WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Effectiveness of Robotic Assisted Gait Training in Spinal Cord Injured Patients – A Literature Review

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ABSTRACT :

Background. This review critically examines the current literature on the effectiveness of robotic-assisted gait training in spinal cord injury patients. It aims to provide evidence-based insights to inform the development of individualized, technology-driven rehabilitation approaches that enhance gait performance, reduce mobility impairments, and improve overall functional outcomes in this population

Methods: : A thorough search was performed in the PubMed database for articles published between 2018 and 2024, focusing on the effectiveness of robotic-assisted gait training in enhancing gait performance for individuals with spinal cord injuries.

Results : Six studies demonstrated that robotic-assisted gait training (RAGT) effectively benefits individuals with spinal cord injuries. RAGT enhances spasticity, muscle tone, cognitive function, ambulation, and muscle activity. Additionally, patients reported greater confidence and independence in mobility post-intervention. While RAGT is not a substitute for traditional rehabilitation methods, it serves as a valuable complement, improving overall therapy effectiveness in spinal cord injury rehabilitation.

Conclusion: The results of this study support the effectiveness of robotic-assisted gait training (RAGT) as a valuable adjunct to conventional rehabilitation in improving gait performance, endurance, and functional mobility in individuals with spinal cord injury. However, a research gap persists in understanding how to implement cost-effective, personalized RAGT protocols that address individual patient needs across various stages of recovery. Therefore, further studies are warranted to explore personalized, economically feasible approaches and to improve knowledge dissemination about the role of RAGT in spinal cord injury rehabilitation.

Keywords: : robotic assisted gait training, spinal cord injury, physiotherapy

Introduction :

A lesion of the neuronal components of the spinal cord is known as a spinal cord injury (SCI)[1]. Spinal cord damage causes the brain's peripheral nervous system to lose nerve contact with the ascending sensory and descending motor pathways. As a component of the central nervous system, the spinal cord facilitates the movement of nerve signals into and out of the brain[10]. It also works in tandem with peripheral nerves to enable voluntary and involuntary motor function, sensory perception, and interaction with the outside world. When a spinal cord injury happens, nerve transmission is either partially or totally cut off[10]. According to current estimates, there are 20,000 new cases of spinal cord injury reported in India which indicates that 1.5 million people with SCI live in India[11]

The major objective of rehabilitation therapies for people with spinal cord injuries (SCI) is independence, which leads to an improved quality of life (QoL)[8]. Taking into account the shared priorities for people with cervical, thoracic, or lumbar lesions, sexual, bowel, and bladder functionalities are the most significant factors affecting the quality of life (QoL) for people with paraplegia, and for people with cervical lesions, recovery of arm/hand function is followed by sexual, bowel, and bladder functionalities[8]. For people with SCI, ambulation recovery is also crucial, regardless of the extent of the injury, the length of time since the accident, or the age of the sufferer[8].

Robotics for rehabilitative intervention is now readily available because of technological advancements. Robots are described as reprogrammable, multipurpose .They use varied, programmed motions to move materials, parts, or specialized devices in order to complete a task. Robot-assisted gait training (RAGT) was first implemented in the late 1990s[1]. . Robot-assisted gait training is the application of cutting-edge robot technology in conjunction with physical therapy concepts to offer gait training and also include usage of robotic equipment in individuals with spinal cord injuries. (Calabrò et al., 2021). There are two types of robots for gait training: wearable and grounded exoskeletons. Grounded exoskeletons, like the Lokomat, utilize bilateral

robotic joints to support patients on treadmills with a harness, allowing for partial body weight support[9]. In contrast, wearable exoskeletons can be used in diverse settings, including indoor and outdoor environments, enabling activities like navigating obstacles and climbing stairs. These devices aid patients with spinal cord injuries in retraining their walking patterns[9].

RAGT offers several advantages, including the ability to increase both the intensity and total duration of training while preserving a natural gait pattern[1]. Additionally, task-specific stepping practice enhances the sensory feedback related to normal walking and can promote plasticity in the motor centers involved. Furthermore, locomotor robotic devices can help reduce the personnel costs associated with manual assistance training, which often requires the support of up to three physical therapists[1].

