and reproducibility of the literature selection methods.

In accordance with PRISMA requirements, we declare that no detailed protocol was prepared prior to the research and no prospective registration was performed for this systematic review.

Initially, 210 records were selected using the following keywords: subacute stroke, robot-assisted gait training, robotic gait training, robot-assisted locomotor training, robotic technology, gait, walking, locomotion, and ambulation.

The following databases were consulted: PubMed (85 records), Scopus (104 records), and PEDro (21 records). Subsequently, 48 duplicate records were removed, resulting in 162 records for screening. Of these, 101 records were excluded during title and abstract screening.

A total of 61 reports were sought for retrieval, of which 14 could not be accessed in full text: 6 identified through PubMed, 4 through Scopus, and 4 through PEDro. For the 14 reports that could not be retrieved in full text, additional attempts were made through the corresponding journal and publisher websites. Full-text access could not be obtained because some articles were not accessible through the authors' institutional subscription, some could not be opened because of access-related technical errors, and several required individual payment for full-text access. Consequently, these reports could not undergo full-text eligibility assessment. The remaining 47 reports were assessed for eligibility, of which 27 were excluded based on the predefined exclusion criteria. Finally, 20 studies that met the predefined inclusion criteria were included in the systematic review.

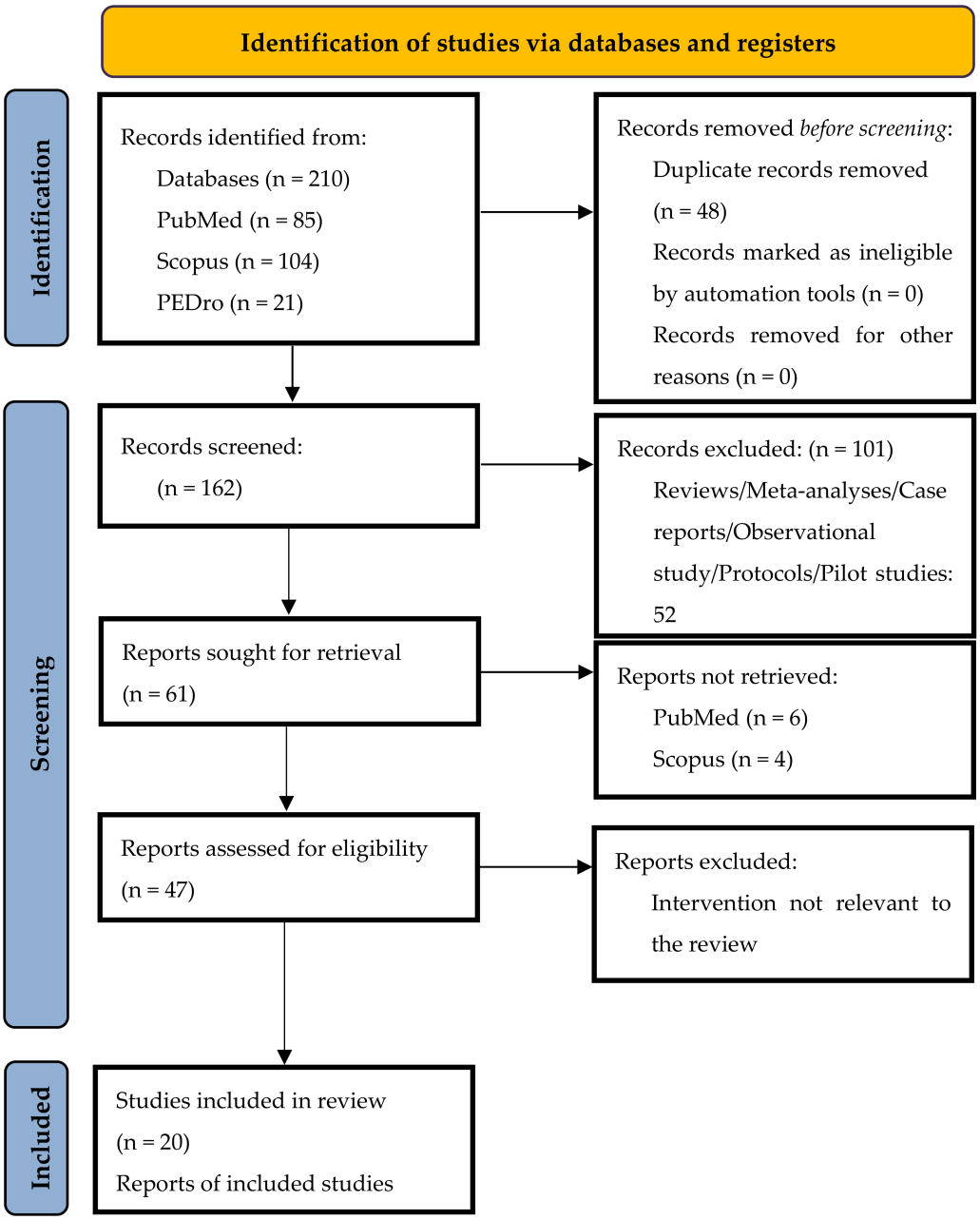

Figure 1. Flowchart of literature search and selection process.

3. Overview of Included Studies

RAGT represents an effective method for providing repetitive training, improving gait function, balance, and ADLs in patients with stroke [40].

Robotic devices provide training that facilitates the principles of motor learning that involve active motor and cognitive participation by patients [75,76].

Robotic devices are particularly advantageous because they can control the lower limbs by mobilizing the joints and minimizing abnormal movements, thereby promoting a physiological gait pattern [77,78].

Although robotic systems for the lower limbs have introduced a new approach for individuals with gait difficulties, there is still limited evidence regarding optimal training parameters. Intensity is an important factor influencing rehabilitation results; however, in clinical practice, resource and time constraints often result in insufficient training duration. This may lead to limited functional recovery and delay the rehabilitation process. Current

evidence demonstrates that there is no standardized protocol for determining the duration of a single training session, with session duration ranging from 10 to 60 min. This variability may result in different outcomes regarding walking capacity and postural control [16,79–87].

Gait and mobility were assessed using the Functional Ambulation Classification (FAC), Fugl-Meyer Assessment of the Lower Extremity (FMA-LE), 10-Meter Walk Test (10MWT), 6-Minute Walk Test (6MWT), Rivermead Mobility Index (RMI), and Motricity Index-Lower (MI-LL/MI), reflecting walking speed, endurance, and functional ambulation capacity.

The FAC is frequently employed in a clinical setting to evaluate walking ability, distinguishing 6 levels of locomotor ability based on the amount of physical support required. Currently, the FMA scale widely serves to evaluate gait quality and is recognized as a predominant clinical method, while the FMA-LE is integrated for a comprehensive clinical examination of the lower limb [88–90].

The 6MWT and the 10MWT were employed to assess walking endurance and speed. The 6MWT quantifies functional mobility based on the distance covered in meters over 6 min. The result represents a measure of endurance, being relevant for assessing the ability to perform continuous activities. Similarly, the 10MWT was also incorporated to assess walking speed [91–95].

The Motricity Index (MI) is an instrument used to assess and monitor improvements in muscle strength by measuring hip flexion, knee extension, and ankle dorsiflexion, while using mobility-related items to evaluate functional capacity [96–98].

Balance and postural control were mainly assessed using the Berg Balance Scale (BBS) and Timed Up and Go (TUG). Most of the included studies reported statistically significant improvements following RAGT, particularly when combined with conventional rehabilitation.

The BBS is a validated instrument used to assess fall risk, whereas the TUG evaluates dynamic balance and involves a sequence of specific functional tasks, such as sit-to-stand transfers, walking stability, and changes in gait trajectory [99–105].

The Functional Independence Measure (FIM) is a standardized instrument for assessing functional independence and disability and consists of 18 items: 13 motor and 5 cognitive items [106].

The Modified Barthel Index (MBI) assesses performance in ADLs, with scores ranging from 0 to 100, with higher scores indicating a higher level of functional independence [107].

Another important scale used in this category is the Barthel Index (BI), which evaluates the level of independence of patients in performing ADLs.

Physical, cognitive, and psychosocial impairments affect more than half of stroke survivors, reducing quality of life and social participation while limiting their ability to perform ADLs. Walking difficulties represent a major cause of disability after stroke and have a significant impact on functional independence. Therefore, restoring gait function is considered one of the primary goals of post-stroke rehabilitation.

