REVIEW | OPEN ACCESS

Medical Science

Walking as Therapy - The Role of Walking Training in the Management of Peripheral Arterial Disease

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To Cite:
Woźniak A, Żyro K, Żyro W, Woźniak K, Stasiak M, Glapiński F. Walking as Therapy - The Role of Walking Training in the Management of Peripheral Arterial Disease. *Medical Science* 2025; 29: e68ms3567
doi: https://doi.org/10.54905/disssi.v29i158.e68ms3567

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Peer-Review History
Received: 03 April 2025
Reviewed & Revised: 07/April/2025 to 09/May/2025
Accepted: 12 May 2025
Published: 18 May 2025

Peer-review Method
External peer-review was done through double-blind method.

Medical Science
pISSN 2321–7359; eISSN 2321–7367

ABSTRACT

Peripheral artery disease (PAD) is a common condition that limits walking and reduces quality of life. Walking training is now recognized as a key part of treatment. This review summarizes recent studies on walking-based exercise in PAD. We researched PubMed for studies published between January 2019 and March 2025. Only randomized trials, meta-analyses, and systematic reviews were included. The primary outcomes were walking distance and exercise tolerance. Moderate-intensity walking improved both pain-free and maximal walking distances better than vigorous exercise. Walking after stenting helped reduce the risk of in-stent restenosis. Mobile health tools supported home-based programs and improved walking ability. Some programs also increased adherence. Effects on quality of life were mixed. Supervised exercise therapy (SET) was as effective as revascularization in improving function while being more cost-effective. Home programs with monitoring worked nearly as well as SET. Blood flow restriction training and arm ergometry helped patients who could not tolerate walking. Short and frequent exercise programs were well tolerated and effective, with satisfying results. SET was found to improve cardiovascular responses and reduce symptoms of anxiety and depression. Walking training is safe and flexible. It should be adapted to patient needs. Future work should focus on adherence and personalizing treatment.

Keywords: Peripheral artery disease, intermittent claudication, walking training, exercise therapy

1. INTRODUCTION

Peripheral artery disease (PAD) is a common manifestation of atherosclerosis. It increases the risk of serious illness, death, and loss of walking ability, and it also lowers quality of life (Hiatt, 2001). There are approximately 237 million people in the world living with PAD (Song et al., 2019). The most common symptom is leg pain during walking, which stops with rest because the muscles do not get

enough oxygen during activity. Over time, poor blood flow can damage muscle fibers and capillaries. These changes reduce endurance and make walking harder for patients. Walking therapy has been highlighted as one of the most essential options for managing PAD in recent years by clinical guidelines (Mazzolai et al., 2024).

This study reviews clinical evidence for walking training as a therapeutic strategy in PAD. It synthesizes the latest randomized trials and meta-analyses and outlines practical strategies for implementing rehabilitation programs based on home walking training and other similar exercise therapies.

