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Effectiveness of Robotic Gait Training in Stroke Subject – A Case Study

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Abstract

A 60-year-old male patient, who had suffered a hemiplegic stroke, was admitted to the hospital's rehabilitation unit with the primary goal of regaining walking ability. Upon admission, the patient exhibited significant difficulty walking due to the residual effects of the stroke, which had resulted in pronounced motor weakness and balance issues. To comprehensively assess the patient's baseline function, a range of standardized measures were employed, including the Berg Balance Scale (BBS), which evaluated balance and risk of falls, the Fugl-Meyer Scale (FMS), which assessed motor function in the lower extremities, and a spatial and temporal gait assessment, which evaluated gait performance. Following baseline assessments, the patient underwent a comprehensive 16-week rehabilitation program, which consisted of robotic gait training and exercise therapy, administered three days per week. Robotic gait training was utilized to provide high-repetition, task-oriented practice, facilitating motor learning and recovery. The exercise therapy program was designed to complement robotic gait training, targeting muscle strength, flexibility, and endurance. Upon completion of the 16-week program, post-test assessments were conducted, revealing significant improvements in balance, motor function, and gait performance, as evidenced by enhanced scores on the BBS, FMS, and spatial and temporal gait assessment. These findings suggest that robotic gait training, combined with exercise therapy, may offer substantial benefits in reducing weakness and improving gait and balance in patients with hemiplegic stroke, highlighting the potential of this innovative locomotor training approach in stroke rehabilitation.

Keywords*: Balance, Gait Training, Robotics, Stroke.*

Introduction

Stroke is a major public health concern, causing significant mortality and morbidity in India and worldwide, with approximately 5.8 million cases occurring annually leading to permanent disability and diminished quality of life. The global burden of stroke is staggering, with millions of cases reported annually, highlighting the need for increased awareness, improved healthcare access, and enhanced support for those affected by this debilitating condition [1, 2]. Stroke is a neurological condition that occurs when blood vessels in the brain become blocked or ruptured, disrupting blood flow and oxygen supply, resulting in sudden brain cell death. The likelihood of experiencing a stroke increase with age, with the risk doubling after age 55.

A disturbing trend has emerged in the global stroke landscape, with a significant increase in strokes affecting younger individuals. Between 1990 and 2016, the proportion of strokes among those aged 20-54 rose alarmingly from 12.9% to 18.6% [3]. This trend is accompanied by significant regional variations in stroke incidence (105-152 per

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100,000 annually) and prevalence (44.29-559 per 100,000). Furthermore, regional stroke incidence and prevalence rates exhibit substantial variability [4]. Multiple factors increase the risk of stroke, including age, family history, and certain medical conditions. While some factors can't be changed, others can be managed to reduce risk. Key modifiable risk factors include high blood pressure, irregular heartbeat, smoking, and poor lifestyle choices, such as physical inactivity and a diet lacking essential nutrients. Additionally, certain factors specifically affect women, including birth control use, migraines, and pregnancy-related conditions has increase the risk of cerebrovascular accident [5]. There are two main categories of strokes: ischemic and hemorrhagic. Ischemic strokes, which comprise approximately 85% of all stroke cases, occur when the brain's blood and oxygen supply is disrupted, often due to blockages or blood clots. Hemorrhagic strokes, accounting for around 10-15% of stroke cases, result from ruptured or leaking blood vessels in the brain, leading to bleeding. This type of stroke has a significantly higher mortality rate [6]. Understanding the difference between these two types is crucial for effective diagnosis, treatment, and management of stroke [3]. Stroke symptoms vary depending on the affected artery. Involvement of the anterior cerebral artery typically affects the legs more than the arms, with symptoms like hand sparing, akinetic mutism, urinary incontinence, and gait apraxia. A stroke affecting the middle cerebral artery can cause language processing difficulties, specifically: Broca's aphasia (expressive language difficulties) if the stroke impacts the artery's upper branch. Wernicke's aphasia (receptive language difficulties) if the stroke affects the lower branch, inattention, involvement of the face, arm, and leg, homonymous hemianopia or quadrantanopia (due to inferior division involvement), and gaze paralysis, often indicating extensive frontal lobe damage. Gait disturbances after stroke significantly impair patients' quality of life, emphasizing the crucial importance of regaining walking ability – a primary objective of rehabilitation programs [9] The consequences of post-stroke disability can be far-reaching, affecting not only physical function but also emotional well-being, leading to depression and stress [10]. However, gait training for severely affected patients poses technical challenges and balance disturbances. Effective rehabilitation strategies are essential to overcome these obstacles and restore mobility [11]. Gait training primarily impacts walking parameters, leading to increased velocity, stride frequency, and stride length, as well as faster. It also enhances balance control, reducing the risk of falls by improving performance in the Berg Balance Scale and functional reach tests. As a result, individuals with chronic stroke may walk faster and with a lower risk of falling. However, it remains uncertain whether these improvements translate into better quality of life [12]. There is growing recognition of assistive technology's potential, including reports of technology-assisted intervention programs for people with various difficulties [13]. Despite numerous studies on robotic-assisted gait training (RAGT) for stroke patients, debate persists over its effectiveness compared to conventional gait training. This study aims to investigate the impact of robotic gait training and balance training on stroke patients' gait and balance characteristics, clarifying the benefits of RAGT versus traditional methods.