RAGT is a safe, intensive, repetitive, and task-specific rehabilitation approach that may help patients with mild to severe motor impairments improve motor coordination and gait performance. RAGT enables patients with limited mobility to repeatedly practice gait-like movements at near-normal speeds and facilitates a more consistent and regular gait pattern, with reduced dependence on the physical efforts of physiotherapists. Furthermore, robotic devices can provide prolonged and intensive gait practice while allowing the level of assistance to be adjusted according to patient functional abilities.

A recent Cochrane review found that patients within the first three months after stroke who received RAGT combined with conventional rehabilitation were more likely to regain walking ability than those who received conventional rehabilitation alone. RAGT may contribute to improvements in walking ability and functional mobility, as well as enhanced cardiorespiratory fitness.

RAGT generally requires the involvement of a trained physiotherapist to perform patient assessments and functional measurements, ensure appropriate positioning within the device, and adjust the robotic device and training parameters accordingly. The acquisition, maintenance, and clinical use of robotic rehabilitation systems can involve considerable costs, thereby limiting their accessibility and widespread implementation, particularly in healthcare settings with limited financial resources.

4. Results

The final analysis included 20 studies published between 2011 and 2026, involving adult participants in the subacute phase after stroke. The included studies compared RAGT with conventional rehabilitation or other rehabilitation strategies. The duration of the interventions ranged from 2 to 8 weeks, with a frequency of 3–6 sessions per week and session durations ranging from 20 to 60 min.

Time from stroke onset to baseline assessment was reported in days, weeks or months, depending on the study design, with comparable values between the experimental and control groups in all included trials (Table 1).

Most studies reported improvements in gait performance, balance, and ADLs following the rehabilitation interventions. These improvements were observed in both the experimental and control groups. Greater improvements were observed when RAGT was combined with conventional rehabilitation.

4.1. Gait Outcomes

Gait performance was assessed using outcome measures, including the FAC, FMA-LE, 10MWT, 6MWT, 2MWT, RMI and MI/MI-LE. Participants in both the experimental and control groups demonstrated improvements in walking speed and endurance, suggesting that conventional rehabilitation is effective, while RAGT may be considered a complementary method rather than a replacement. The greatest benefits were reported in studies that implemented high-intensity, repetitive, and task-oriented training protocols.

Lee et al. [61] and Ochi et al. [72] demonstrated a more marked improvement in the FAC score from baseline to post-intervention than the control group. The robotic group showed more considerable changes after treatment compared with baseline values; however, the within-group difference regarding the changes in the scales used after treatment compared with baseline values was not statistically significant.

Fiedorova et al. [73] demonstrated a higher proportion of patients who achieved clinically relevant improvements in functional ambulation after RAGT. The results suggest that robotic training may improve walking capacity rather than modify isolated individual gait parameters. All patients showed an improvement of at least 1 FAC point over the course of 3 months. The improvement was observed in all patients in the RAGT group within the first three weeks, compared with 78.9% in the conventional group.

Gorsler et al. [68] did not identify a statistically significant difference between robotic training and conventional rehabilitation in terms of functional ambulation. Although the effect estimate suggested a possible advantage of gait training in the per-protocol analysis, the wide confidence interval indicated considerable uncertainty. Exploratory results suggested that potential benefits might be more pronounced in patients with lower baseline walking capacity.

Similarly, Han et al. [67] reported a significant difference in FAC in favor of RAGT, despite the absence of a significant difference between groups for FMA-LE. This result further supports the possibility that the effect of RAGT may be more pronounced on walking capacity than on measures of motor impairment. The Wilcoxon rank-sum test was applied to change scores as part of the sensitivity analysis, yielding consistent results. Participants

who received RAGT showed a greater improvement in walking assistance levels than those who received conventional rehabilitation alone, indicating a greater improvement in ambulatory independence over the intervention period. Similarly, Alingh et al. [69] reported significant improvements over time in gait speed and efficiency. These improvements were not specifically attributed to robotic training.

Overall, the evidence suggests a potentially substantial and more consistent benefit of RAGT for functional ambulation and certain gait outcomes, particularly FAC, while superiority for all quantitative gait parameters remains less consistent.

4.2. Balance Outcomes

Balance and postural control were assessed using the BBS and TUG. Clinically relevant improvements in postural control and dynamic balance were demonstrated following the integration of RAGT into rehabilitation. These improvements were observed across all groups. Protocols that required active participant involvement and a reduced level of robotic assistance were associated with significant improvements in balance and motor control.

The majority of the studies reported improvements in balance following both robotic and conventional rehabilitation. However, several studies demonstrated greater improvements in the RAGT groups. Huo et al. [74] reported significantly higher improvements in BBS in the robotic group compared with the control group, together with a significant between-group effect for functional ambulation.

Gorsler et al. [68] identified a substantial improvement in BBS score in the experimental group, as well as a higher proportion of participants who achieved a clinically relevant change. Bergmann et al. [63] reported a significantly greater short-term advantage of the intervention group regarding balance performance.

Concurrently, Lin et al. [58] showed improvements in BBS in both groups, with no significant differences between them. All participants presented difficulties with walking, but both after robotic intervention and after conventional rehabilitation, one participant in the experimental group and three in the control group managed to walk independently. Additionally, seven and five participants in the two groups, respectively, were able to walk with assistance from a device. Three months after the intervention, seven participants in the RAGT group and four in the conventional rehabilitation group managed to walk without assistance. Eight and twelve participants in the two groups, respectively, achieved the feasibility of assisted walking with a device. It was found that fifteen participants in the experimental group and sixteen in the control group were able to walk. Considering the number of patients capable of walking, no statistically significant difference was recorded between the groups.

Similarly, Chang et al. [60] identified improvements in the same scale in both groups, with no significant differences.

Overall, the results indicate that RAGT may enhance balance and postural control; the additional benefit compared with conventional rehabilitation appears to be less consistent than that observed for walking performance. Between-group effects vary depending on the specific instrument used to assess balance and the timing of the assessment.

4.3. ADL Outcomes

Functional independence was assessed using the FIM, MBI, and BI. Improvements were reported in both the experimental and control groups. Although the differences between groups were not always statistically significant, the combination of RAGT and conventional rehabilitation demonstrated greater functional benefits than rehabilitation strategies applied independently.

Tang et al. [65] also identified a between-group effect in favor of RAGT for MBI; however, this result was not accompanied by a significant time × group interaction, which limits the extent to which the improvement can be specifically attributed to the robotic intervention. In contrast, Chang et al. [60] showed improvements in FIM in both groups, without a significant difference between them, and similarly, other studies reported improvements in functional outcomes without demonstrating a greater effect of RAGT.

Significant improvements over time were observed in MBI score with the conventional and assistive treatment groups showing relevant improvements in the study by Xie et al. [70]. Thus, although RAGT may contribute to enhancing ADLs and functional independence, the evidence regarding an additional benefit compared with conventional rehabilitation is less consistent than that for gait outcomes. Improvements in ADLs may reflect the combined effects of gait training, conventional rehabilitation, increased activity levels, and neurological recovery, while between-group comparisons highlight that the additional benefit of RAGT is not uniform across all functional domains.

Many studies demonstrated significantly greater improvements in these outcomes in the intervention groups, whereas others reported comparable improvements between groups. The available evidence supports the integration of RAGT as a potential adjunctive intervention to conventional rehabilitation; thus, the variability in between-group outcomes indicates that the effectiveness of RAGT may depend on participant characteristics, initial functional status, and the type of robotic devices used.

Tables 1 and 2 summarize the main characteristics of the included studies, as well as the effects of RAGT on gait, balance, and ADLs in patients with subacute stroke.

Table 2. Summary of the key characteristics of studies included in the review.