Materials and Methods :

Study design: Literature review

Study setting: St Johns Medical College, Bangalore

Study criteria :

Inclusion criteria:

*Systematic review,randomized control trial and meta analysis.

*Full text articles published in English only.

*Time line=2018-2024.

*Article available online at free of cost.

Exclusion criteria:

*Duplicate articles

*Article with poor quality. (CASP, Pedro, JBI<7)

Search strategy

A web-based search for studies from 2018-2024 was conducted in databases PubMed in which randomized control trial, systematic review,meta analysis were included. . For further relevant studies, we manually reviewed references from the collections. To decide whether the studies met the predetermined inclusion requirements, we checked authors, titles, and abstracts. The following keywords were used, “robotic assisted gait training”, “spinal cord injury”and “physiotherapy”.

REVIEW OF LITERATURE :

1.Stephen Clive Hayes et al (2018)[6]

Twelve studies met the inclusion criteria, involving 5 to 130 participants with injuries from C2 to T12 (ASIA A-D). Three used overground RAGT, and nine used treadmill-based RAGT. Both types did not lead to higher walking speeds than conventional gait training, and none showed significant improvements for community ambulation.

2..Yildirim et al (2019)[7]

The study found that the robot-assisted gait training system Lokomat significantly improved the FIM scores of the robotic group at entry and after treatment, compared to the control group. The robot group showed a 5.0% improvement in the WISCI-II score and a 4.0% improvement in the FIM score compared to the control group. This suggests that robot-assisted gait training can be a valuable tool for rehabilitation

3.Chia-Ying Fang et al (2020)[4]

A total of 225 studies were identified, with 18 meeting the inclusion criteria, involving 301 participants (7 RCTs and 11 non-RCTs). Non-RCTs showed significant improvements in spasticity (AS: 95%CI = -0.202 to -0.068, $p \leq 0.001$; MAS: 95%CI = -2.886 to -1.412, $p \leq 0.001$). There were no significant pain changes in either RCTs or non-RCTs, but walking ability and LEMS improved significantly with RAGT.

4. Sergiu Albu et al (2022)[3]

Out of 319 studies reviewed, 12 studies met the criteria and were included in our analysis. These studies spanned from 2013 to 2021 and involved 353 valid data points (N=353) on patients with spinal cord injuries (SCI) who used wearable Exoskeleton-Assisted Walking (EWA) and received Lokomat training. When using wearable EAW, patients showed significant increases in the 10-meter walk test distance (0.85, 95% CI = 0.35, 1.34) and speed scores (-1.76, 95% CI = -2.79, -0.73). The 6-minute walk test distance decreased (-1.39, 95% CI = -2.01, -0.77), the timed up and go (TUG) test scores

significantly increased (1.19, 95% CI = 0.74, 1.64), and no significant difference was observed in the walking index for spinal cord injury (WISCI-II) (-0.33, 95% CI = -0.79, 0.13).

5. Nicoleta Negrut et al (2023)[2]

In a meta-analysis of 11 studies, the results indicated the following: gait distance had a weighted mean difference (WMD) of 16.05 with a 95% confidence interval (CI) of -15.73 to 47.83 and an I2 value of 69%; gait speed (robot-assisted gait training (RAGT) vs. regular treatment) had a WMD of 0.01 with a 95% CI of -0.04 to 0.05 and an I2 value of 43%; gait speed (RAGT vs. no intervention) had a WMD of 0.07 with a 95% CI of 0.01 to 0.12 and an I2 value of 0%; leg strength had a WMD of 0.59 with a 95% CI of -1.22 to 2.40 and an I2 value of 29%; Timed Up and Go (TUG) test had a WMD of 9.25 with a 95% CI of 2.76 to 15.73 and an I2 value of 74%; 10 MWT had a WMD of 0.01 with a 95% CI of -0.15 to 0.16 and an I2 value of 0%; and 6 MWT had a WMD of 1.79 with a 95% CI of -21.32 to 24.90 and an I2 value of 0%.