Material And Methods

Case Presentation

A 60-year-old male patient was admitted to the hospital's rehabilitation unit following a hemiplegic stroke. His medical history revealed type 2 diabetes mellitus and systemic hypertension, for which he was receiving medication. Upon admission, the patient exhibited significant difficulty walking due to the residual effects of the stroke. He required substantial support to perform daily activities and was at risk of falls when attempting to execute these tasks independently. To comprehensively evaluate the patient's motor function, gait, and balance, a series of standardized assessments were conducted. These assessments include the Berg Balance Scale, which yielded a score of 20/56 during the initial week, the Fugl-Meyer Scale, which revealed a score of 19/34 prior to the intervention and the Functional Gait Assessment, which evaluated the patient's spatial and temporal gait parameters, including velocity (0.23 m/s), cadence (40 steps), stride length (10 cm), and step length (5 cm).

Rehabilitation Intervention

Following an explanation of the treatment protocol and obtaining informed consent, the patient underwent a comprehensive rehabilitation program which includes Robotic Gait Training and exercise therapy. The patient received robotic gait training for an average of 40 minutes per day, three days a week. This training utilized a robotic gait trainer equipped with a weight-supporting apparatus, an overhead railing, and a wearable harness. This setup enabled secure and customized weight support during gait training. Gentle passive stretching exercises were administered to the patient's bilateral lower limb muscles for 5-10 minutes. Comprehensive Exercise Program in which the patient participated in a 30-minute exercise program, which included breathing exercises, passive stretches, facilitatory techniques, and bed mobility exercises such as pelvic bridging, rolling, and transfer facilitation. The primary objective of this rehabilitation program was to enhance the patient's gait function, balance, and overall mobility. By achieving these goals, the patient would be empowered to perform daily activities independently and safely, thereby improving his overall quality of life.

Outcome Measures

Berg Balance Scale is a reliable and widely used assessment tool for evaluating balance and identifying fall risk in vulnerable populations, including older adults and individuals with neurological or musculoskeletal conditions [14]. The Fugl-Meyer Scale is a valuable assessment instrument in stroke rehabilitation, providing a holistic evaluation of motor, balance, and sensory functions to guide rehabilitation strategies [15]. Functional Gait Assessment scale used to assess gait performance which is highly reliable [16].

Result

The patient demonstrated significant improvements in balance, motor function, and gait performance over the 16-week intervention. Berg Balance Scale scores increased from 20/56 to 45/56, indicating enhanced balance and reduced fall risk. Fugl-Meyer Scale scores improved from 19/34 to 25/34, reflecting gains in motor function. Functional Gait Assessment scores also showed notable improvements, with velocity increasing from 0.23m/s to 0.79m/s. Overall, the patient achieved substantial functional gains and enhanced mobility (Table 1).