Author (Year)	Control/ Comparison	Duration/ Intensity	Outcome Measures	Main Findings
Kim et al., 2025 [56]	conventional rehabilitation, occupational therapy, and electrical stimulation therapy	30 min/session, 3 sessions/week, 8 weeks, 24 sessions	FMA-LE, BBS	Significant improvements in walking ability were reported in the experimental group compared with the control group. These findings were observed at both the 8-week and 16-week follow-up assessments
Huang et al., 2026 [57]	conventional rehabilitation + FES + RAGT and placebo group with same schedule	60 min/session, 5 sessions/week, 3 weeks, 15 sessions	10MWT, BBS, FMA-LE	Therapeutic benefits were identified in the experimental group compared with both the control and placebo group. The control group showed superior results compared to the placebo group
Lin et al., 2022 [58]	conventional rehabilitation	30 min/session, 5 sessions/week, 3–4 weeks, 15 sessions	FMA-LE, FMA-Total, BBS	The experimental group showed significantly greater improvements in FMA-LE and FMA-Total compared to control. BBS scores indicated improvements in both groups compared with baseline
Li et al., 2021 [59]	conventional rehabilitation	30 min/session, 5 sessions/week, 4 weeks, 20 sessions	6MWT, FAC, FMA-LE	Parameters such as gait speed, cadence, step length, and gait cycle duration showed significant changes in the group that received RAGT compared with the group that received conventional rehabilitation

Table 2. *Cont.*

Author (Year)	Control/ Comparison	Duration/ Intensity	Outcome Measures	Main Findings
Chang et al., 2025 [60]	conventional gait training	30 min/session, 5 sessions/week, 4 weeks, 20 sessions	MI-LL, FIM, BBS	BBS and FIM scores significantly improved from baseline (T0) to post-intervention (T1) in both the experimental and control groups; no significant between-group differences were observed at T1
Lee et al., 2023 [61]	conventional rehabilitation	30 min/session, 5 sessions/week, 4 weeks, 20 sessions	FAC, MI, FMA-LE, RMI, 10MWT, BBS, MBI	The group that used robots demonstrated a greater improvement in FAC scores than the control group. The robot group showed greater improvements from baseline in MI, FMA-LE, RMI, 10MWT, BBS, and MBI compared with the control group
Han et al., 2016 [62]	conventional rehabilitation	30 min/session, 5 sessions/week, 4 weeks, 20 sessions	MBI, BBS, FAC, FMA-LL	RAGT + conventional rehabilitation was more effective in improving cardiopulmonary fitness than conventional rehabilitation alone. Both groups showed significant improvements in all parameters, as measured by the functional assessment scales
Bergmann et al., 2018 [63]	conventional rehabilitation	30 min/session, 5 sessions/week, 2 weeks, 8–10 sessions	FAC	RAGT resulted in a significantly greater reduction in pusher behavior compared with conventional rehabilitation at post-intervention and follow-up. Changes in the FAC did not differ between the groups
Thimabut et al., 2022 [64]	conventional rehabilitation	40 min/session, 5 sessions/week, 6 weeks, 30 sessions	FIM-walk, 6MWT, BI	The RAGT group demonstrated significantly greater improvements from baseline in FIM-walk, 6MWT, and BI scores compared with the control group. Other gait parameters showed a trend toward improvement in the RAGT group, but between-group differences were not statistically significant
Tang et al., 2026 [65]	conventional rehabilitation, occupational therapy	30 min/session, 6 sessions/week, 3 weeks, 18 sessions	MBI, BBS, FMA-LE	Favorable changes in FMA-LE and BBS scores were reported in both the experimental and control groups. Regarding MBI scores, the improvements were greater in the experimental group
Chang et al., 2011 [66]	conventional rehabilitation	40 min/session, 5 sessions/week, 4 weeks, 20 sessions	FMA-LE, MI-LE, FAC	A significant interaction effect was reported between the pre-training and post-training periods and the type of intervention, measured by the FMA-LE

Table 2. *Cont.*

Author (Year)	Control/ Comparison	Duration/ Intensity	Outcome Measures	Main Findings
Han et al., 2026 [67]	conventional rehabilitation	30 min/session, 5 sessions/week, 4 weeks, 20 sessions	FAC	FAC demonstrated a significant between-group difference favoring the experimental group, with greater improvements in functional ambulation compared with conventional rehabilitation
Gorsler et al., 2025 [68]	conventional rehabilitation	30 min/session, 3 sessions/week, 3 weeks, 9 sessions	BBS	The findings demonstrate greater improvements in the gait training group compared to standing training group
Alingh et al., 2021 [69]	conventional rehabilitation	30 min/session, 3 sessions/week, 6 weeks, 18 sessions	10MWT, 6MWT, TUG, FMA-LE, MI-L	Most spatiotemporal gait parameters and measures improved in both groups at 1 week and 4 months after the intervention. No between-group differences were found, except for step width from baseline to 1 week and paretic step length from baseline to 4 months
Xie et al., 2026 [70]	conventional rehabilitation	30 min/session, 5 sessions/week, 2 weeks, 10 sessions	FMA-LE, BBS, MBI, FAC	FMA-LE, BBS, and MBI scores significantly improved over time, while FAC improved in the assistive and conventional groups. No significant between-group differences were observed
Zhang et al., 2024 [71]	conventional rehabilitation	30 min/session, 5 sessions/week, 2 weeks, 10 sessions	FMA, RMI, TUG	Adding the A3 rehabilitation robot significantly improved FMA, RMI, and TUG scores, as well as gait frequency, stride length, and walking speed
Ochi et al., 2015 [72]	conventional rehabilitation	20 min/session, 5 sessions/week, 4 weeks, 20 sessions	FMA-LE, FAC, 10MWT, FIM	The experimental group showed greater torque gains on the unaffected side, while no significant between-group difference was found on the affected side. Walking speed tended to improve more in the experimental group
Fiedorova et al., 2026 [73]	conventional rehabilitation	20–50 min/session, 5 sessions/week, 3 weeks, 15 sessions	FAC, 10MWT, TUG, BBS	The RAGT group showed significant improvements in 10MWT, TUG, and BBS at 3 weeks and 3 months. TUG and BBS improvements were significantly greater than in the conventional group, while 10MWT improvement was not significant in the conventional group

Table 2. *Cont.*

Author (Year)	Control/ Comparison	Duration/ Intensity	Outcome Measures	Main Findings
Huo et al., 2024 [74]	conventional rehabilitation	30 min/session, 5 sessions/week, 4 weeks, 20 sessions	BBS, FAC, FMA-LE, MBI	Both groups showed significant clinical and gait improvements after 4 weeks, with greater improvements in BBS, FMA-LE, FAC, and MBI in the robot group. The experimental group also demonstrated improvements in several gait parameters, including stride length, support phase, and toe-off angle
Hesse et al., 2012 [44]	conventional rehabilitation	60 min/session, 5 sessions/week, 4 weeks, 20 sessions	FAC, RMI	The experimental group showed significantly greater improvements in functional ambulation compared with the control group, with benefits maintained at 3 months follow-up. A greater proportion of patients in the experimental group achieved independent ambulation

6MWT: 6-Minute Walk Test; 10MWT: 10-Meter Walk Test; FMA-LE: Fugl-Meyer Assessment-Lower Extremity; BBS: Berg Balance Scale; FES: Functional Electrical Stimulation; FMA-Total: Fugl-Meyer Assessment-Total; FAC: Functional Ambulation Classification; MI-LL: Motricity Index of the Lower Extremities; FIM: Functional Independence Measure; MI: Motricity Index; RMI: Rivermead Mobility Index; MBI: Modified Barthel Index; FIM-walk: Functional Independence Measure-walk; BI: Barthel Index; TUG: Timed Up and Go Test; MI-L: Motricity Index-Lower Limb.

5. Discussion

Previous studies that evaluated and monitored the effectiveness of RAGT, complemented by conventional strategies, involving patients with stroke, reported improvements in lower limb motor function, gait function, balance, and ambulatory performance immediately after the respective interventions. The outcomes were greater when RAGT was supported by conventional rehabilitation [108–116].

Robotic therapy can stimulate cortical reorganization, enhance the excitability of the corticospinal tract, activate the central pattern generator, and improve neural plasticity and motor function through high-intensity, task-specific, repetitive gait training [117–119].

Likewise, robotic devices dynamically adjust the movement parameters of the lower limbs during gait training, correcting impaired walking patterns, reducing compensatory movements, and optimizing hip-knee coordination, thereby supporting the development of more coordinated and physiologically appropriate gait patterns [120–122].

RAGT can extend the duration of task-specific training, allow real-time adjustment of training intensity and body-weight support, and provide support for postural control, while potentially improving cardiopulmonary function through intensive training [60,123–126].

It has been demonstrated that RAGT enhances the ability of patients to distribute body weight, increasing left-right symmetry and thereby influencing overall balance [127].

