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Automatic data collection provided by some RAGT devices, including the technology used in this study, enables detailed analysis and progress tracking, allowing for adjustments to therapeutic interventions to achieve optimal outcomes. Moreover, actively engaging patients, combined with the increased motivation fostered by incorporating games into therapy, can further enhance its overall effectiveness [35,36].

Most prior research on the impact of RAGT for gait rehabilitation in children with neurological disorders has focused primarily on CP. A significant proportion of these studies used exoskeleton devices [26,27,37,38], with fewer employing end-effector systems [28-31]. The evidence suggests that RAGT positively affects gait parameters, overall mobility, and gross motor skills in pediatric CP patients, which aligns with the findings of the current study. However, the studies differ in the extent of achieved results, which may be attributed to various factors, such as differences in protocols or the severity of patients's conditions. Smaina et al. [29] investigated an end-effector device in 18 children with CP, reporting a 9% increase in gait speed and a 23% increase in walking distance after 10 sessions. Hwang et al. [28] observed a 17% improvement in gait speed following 24 sessions. Variability in outcomes for exoskeleton devices is noted, with Meyer-Heim et al. [37] showing a 16.6% increase in gait speed and a 13.1% increase in distance after 20 sessions, while Ma et al. [38] reported improvements of 37% and 48% in speed and distance, respectively, after 40 sessions. There is a very limited number of studies involving pediatric patients with various neurological conditions and all of them utilize exoskeletons. In the study by Beretta et al. [39] comprising patients with CP and acquired brain injury (ABI), a 21.5% improvement after 20 therapy sessions in walking distance was noted, with better outcomes in the ABI group. Similarly, another study by Gazzellini et al. [40] reported a 24% increase in walking distance and a 29% improvement in walking speed among 47 pediatric patients with unspecified neurological conditions.

Despite fewer therapy sessions, the current study achieved superior outcomes compared to the studies mentioned above. This difference may partly be due to the direct assessment of gait parameters through device-generated data, as opposed to the 10MWT and 6MWT tests used in most of the previous research. The robotic device provides patients with enhanced support and stability compared to overground walking. This helps reduce the risk as well as fear of falling which can cause hesitation and slower walking, ultimately leading to increased walking speed and greater distance covered. In addition, the patient's lower limbs in an end-effector device are fixed only at the feet, which provides distinct advantages over exoskeleton systems. This configuration allows for greater freedom of movement in all anatomical planes, facilitating more active patient participation during therapy, which is directly related to improved therapeutic outcomes [41].

The primary limitation of this study is the absence of a control group, which would allow for a more robust evaluation of the effectiveness of RAGT compared to the conventional approach. Furthermore, progress was assessed only based on device-generated values from the first and last therapy sessions, without any follow-up evaluation. To better capture the therapy's benefits, it would be useful to incorporate additional assessment methods that reflect the patient's functional abilities and independence in daily life over a longer-term scale. Another drawback is the broad diversity of diagnoses within the "Others" group, which, due to the small sample size for each condition, prevents drawing meaningful conclusions about these specific disorders. Despite these limitations, this study contributes to the field as it is the first to explore the effectiveness of end-effector RAGT across various neurological disorders in children. While the sample sizes for individual conditions in the "Others" group were limited, the results suggest a trend indicating the device's potential effectiveness for a range of neurological conditions. For future research, it would be valuable to include a larger sample of patients for each condition. Combined with economic evaluations, this could assist potential clients in determining whether RAGT is a worthwhile investment based on the distribution of patients by diagnosis in their specific facilities.

Conclusion

Pediatric patients with various neurological disorders demonstrated statistically significant improvements in all assessed parameters following rehabilitation program including a novel end-effector-based RAGT system. Based on the evaluation of gait parameters generated by the device, increases of approximately 48%, 63%, and 39% were observed in the number of steps, distance walked, and walking speed, respectively. These findings indicate a positive impact of the RAGT system on gait, benefiting not only pediatric patients with CP but also those with other neurological conditions, which may contribute to enhancing functionality and independence in daily life.

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