6. Wardhana et al (2023)[5]

The odds ratios (OR) and 95% confidence intervals (CI) for ASIA Impairment Scale (AIS) grades are as follows: AIS grade A, OR = 0.093 (0.011–0.754, p = 0.026); AIS grade B, OR = 0.875 (0.395–1.939, p = 0.743); AIS grade C, OR = 3.626 (1.556–8.449, p = 0.003); AIS grade D, OR = 8.496 (1.394–51.768, p = 0.020). Robotic intervention significantly decreased AS (95% CI = -0.239 to -0.045, p = 0.004) and MAS (95% CI = -3.657 to -1.066, p ≤ 0.001). The study also investigated spasticity and walking ability

RESULTS :

This review highlights the effectiveness of robotic assisted gait training in spinal cord injured patients. As a result of all these articles, it is proven that RAGT is a very good technique which can be used for spinal cord injured patients. It is utilized to enhance muscle tone, cognitive functions ,ambulation and muscle activity. Additionally, several studies reported increased patient confidence and enhanced independence in ambulation following the interventions. Importantly, robotic-assisted gait training is not a replacement for traditional rehabilitation methods but serves as a valuable addition, enhancing the overall effectiveness of therapy in spinal cord injury rehabilitation. There is a limited knowledge and understanding of how the robotic assisted gait training works in spinal cord injured rehabilitation field due to the paucity of research in this topic, which recommends us that further studies have to be conducted to bridge this gap.

DISCUSSION :

Spinal cord injury (SCI) is a debilitating disorder affecting a person's life, affecting their locomotor abilities and quality of life. Approximately 1.5 million persons with SCI reside in India. Every year, over 20,000 new cases of SCI are reported, where the most of them are men between the ages of 16 and 30[11].

The main focus of this review was to find out the effectiveness of robotic-assisted gait training in spinal cord injured patients. This review covered 6 articles obtained from PubMed, comprising of 4 mete analysis ,1systematic review,1RCT .Article published from 2018-2024 were included in this review.

The two primary categories of rehabilitation robots are wearable exoskeletons (like ReWalk and Ekso) and grounded exoskeletons (like Lokomat).The majority of the study assessed the participants' locomotor abilities using the 10-MWT, 6-MWT, TUG test, and WISCI-II. As a result of all these articles, it is proven that RAGT is a very good technique which can be used for spinal cord injured patients. It is utilized to enhance spasticity, muscle tone, cognitive functions ,ambulation and muscle activity . According to studies the protocol is for one hour, two to three times a week. After an injury, motor damage healing usually starts in the first two months and lasts for three to six months. Neuroplasticity persists and accelerates during this time.

The current findings point to a number of reasons for the absence of appreciable assistance from machine-assisted rehabilitation in India .First off, machine-assisted rehabilitation technology is not yet developed enough to completely replace human therapy. Due to the limited capabilities and applications of the equipment, it is challenging to meet every patient's rehabilitation demands. Second, no two people are alike in their physical condition or rehabilitation needs, therefore machine-assisted rehabilitation technology is unable to create personalized plans that take into account each person's specific situation. Thirdly, supervision and advice for machine-assisted rehabilitation must be provided by qualified medical professionals; otherwise, the results may be insufficient. Lastly, the rehabilitative impact of machine-assisted rehabilitation equipment depends on long-term monitoring and evaluation, and the lack of such monitoring may result in less notable rehabilitation outcomes. And most important reason for all this is poor socioeconomic status of the country. So further research should be done to increase the effect of RAGT in spinal cord injured patients in cost effective manner.

CONCLUSION :

In conclusion, robotic-assisted gait training (RAGT) has emerged as an effective adjunct to conventional rehabilitation in individuals with spinal cord injury, contributing significantly to improvements in gait performance, endurance, functional mobility, and patient confidence. Evidence supports its potential to enhance overall functional outcomes and promote greater independence throughout various stages of recovery. Despite these benefits, a notable research gap remains in establishing cost-effective, individualized RAGT protocols that cater to specific patient needs. Therefore, future research should focus on developing tailored, economically viable approaches and improving awareness of RAGT's role in spinal cord injury rehabilitation.

CONFLICT OF INTEREST :

The authors declare no conflict of interest related to this study.

ACKNOWLEDGEMENT

The authors express gratitude to St. John's Medical College for their support and resources in conducting this review. Special thanks to colleagues and researchers whose work contributed to this study.

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