Assessment using the BBS and FMA demonstrated favorable changes in balance and motor function, supporting the importance of RAGT for patients with stroke compared with conventional rehabilitation [128–131].

Regarding functional independence and ADLs, the results suggest that RAGT contributes to improvements in overall functional recovery.

Several of the selected studies reported clinically meaningful improvements in ADLs, such as transfers, mobility, and self-care, indicating that the motor benefits gained through robotic training extend beyond the task directly assessed.

Recent studies have shown that neurorehabilitation programs should be intensive, repetitive, and task-oriented to improve gait capacity.

The present systematic review assessed the efficacy of combining RAGT with conventional rehabilitation in adults with subacute stroke through an analysis of 20 studies. The combination of RAGT and conventional rehabilitation may increase the likelihood of achieving independent walking compared with conventional rehabilitation alone.

The results of this review suggest that RAGT may provide additional benefits when combined with conventional rehabilitation programs in patients with subacute stroke. In addition to conventional rehabilitation, other strategies, such as occupational therapy and FES, were also integrated, as described by Kim et al. [56], Huang et al. [57], and Tang et al. [65]. In the included studies, improvements in gait performance, balance, and ADLs were observed in both the experimental and control groups; however, the consistency of between-group differences varied according to the domain assessed. This may explain why the effect of integrating RAGT was not uniform across all components of functional recovery.

The most consistent evidence in favor of a possible advantage of RAGT was identified regarding gait performance. The studies analyzed demonstrated significantly greater improvements in FAC among participants who received RAGT compared with those who underwent conventional rehabilitation alone. Similarly, several studies reported significant improvements in BBS or other parameters associated with balance following robotic intervention.

In the study conducted by Han et al. [62], the control group underwent a conventional rehabilitation program provided by physiotherapists who delivered a program focused on balance and mobility. The functional tasks consisted of balance exercises in standing and sitting positions, active transfers performed by the participants, sit-to-stand transitions, and muscle-strengthening exercises. The subsequent tasks included functional exercises for dynamic balance in the sitting position and gait training assisted by a physiotherapist. Occupational therapy was included in the majority of studies and involved stretching and strengthening exercises for the upper extremities, task-oriented therapy for ADLs, fine motor training, and sensorimotor recovery. Participants in both groups demonstrated favorable changes in the assessed parameters, using the BBS and other measures for gait evaluation. Conventional rehabilitation was performed using neurodevelopmental treatment techniques, as described in the majority of the studies analyzed.

Regarding functional independence and ADLs, evidence concerning the effectiveness of the robotic component was limited. Although some studies reported greater improvements in MBI, other studies demonstrated comparable improvements in both intervention groups. An important aspect is also the difference between within-group and between-group changes. Most studies reported significant improvements following the rehabilitation intervention, regardless of whether participants received RAGT or conventional rehabilitation. The significant improvements observed within the experimental groups were not consistently accompanied by significant differences compared with the control group. This perspective is important when interpreting the effectiveness of RAGT, as the observed improvements cannot automatically be attributed to the robotic intervention and may reflect the combined effects of spontaneous recovery, conventional rehabilitation, increased activity levels, and the additional contribution of robotic training.

Differences between studies may be explained by the heterogeneity of RAGT protocols, with different robotic devices, training intensities, session durations, and frequencies, levels of robotic assistance, and degrees of body-weight support being used across the studies

analyzed. These differences in rehabilitation protocols may influence the level of active participation required from patients and, consequently, the effectiveness of the intervention.

Thus, it is plausible that rehabilitation outcomes may be influenced by the degree of active patient involvement and the progressive reduction in robotic assistance; however, the included trials did not directly establish this relationship. The use of robotic devices was provided by qualified physiotherapists individualized the program according to the abilities of each participant. Therefore, therapeutic progress may depend on how robotic technology is integrated rather than solely on its use.

The included studies used robotic devices for gait rehabilitation, highlighting the technological diversity of RAGT systems. The implementation of repetitive and controlled training using robotic devices supports the adaptation of rehabilitation strategies to the individual needs of patients. These systems included wearable lower-limb exoskeletons, such as Angel Legs M, Flexbot, MRG-P100, BEAR-H1, Morning Walk, Welwalk, UGO220, R-Bot Plus, AiWalker, A3, and GAR, as well as end-effector systems, such as G-EO and LiteStepper. Other studies integrated the Lokomat exoskeleton, which involve walking on a treadmill. These devices have been widely investigated in clinical rehabilitation studies and are frequently cited in scientific research. They differ in terms of mechanical design, degree of assistance, control strategies, and ability to provide repetitive and task-specific gait training. Therefore, these characteristics should be considered when interpreting differences between functional outcomes across the studies analyzed.

Current evidence is insufficient to establish the consistent superiority of robotic rehabilitation over conventional rehabilitation in improving key outcomes, including walking capacity and motor function.

In the study conducted by Han et al. [67], it was highlighted that evidence regarding the effectiveness of FES combined with RAGT remains unclear, although a systematic review analyzed the effectiveness of FES combined with various robotic technologies for lower-limb rehabilitation in patients with stroke. The results showed that the combination of FES and robotic training was superior to robotic training alone or conventional rehabilitation [132].

An additional important aspect is the integration of concomitant rehabilitation interventions in the studies described by Huang et al. [57] and Kim et al. [56], through strategies such as FES. These therapeutic interventions may contribute to the recovery process, and their concomitant use makes it difficult to isolate the specific effect of RAGT. Consequently, between-group differences may reflect the combined effect of RAGT and the additional intervention. This aspect represents an important source of clinical and methodological heterogeneity among the included studies.

Recent studies evaluating the efficacy of RAGT as an adjunct to conventional rehabilitation have reported favorable outcomes in walking capacity, lower-extremity motor function, and balance. The outcomes following the combination of RAGT with conventional rehabilitation were comparable to those observed in patients who received conventional rehabilitation alone. Furthermore, previous studies have reported that the effects of RAGT on gait function, balance, and ADLs were not superior to those achieved through conventional rehabilitation.

Overall, the results regarding gait performance, balance, and ADLs support the use of RAGT as an adjunctive intervention to functional rehabilitation. However, improvements were also observed following conventional rehabilitation, and between-group differences were not consistently demonstrated. Therefore, RAGT appears to represent a complementary intervention that may reinforce conventional rehabilitation rather than consistently replace it.

The pre- and post-intervention functional outcomes reported in the included studies are presented in Table 3.

Table 3. Functional outcomes before and after intervention in the included studies on RAGT in post-stroke.