Table 1. Outcome Measures at 1, 10, and 16 Week of intervention

Outcome Measure	**At 1 ST Week**	**At 1OTH Week**	**At 16TH Week**
Berg balance scale	20/56	32/56	45/56
Fugl meyer scale	19/34	22/34	25/34
Functional Gait Assessment scale for gait	Velocity- 0.23m/s	Velocity-0.41m/s	Velocity- 0.79 m/s
	Cadence-40 steps	Cadence- 57steps	Cadence- 80 steps

performance	Stride length-10 cm	Stride length- 25cm	Stride length-40cm
	Step length- 5cm	Step length- 10 cm	Step length- 25 cm

Discussion

The findings of this case study suggest that the combination of robotic gait training and exercise therapy may be a highly effective approach in post-stroke rehabilitation, yielding substantial gains in the patient's motor function and activity measured using fugl Meyer, balance measured using berg balance scale and gait parameter using function gait assessment scale.

Stroke, a condition characterized by cerebral ischemia, is a major neurological disorder that arises from vascular injury, leading to central nervous system infarction, and is the most common cause of disability globally [17]. Stroke impacts motor and cognitive function and poses psychological, social, and economic challenges for patients and healthcare systems [18]. Neurological impairment after stroke depends on lesion location and severity, blood flow disruption time, collateral circulation, and biomarkers of hemorrhagic transformation." [19]. The evolution of robotic systems in healthcare and rehabilitation, enhances assistive care capabilities [20]. Studies suggest that Robotic gait training may facilitate neuroplasticity by stimulating the growth of new neurons, forming new neural connections, and strengthening existing ones [21]. In addition to that another study suggest that the repetitive practice provided by robotic gait training may enhance motor learning and recovery by improving motor planning and execution, increasing muscle strength and endurance, and promoting neural adaptation [22]. Exercise therapy that targets the muscles of the lower extremities is essential for improving functional mobility, balance, and reducing the risk of falls and injuries [23]. In patients with stroke-related gait abnormalities, balance deficits, mobility impaired and gait performance were poor and balance assessed using the Berg Balance Scale (BBS) [14] Motor function, balance, and mobility were evaluated using the Fugl-Meyer Assessment (FMA) [15] and gait performance was quantified using the Functional Gait Assessment (FGA) scale [16].

At the commencement of the study, the patient's Berg Balance Scale score was 20/56, and their Fugl-Meyer Assessment score was 19/34. The initial spatial and temporal gait assessment revealed a velocity of 0.23 m/s, cadence of 40 steps, stride length of 10 cm, and step length of 5 cm. By the 10th week, the patient had shown notable improvement, with a Berg Balance Scale score of 32/56 and a Fugl-Meyer Assessment score of 22/34. The spatial and temporal gait assessment at this stage indicated a velocity of 0.41 m/s, step length of 10 cm, stride length of 25 cm, and cadence of 57 steps. However, at the 16th week, as it was 45/56. By the end of the 16th week, the patient's Fugl-Meyer Assessment score had improved to 25/34, and the spatial and temporal gait assessment revealed a velocity of 0.79 m/s, cadence of 80 steps, step length of 25 cm, and stride length of 40 cm. Overall, the patient demonstrated remarkable progress in their rehabilitation by the end of the 16th week, marking a significant milestone in their journey towards recovery.

The findings of this case study have significant implications for clinical practice, suggesting that robotic gait training is a valuable complementary therapy to traditional physical therapy in stroke rehabilitation, with potential to enhance functional outcomes and improve overall quality of life. Limitation of the study includes the generalizability of the study's results compromised by the single-patient design, which may not accurately reflect the experiences and outcomes of other individuals with stroke. Lack of control group is another limitation. Futher study can includes

Larger RCT and can also evaluate the feasibility and cost effectiveness of robotic gait training. By continuing to explore the therapeutic potential of robotic gait training, clinicians and researchers can work towards developing evidence-based guidelines for its use in stroke rehabilitation, ultimately improving the lives of individuals affected by stroke.

Conclusion

In conclusion, the findings of this case study demonstrate the effectiveness of combining robotic gait training with exercise therapy in post-stroke rehabilitation. By continuing to explore the therapeutic potential of robotic gait training, clinicians and researchers can work towards developing evidence-based guidelines for its use in stroke rehabilitation, ultimately improving the lives of individuals affected by stroke. The use of robotic gait training has the potential to revolutionize the field of rehabilitation, offering new hope and improved outcomes for individuals with stroke.

Conflict of Interest

All the author declares no conflict of interest regrading publication of study.

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