Author (Year)	Scale/ Test	Pre-Intervention	Post-Intervention	Statistical Comparison and *p*-Value
Kim et al., 2025 [56]	FMA-LE (SD) BBS (SD)	Experimental group: 22.06 ± 4.09 Control group: 22.13 ± 3.05 Experimental group: 35.60 ± 8.02 Control group: 35.93 ± 8.64	Experimental group: 26.03 ± 3.83 Control group: 22.73 ± 2.67 Experimental group: 40.70 ± 6.40 Control group: 37.63 ± 7.88	(between-group) $p < 0.001$ $p = 0.011$
Huang et al., 2026 [57]	BBS (SD) 10MWT (SD) FMA-LE (SD)	Experimental: 7.93 (2.17) Control: 8.05 (2.19) Placebo: 8.00 (2.42) Experimental: 0.27 (0.03) Control: 0.28 (0.03) Placebo: 0.27 (0.03) Experimental: 9.06 (2.49) Control: 8.65 (1.77) Placebo: 9.00 (1.93)	Experimental: 30.75 (2.59) Control: 24.06 (3.21) Placebo: 21.59 (1.87) Experimental: 0.53 (0.08) Control: 0.43 (0.06) Placebo: 0.43 (0.04) Experimental: 19.00 (1.46) Control: 16.65 (2.18) Placebo: 15.80 (2.14)	(time × group) $p < 0.0001$ $p < 0.0001$ $p < 0.0001$
Lin et al., 2022 [58]	FMA-LE (SD) FMA-Total (SD) BBS (SD)	Experimental: 7.0 ± 4.7 Control: 8.1 ± 4.9 Experimental: 11.4 ± 5.4 Control: 11.7 ± 5.7 Experimental: 8.2 ± 8.4 Control: 8.8 ± 9.7	Experimental: 12.5 ± 5.8 Control: 11.5 ± 6.3 Experimental: 17.3 ± 6.9 Control: 15.8 ± 7.3 Experimental: 22.8 ± 16.7 Control: 22.4 ± 17.8	(between-group) $p = 0.014$ $p = 0.002$ $p = 0.394$
Li et al., 2021 [59]	6MWT (SD) FAC (SD) FMA-LE (SD)	Experimental group: 107.88 (67.62) Control group: 137.80 (75.07) Experimental group: 2.65 (0.86) Control group: 2.93 (0.59) Experimental group: 20.41 (5.33) Control group: 20.47 (5.69)	Experimental group: 197.24 (86.78) Control group: 179.80 (80.86) Experimental group: 3.76 (0.90) Control group: 3.67 (0.72) Experimental group: 26.18 (4.46) Control group: 23.13 (6.31)	(between-group) $p = 0.022$ $p = 0.313$ $p = 0.044$
Chang et al., 2025 [60]	MI-LL (SD) BBS (SD) FIM (SD)	Experimental: 46.0 ± 19.2 Control: 41.2 ± 17.6 Experimental: 10.5 ± 11.8 Control: 7.1 ± 6.3 Experimental: 66.4 ± 15.5 Control: 66.2 ± 15.9	Experimental: 64.0 ± 20.1 Control: 54.1 ± 16.5 Experimental: 32.8 ± 14.9 Control: 29.8 ± 15.6 Experimental: 85.1 ± 18.0 Control: 87.7 ± 17.2	(between-group) $p < 0.05$
Lee et al., 2023 [61]	FAC (SD) MI (SD) FMA-LE (SD) RMI (SD) 10MWT (SD) BBS (SD) MBI (SD)	Experimental: 0.96 ± 0.87 Control: 1.04 ± 0.93 Experimental: 53.19 ± 15.57 Control: 43.48 ± 18.11 Experimental: 19.85 ± 8.92 Control: 16.13 ± 8.83 Experimental: 4.35 ± 2.64 Control: 3.91 ± 2.17 Experimental: 0.30 ± 0.26 Control: 0.22 ± 0.13 Experimental: 25.08 ± 22.67 Control: 19.65 ± 21.25 Experimental: 34.50 ± 16.82 Control: 34.48 ± 16.60	Experimental: 3.35 ± 1.23 Control: 2.48 ± 1.12 Experimental: 67.54 ± 14.28 Control: 56.09 ± 13.47 Experimental: 27.42 ± 4.87 Control: 21.65 ± 7.86 Experimental: 9.15 ± 2.95 Control: 8.30 ± 2.74 Experimental: 0.60 ± 0.36 Control: 0.43 ± 0.29 Experimental: 47.58 ± 21.33 Control: 38.87 ± 22.56 Experimental: 63.85 ± 19.52 Control: 60.87 ± 21.45	(between-group) $p = 0.005$ $p = 0.641$ $p = 0.225$ $p = 0.552$ $p = 0.771$ $p = 0.350$ $p = 0.685$
Han et al., 2016 [62]	MBI (SD) BBS (SD) FAC (SD) FMA-LL (SD)	Experimental: 25.54 ± 20.25 Control: 29.00 ± 17.05 Experimental: 5.13 ± 4.39 Control: 7.61 ± 6.36 Experimental: 0.10 ± 0.31 Control: 0.27 ± 0.46 Experimental: 6.03 ± 3.67 Control: 8.67 ± 7.76	Experimental: 55.92 ± 19.42 Control: 60.94 ± 20.32 Experimental: 21.37 ± 13.24 Control: 20.83 ± 13.69 Experimental: 1.33 ± 1.21 Control: 1.95 ± 1.75 Experimental: 13.43 ± 8.34 Control: 16.14 ± 8.13	(between-group) $p = 0.766$ $p = 0.392$ $p = 0.277$ $p = 0.971$
Bergmann et al., 2018 [63]	FAC (IQR)	Experimental group: 0 (0–1) Control group: 0 (0–0)	Experimental group: 0 (0–1) Control group: 0 (0–1)	(within-group) $p = 0.097$ $p = 0.023$
Thimabut et al., 2022 [64]	FIM-walk (SD) 6MWT (SD) BI (SD)	Experimental group: 2.31 ± 0.95 Control group: 2.23 ± 0.83 Experimental group: 26.96 ± 13.55 Control group: 29.14 ± 19.90 Experimental group: 10 ± 2.61 Control group: 11.23 ± 2.31	Experimental group: 5.62 ± 1.04 Control group: 4.62 ± 1.56 Experimental group: 120.08 ± 115.50 Control group: 55.14 ± 27.54 Experimental group: 17.31 ± 2.10 Control group: 15.85 ± 2.27	(between-group) $p = 0.453$ $p = 0.384$ $p = 0.212$

Table 3. *Cont.*

Author (Year)	Scale/ Test	Pre- Intervention	Post- Intervention	Statistical Comparison and *p*-Value
Tang et al., 2026 [65]	MBI (SD) BBS (SD) FMA-LE (SD)	Experimental group: 45.13 ± 17.01 Control group: 37.57 ± 20.93 Experimental group: 16.50 ± 12.08 Control group: 21.03 ± 15.91 Experimental group:17.80 ± 6.73 Control group: 16.00 ± 7.93	Experimental group: 69.43 ± 18.53 Control group: 54.90 ± 19.48 Experimental group: 32.20 ± 13.83 Control group: 29.97 ± 14.94 Experimental group: 25.80 ± 6.59 Control group: 19.97 ± 7.17	(between-group) $p < 0.001$ $p < 0.001$ $p > 0.05$
Chang et al., 2012 [66]	FMA-LE (SD) MI-LE (SD) FAC (SD)	Experimental: 17.2 ± 5.5 Control: 16.8 ± 5.7 Experimental: 46.8 ± 9.1 Control: 47.3 ± 12.1 Experimental: 0.5 ± 0.5 Control: 0.4 ± 0.5	Experimental: 22.7 ± 5.7 Control: 19.6 ± 5.6 Experimental: 56.2 ± 11.0 Control: 53.5 ± 12.0 Experimental: 1.3 ± 0.7 Control: 1.4 ± 0.8	(between-group) $p = 0.037$ $p = 0.200$ $p = 0.232$
Han et al., 2026 [67]	FAC (SD)	Experimental group: 0.93 ± 0.70 Control group: 0.67 ± 0.72	Experimental group: 2.60 ± 1.72 Control group: 1.33 ± 1.40	(between-group) $p = 0.041$
Gorsler et al., 2025 [68]	BBS (SD)	GT group: 2.2 (3.2) ST group: 2.0 (3.3)	GT group: 7.3 (6.3) ST group: 3.5 (4.7)	NR
Alingh et al., 2021 [69]	10MWT (SD) 6MWT (SD) TUG (SD) FMA-LE (SD) MI-L (SD)	Experimental group: 0.61 ± 0.35 Control group: 0.76 ± 0.38 Experimental group: 220 ± 149 Control group: 247 ± 130 Experimental group: 23.1 ± 15.0 Control group: 19.5 ± 11.8 Experimental group: 24.2 ± 4.6 Control group: 23.4 ± 6.8 Experimental group: 63.9 ± 17.0 Control group: 62.5 ± 26.4	Experimental group: 1.07 ± 0.27 Control group: 1.07 ± 0.40 Experimental group: 398 ± 119 Control group: 383 ± 138 Experimental group: 11.4 ± 6.1 Control group: 12.4 ± 6.4 Experimental group: 28.9 ± 4.1 Control group: 26.8 ± 5.5 Experimental group: 86.2 ± 13.2 Control group: 72.5 ± 22.2	(group × time) $p < 0.05$
Xie et al., 2026 [70]	FMA-LE (SD) BBS (SD) MBI (SD) FAC (IQR)	Assistive training group: 19.02 ± 5.32 Passive training group: 13.33 ± 6.44 Control group: 20.00 ± 7.98 Assistive training group: 29.38 ± 10.54 Passive training group: 19.22 ± 16.07 Control group: 31.50 ± 14.99 Assistive training group: 51.69 ± 22.69 Passive training group: 47.89 ± 22.70 Control group: 61.75 ± 23.07 Assistive training group: 0.5(0–3) Passive training group: 1(0–1.5) Control group: 1.5(0–3)	Assistive training group: 20.81 ± 5.26 Passive training group: 17.00 ± 7.47 Control group: 22.69 ± 6.26 Assistive training group: 34.70 ± 10.87 Passive training group: 25.78 ± 17.61 Control group: 37.19 ± 13.10 Assistive training group: 63.19 ± 21.38 Passive training group: 53.44 ± 21.86 Control group: 67.69 ± 19.83 Assistive training group: 2 (0.25–3) Passive training group: 1(0–2.5) Control group: 2 (0.25–3)	(between-group) $p = 0.97$ $p = 0.13$ $p = 0.27$ $p = 0.53$
Zhang et al., 2024 [71]	FMA (SD) RMI (SD) TUG (SD)	Experimental group: 20.07 ± 5.643 Control group: 21.22 ± 5.820 Experimental group: 8.75 ± 1.936 Control group: 8.44 ± 1.281 Experimental group: 32.404 ± 14.726 Control group: 29.643 ± 12.348	Experimental group: 23.57 ± 5.473 Control group: 22.19 ± 6.032 Experimental group: 10.82 ± 1.679 Control group: 8.85 ± 1.460 Experimental group: 20.029 ± 7.228 Control group: 26.842 ± 9.600	(between-group) $p < 0.01$ $p < 0.01$ $p < 0.01$
Ochi et al., 2015 [72]	FMA-LE (IQR) FAC (IQR) 10MWT (IQR) FIM (IQR)	Experimental group: 3 (3–5) Control group: 5 (3–6) Experimental group: 1 (1–2) Control group: 2 (1–2) Experimental group: N/A Control group: N/A Experimental group: 7 (6–10) Control group: 7 (7–9)	Experimental group: 9 (5–17) Control group: 9 (4–14) Experimental group: 3 (3–4) Control group: 3 (3–3) Experimental group: 0,26 Control group: 0,17 Experimental group: 13 (13–21) Control group: 13 (12–17)	(within-group) $p < 0.01$ $p < 0.01$ $p < 0.01$

Table 3. *Cont.*

Author (Year)	Scale/ Test	Pre-Intervention	Post-Intervention	Statistical Comparison and *p*-Value
Fiedorova et al., 2026 [73]	FAC (IQR) 10MWT (IQR) TUG (IQR) BBS (IQR)	Experimental group 0: 4 (21.1) 1: 6 (31.6) 2: 5 (26.2) 3: 4 (21.1) 4: N/A 5: N/A Control group 0: 4 (17.4) 1: 7 (30.4) 2: 5 (21.8) 3: 7 (30.4) 4: N/A 5: N/A N/A N/A N/A	Experimental group 0: N/A 1: N/A 2: 1 (5.9) 3: 1 (5.9) 4: 9 (52.9) 5: 6 (35.3) Control group 0: N/A 1: 1 (5.3) 2: 3 (15.8) 3: 2 (10.5) 4: 8 (42.1) 5: 5 (26.3) Experimental group Baseline to 3 months: 0.24 (0.14; 0.70) Baseline to 3 weeks: 0.26 (0.11; 0.53) 3 weeks to 3 months: 0.05 (0.01; 0.19) Control group Baseline to 3 months: 0.36 (0.07; 0.55) Baseline to 3 weeks: 0.24 (0.01; 0.41) 3 weeks to 3 months: 0.07 (−0.01; 0.19) Experimental group Baseline to 3 months: 11.2 (10.4; 12.3) Baseline to 3 weeks: 9.5 (7.7; 12.2) 3 weeks to 3 months: 1.0 (−0.6; 2.1) Control group Baseline to 3 months: 6.4 (4.6; 8.1) Baseline to 3 weeks: 6.0 (4.0; 6.4) 3 weeks to 3 months: 0.6 (−0.5; 2.8) Experimental group Baseline to 3 months: 28 (19.36) Baseline to 3 weeks: 17 (10.26) 3 weeks to 3 months: 9 (2.13) Control group Baseline to 3 months: 15 (10; 28) Baseline to 3 weeks: 11 (6; 17) 3 weeks to 3 months: 5 (2; 11)	(between-group) Baseline to 3 months: N/A Baseline to 3 weeks: $p = 0.106$ 3 weeks to 3 months: $p = 0.730$ Baseline to 3 months: $p = 0.897$ Baseline to 3 weeks: $p = 0.829$ 3 weeks to 3 months: $p > 0.999$ Baseline to 3 months: $p = 0.034$ Baseline to 3 weeks: $p = 0.043$ 3 weeks to 3 months: $p = 0.898$ Baseline to 3 months: $p = 0.049$ Baseline to 3 weeks: $p = 0.027$ 3 weeks to 3 months: $p = 0.525$
Huo et al., 2024 [74]	BBS (SD) FAC (SD) FMA-LE (SD) MBI (SD)	Experimental group: 25.43 ± 13.75 Control group: 24.13 ± 16.75 Experimental group: 2.00 ± 1.41 Control group: 1.69 ± 1.58 Experimental group: 20.50 ± 5.42 Control group: 17.00 ± 6.48 Experimental group: 62.43 ± 24.49 Control group: 55.13 ± 26.30	Experimental group: 41.00 ± 9.40 Control group: 29.69 ± 14.31 Experimental group: 3.43 ± 1.16 Control group: 2.19 ± 1.28 Experimental group: 24.64 ± 5.54 Control group: 19.94 ± 5.00 Experimental group: 82.93 ± 16.73 Control group: 67.44 ± 22.16	(between-group) $p = 0.091$ $p = 0.010$ $p = 0.021$ $p = 0.042$
Hesse et al., 2012 [44]	FAC (SD) RMI (SD)	Experimental group: 1.5 ± 0.5 Control group: 1.4 ± 0.5 Experimental group: 3.9 ± 1.1 Control group: 3.7 ± 1.1	Experimental group: N/A Control group: N/A Experimental group: N/A Control group: N/A	(between-group) $p < 0.01$ $p < 0.02$

Data are presented as reported in the original studies (mean ± SD, median [IQR], or median [range], as applicable).

Considering the selection of studies, no adverse events or major complications were reported in the groups analyzed. The main reason for withdrawal from the study in the experimental group was the desire to discontinue treatment. In the control group, no participant withdrew for this reason. No significant differences were observed in the characteristics of patients who withdrew from the study and those who completed it in the RAGT group. These findings suggest that treatment adherence and tolerability should be considered when implementing RAGT, particularly in patients with stroke who may have greater functional limitations.

5.1. Risk of Bias Assessment

The Cochrane Risk of Bias 2 (RoB2) tool was used to assess the risk of bias in the RCTs included in the systematic review. Five domains were evaluated: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in the measurement of the outcome, and bias in the selection of the reported result.

Most included RCTs were judged as presenting certain concerns regarding the overall risk of bias, as follows: the randomization process was well conducted, although some concerns were identified in studies with insufficient information regarding allocation concealment or the randomization procedures; because blinding of participants and therapists is generally difficult in RAGT trials, lack of blinding alone was not considered sufficient to determine the judgment for deviations from intended interventions. Domain 2 judgments were based on whether deviations from the intended intervention occurred because of the trial context and whether the statistical analysis appropriately estimated the effect of assignment to intervention; missing outcome data showed a low risk of bias, considering that only a limited number of studies raised concerns related to participant attrition during the intervention period; the risk of bias in the measurement of outcomes was low when outcome assessors were blinded to participant allocation. The risk of bias assessments are presented in Table 4 and Figure 2 (Traffic Light Plot of Risk of Bias).

Table 4. Risk of bias assessment of RCTs using the Cochrane RoB2 Tool.

Study	D1	D2	D3	D	D5	Overall
Kim et al., 2025 [56]	Low	Low	Low	Some concerns	Low	Some concerns
Huang et al., 2026 [57]	Low	Low	Some concerns	Low	Low	Some concerns
Lin et al., 2022 [58]	Some concerns	Low	Low	Low	Low	Some concerns
Li et al., 2021 [59]	Some concerns	Low	Some concerns	Some concerns	Low	High
Chang et al., 2025 [60]	Low	Low	High	Low	Low	High
Lee et al., 2023 [61]	Some concerns	Low	Some concerns	Low	Low	Some concerns
Han et al., 2016 [62]	Some concerns	Low	Some concerns	Low	Low	Some concerns
Bergmann et al., 2018 [63]	Low	Low	High	Low	Low	High
Thimabut et al., 2022 [64]	Low	Low	Low	Low	Low	Low
Tang et al., 2026 [65]	Some concerns	Some concerns	Some concerns	Low	Low	Some concerns
Chang et al., 2012 [66]	Some concerns	Low	Low	Low	Low	Some concerns
Han et al., 2026 [67]	Low	Low	Low	Low	Low	Low
Gorsler et al., 2025 [68]	Some concerns	Low	Low	Low	Low	Some concerns
Alingh et al., 2021 [69]	Low	Low	Low	Low	Low	Low
Xie et al., 2026 [70]	Low	Low	Some concerns	Low	Low	Some concerns
Zhang et al., 2024 [71]	Low	Low	Some concerns	Low	Low	Some concerns
Ochi et al., 2015 [72]	Low	Low	Low	Low	Low	Low
Fiedorova et al., 2026 [73]	Some concerns	Low	Some concerns	Low	Low	Some concerns
Huo et al., 2024 [74]	Low	Low	High	Low	Low	High
Hesse et al., 2012 [44]	High	Low	Low	Low	Low	High

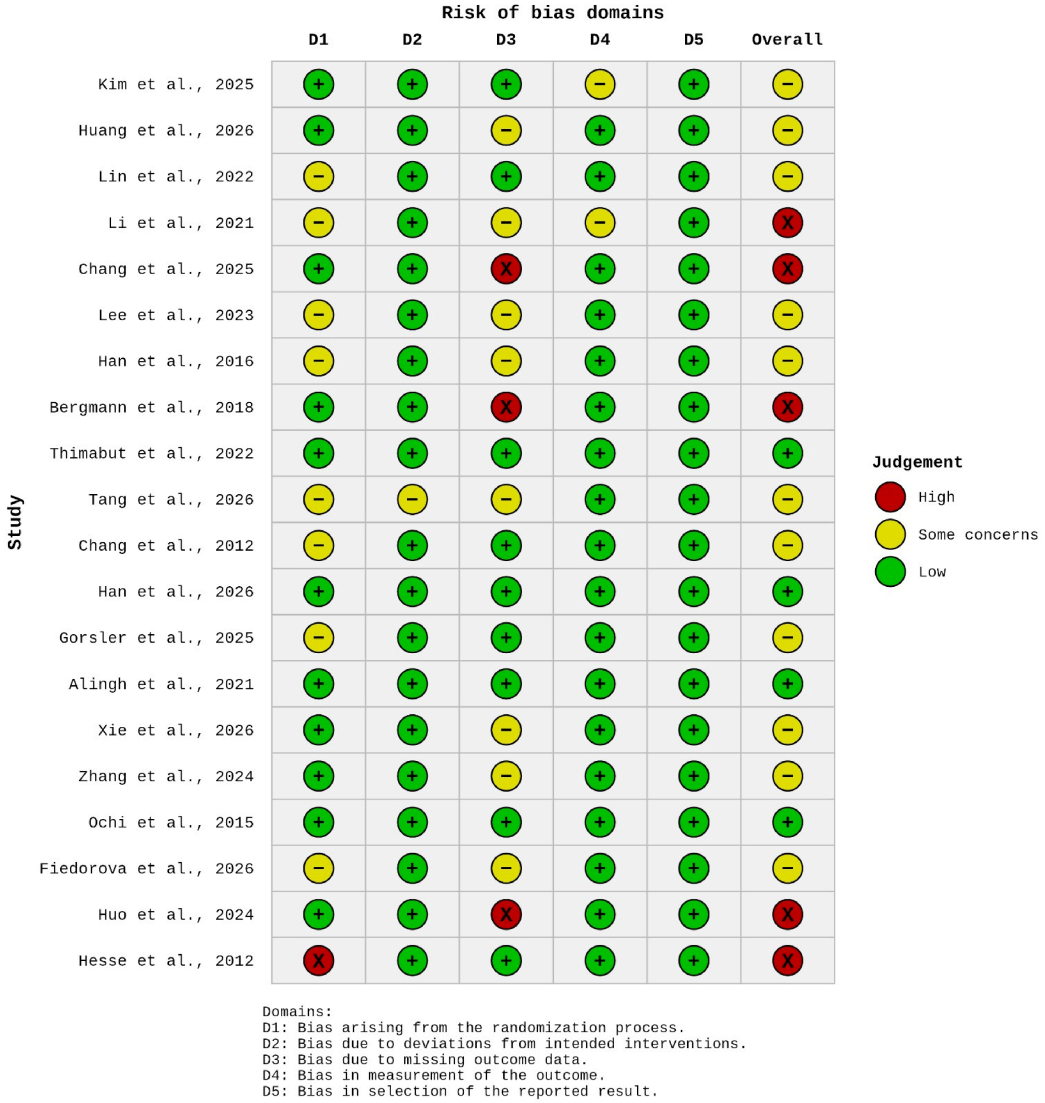

Figure 2. Risk of bias assessment of the included studies using the Cochrane RoB 2 tool: Kim et al., 2025 [56]; Huang et al., 2026 [57]; Lin et al., 2022 [58]; Li et al., 2021 [59]; Chang et al., 2025 [60]; Lee et al., 2023 [61]; Han et al., 2016 [62]; Bergmann et al., 2018 [63]; Thimabut et al., 2022 [64]; Tang et al., 2026 [65]; Chang et al., 2012 [66]; Han et al., 2026 [67]; Gorsler et al., 2025 [68]; Alingh et al., 2021 [69]; Xie et al., 2026 [70]; Zhang et al., 2024 [71]; Ochi et al., 2015 [72]; Fiedorova et al., 2026 [73]; Huo et al., 2024 [74]; Hesse et al., 2012 [44]. Domains: D1, bias arising from the randomization process; D2, bias due to deviations from intended interventions; D3, bias due to missing outcome data; D4, bias in measurement of the outcome; D5, bias in selection of the reported result. Symbols: +, low risk of bias; −, some concerns; X, high risk of bias.

5.2. Certainty of Evidence Assessment

The quality of evidence for five clinically relevant outcomes—functional ambulation/independent walking, gait speed, walking endurance, balance, and activities of daily living—was assessed using the GRADE approach (Table 5). Evidence derived from RCTs was initially assigned as high certainty and was subsequently downgraded, when necessary, based on risk of bias, inconsistency, indirectness, imprecision, and publication bias. Because a meta-analysis was not performed, judgments were based on the consistency and direction of between-group effects, RoB2 assessments, applicability of the study populations and interventions, the number of contributing participants and trials, and the precision of the estimates reported by individual studies. Certainty was classified as high, moderate, low, or very low.

Table 5. GRADE assessment of the certainty of evidence for the main outcomes.

Outcome	Studies/ Participants	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Certainty of Evidence	Interpretation
Functional ambulation/independent walking (FAC, FIM-walk)	12 RCTs/~433 participants	Serious [a]	Serious [b]	Not serious	Not serious	Undetermined [e]	⊕⊕○○ Low	RAGT may improve functional ambulation when added to conventional rehabilitation, but the additional effect is not consistent across trials.
Gait speed (10MWT)	5 RCTs/~186 participants	Not serious	Serious [b]	Not serious	Serious [c]	Undetermined [e]	⊕⊕○○ Low	RAGT may provide an additional improvement in gait speed, but results are inconsistent and the evidence is imprecise.
Walking endurance (6MWT)	3 RCTs/ ~89 participants	Serious [a]	Serious [b]	Not serious	Serious [c]	Undetermined [e]	⊕○○○ Very low	The evidence is very uncertain regarding an additional effect of RAGT on walking endurance.
Balance (BBS, TUG)	13 RCTs/~637 participants	Serious [a]	Serious [b]	Not serious	Not serious	Undetermined [e]	⊕⊕○○ Low	RAGT may improve selected balance outcomes, although superiority over conventional rehabilitation is inconsistent.
Activities of daily living/functional independence (FIM, MBI, BI)	8 RCTs/~370 participants	Serious [a]	Serious [b]	Not serious	Not serious [d]	Undetermined [e]	⊕⊕○○ Low	RAGT may improve functional independence, but a consistent additional benefit over conventional rehabilitation has not been demonstrated.

[a]. Risk of bias: Downgraded by one level because several trials contributing to the outcome were rated as having some concerns or high overall risk of bias according to RoB 2. Overall, 4 of the 20 included RCTs were rated as low risk, 11 as having some concerns, and 5 as high risk of bias. [b]. Inconsistency: Downgraded by one level because the direction and statistical significance of between-group effects varied across trials, with some studies favoring RAGT and others showing comparable improvement with conventional rehabilitation. [c]. Imprecision: Downgraded by one level because the outcome was evaluated in a limited number of participants and trials, and pooled effect estimates and confidence intervals were unavailable. [d]. Imprecision for ADLs: No additional downgrade was applied because evidence was derived from several RCTs and approximately 370 participants; however, the absence of pooled estimates should be considered when interpreting the findings. [e]. Publication bias: Publication bias could not be reliably assessed because no meta-analysis was performed and the number of studies contributing to individual outcomes was limited; no additional downgrade was applied. GRADE certainty of evidence symbols: ⊕⊕○○, low certainty; ⊕○○○, very low certainty. The individual studies contributing to each GRADE outcome are listed in Table 6.

Table 6. Studies contributing to each GRADE outcome.

Outcome	Contributing Studies
Functional ambulation/independent walking (FAC, FIM-walk)	Li et al. [59]; Lee et al. [61]; Han et al. [62]; Bergmann et al. [63]; Thimabut et al. [64]; Chang et al. [66]; Han et al. [67]; Xie et al. [70]; Ochi et al. [72]; Fiedorova et al. [73]; Huo et al. [74]; Hesse et al. [44]
Gait speed (10MWT)	Huang et al. [57]; Lee et al. [61]; Alingh et al. [69]; Ochi et al. [72]; Fiedorova et al. [73]
Walking endurance (6MWT)	Li et al. [59]; Thimabut et al. [64]; Alingh et al. [69]
Balance (BBS, TUG)	Kim et al. [56]; Huang et al. [57]; Lin et al. [58]; Chang et al. [60]; Lee et al. [61]; Han et al. [62]; Tang et al. [65]; Gorsler et al. [68]; Alingh et al. [69]; Xie et al. [70]; Zhang et al. [71]; Fiedorova et al. [73]; Huo et al. [74]
Activities of daily living/functional independence (FIM, MBI, BI)	Chang et al. [70]; Lee et al. [61]; Han et al. [62]; Thimabut et al. [64]; Tang et al. [65]; Xie et al. [70]; Ochi et al. [72]; Huo et al. [74]

Because a meta-analysis was not performed, no pooled comparative effect estimates were calculated. Comparative between-group effect estimates and 95% confidence inter-

vals were considered where they were reported by the individual studies; however, these data were not uniformly available across the included trials. Therefore, the GRADE judgments were based on the direction and consistency of between-group effects, risk of bias, applicability, sample size, and the precision of the available study-level estimates.

6. Limitations

Nevertheless, some limitations should be acknowledged. The absence of a prospectively registered protocol represents an important limitation and may have allowed methodological flexibility in eligibility criteria, outcome prioritization, and risk-of-bias decisions. The majority of the included studies involved relatively small participant groups, potentially limiting the extent to which the findings can be generalized to broader population.

Furthermore, methodological heterogeneity across intervention protocols, session duration, and outcome measures limits the extent to which direct comparisons can be made between studies.

Because the search strategy prioritized terminology specifically related to robot-assisted gait training rather than broader electromechanical rehabilitation terms, relevant studies indexed exclusively under broader device-related terminology may not have been identified.

The inability to retrieve 14 of the 61 reports sought for full-text assessment represents a potential source of availability bias. Because eligibility could not be verified for these reports, their absence may have affected the completeness of the evidence synthesis.

Future research should prioritize larger, methodologically robust clinical trials with consistent intervention protocols and long-term follow-up, thereby enabling a more precise evaluation of the benefits and appropriate application of RAGT in stroke rehabilitation. Further research is needed to develop and validate standardized protocols for RAGT in patients with stroke. Prospective research is needed to achieve a more detailed understanding of the mechanism and clinical attributes of robotic therapy. Through this approach, a much more extensive investigation of the effectiveness of RAGT will be enabled.

7. Conclusions and Future Directions

The present review provides an overview of the potential benefits of RAGT for improving walking ability, balance, and functional recovery in post-stroke patients. One of the strengths of this review lies in its systematic approach, focused on identifying, analyzing, and synthesizing relevant studies. This approach provides a comprehensive synthesis of the existing evidence in the field.

This systematic review aimed to investigate the effects of RAGT on walking capacity, functional recovery, and ADLs across intervention periods ranging from 2 to 8 weeks. Improvements in physical function were observed based on the assessment scales used before and after RAGT. The use of robotic devices, in combination with conventional rehabilitation, may contribute to improvements in walking ability and functional recovery.

Most included studies reported improvements in gait, balance, and ADLs in both the experimental and control groups. However, between-group differences were not consistently significant. Based on the available evidence, RAGT may provide additional benefits when integrated as an adjunct to conventional rehabilitation, particularly for selected gait and balance outcomes. RAGT may facilitate the delivery of intensive, repetitive, and task-specific gait practice, but it does not fully replace conventional rehabilitation approaches. The available evidence suggests that combining RAGT with conventional rehabilitation may provide additional benefits in selected functional outcomes, although these effects are not consistently demonstrated across all domains.

The GRADE assessment indicated low-certainty evidence for functional ambulation/independent walking, gait speed, balance, and activities of daily living, and very-low-certainty

evidence for walking endurance. Certainty was primarily reduced because of risk-of-bias concerns and inconsistency in between-group effects. Gait speed was additionally downgraded for imprecision, whereas walking endurance was downgraded for risk of bias, inconsistency, and imprecision. No outcome was downgraded for indirectness because the included populations were consistent with the predefined subacute post-stroke period (<6 months).

Based on the current scientific literature, the following conclusions can be drawn in response to the research questions presented at the beginning of this review:

1. RAGT may provide additional benefits for selected aspects of functional walking ability when used as an adjunct to conventional rehabilitation, particularly for functional ambulation and some balance-related outcomes. However, improvements were frequently observed in both the RAGT and control groups, and between-group superiority was not consistently demonstrated for gait speed, walking endurance, or other quantitative gait parameters. Therefore, the current evidence supports RAGT primarily as a complementary rather than a replacement intervention, with low certainty for most outcomes and very low certainty for walking endurance.
2. Active participation is now described as a plausible mechanism requiring further investigation rather than as an established mediator of treatment effect. The evidence suggests that reducing excessive guidance, using assist-as-needed strategies, and encouraging active neuromuscular engagement may contribute to more favorable outcomes.
3. The available evidence is insufficient to establish that improvements obtained with RAGT consistently transfer to free-living or community walking or are maintained over the long term. Some studies reported sustained clinical improvements at follow-up, but most trials assessed gait and mobility using clinical or laboratory-based measures rather than community ambulation, accelerometry, participation outcomes, or prolonged follow-up. Consequently, real-life transfer and long-term durability of RAGT-related gains remain uncertain.

Overall, RAGT may be considered a complementary intervention to conventional rehabilitation in patients with subacute stroke. Although selected functional outcomes may improve with its addition, superiority over conventional rehabilitation is not consistently demonstrated, and the certainty of evidence remains low or very low across the principal outcomes.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/life16122012/s1, Supplementary File S1: PRISMA 2020 Checklist; Supplementary File S2: Risk of bias; Supplementary File S3: Article; reason of exclusion.

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Informed Consent Statement: Not applicable.

Data Availability Statement: All relevant data extracted from the studies, including study characteristics and scores of assessment scales—such as FMA-LE, BBS, FAC, 10MWT, and others—are presented in full in the tables and results section of this article/Supplementary Materials.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

RAGT	Robot-Assisted Gait Training
RCT	Randomized controlled trials
ADL	Activities of daily living
FES	Functional Electrical Stimulation
FAC	Functional Ambulation Classification
FMA-LE	Lower extremity of the Fugl Meyer Assessment
10MWT	10-Meter Walk Test
6MWT	6-Minute Walk Test
RMI	Rivermead Mobility Index
MI-LL	Motricity Index of the Lower Extremities
MI	Motricity Index
BBS	Berg's Balance Scale
TUG	Timed Up and Go Test
FIM	Functional Independence Measure
MBI	Modified Barthel Index
BI	Barthel Index

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