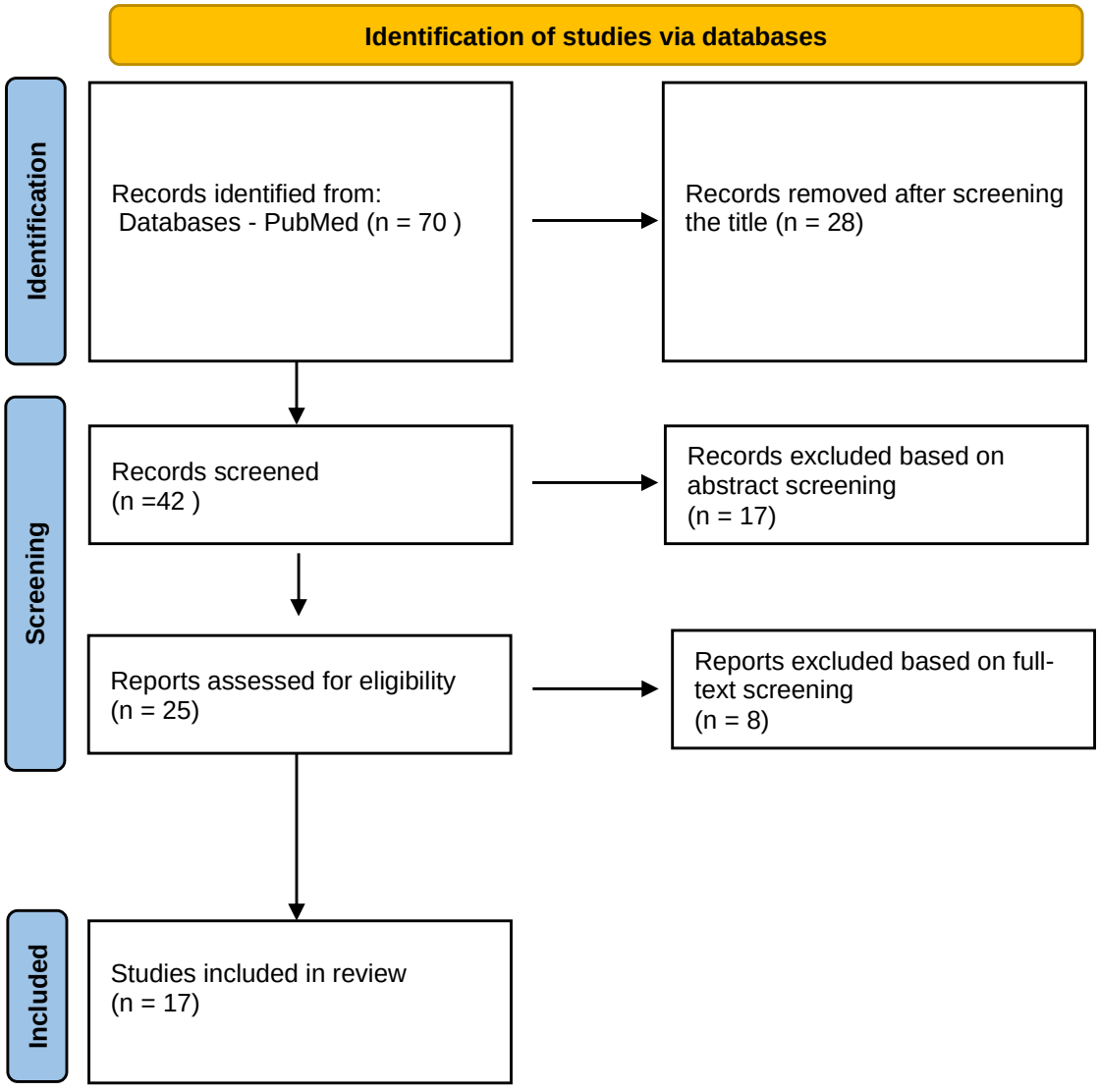

Figure 1. PRISMA flow diagram

2. MATERIALS AND METHODS

We searched PubMed for studies published between January 2019 and March 2025. The goal was to find studies on walking-based exercise therapy in people with PAD. To find proper literature, the following terms were used to search: ("Peripheral Arterial Disease") AND ("Walking training" OR "Supervised Exercise Therapy" OR "Exercise Therapy"[MeSH]) AND ("Treatment Outcome"[MeSH] OR "Walking distance" OR "Functional capacity"). Only studies published in English were included. Only human-based studies categorized as randomized controlled trials, systematic reviews, meta-analyses, or narrative reviews were considered. Studies had to assess walking-based interventions and report outcomes related to functional capacity, such as walking distance or exercise tolerance. Case reports, expert opinions, and studies unrelated to walking interventions were excluded. We used the title and abstract to choose

studies meeting the inclusion criteria. The aim was to summarize high-quality evidence supporting walking training as a central element of PAD management. The article selection process adhered to the PRISMA guidelines (Fig.1).

3. RESULTS AND DISCUSSION

This discussion summarizes and interprets key findings from recent studies on various exercise modalities in patients with PAD. Evidence from randomized controlled trials and meta-analyses is grouped by training intensity, setting, and therapeutic context. The summary of walking-based interventions in PAD is presented in Table 1.

Table 1. Summary of Walking-Based Interventions in PAD

Study / Source	Intervention Type	Main Outcomes	Advantages
Fassora et al., 2022	Moderate vs. vigorous walking	↑ PFWD, ↑ MWD (better in moderate)	High tolerability, functional gains
Kato et al., 2022	Post-stenting walking	↓ In-stent restenosis, ↑ ABI, ↑ MWD	Safe, improves vascular patency
Kim et al., 2021	mHealth-based home training	↑ 6MWT, ↑ adherence, mixed QoL	High adherence, remote feasibility
Koelemay et al., 2022	SET vs. Revascularization	Similar MWD, better QoL with ER, ↑ cost-effectiveness	SET effective and cheaper
Slysz et al., 2021	SET	↓ SBP, ↓ HR, ↑ 6MWD	Cardiovascular benefits
Parkington et al., 2023	Blood flow restriction (BFR)	↑ 6MWD, ↓ pain	Well tolerated, useful alternative
Magalhães et al., 2024	Arm ergometry vs. treadmill	↑ VO_2, ↑ QoL (both), ↑ 6MWD (treadmill better)	Alternatives for non-walkers
Sun et al., 2025	Nordic walking	Comparable to SET, better than unsupervised	Practical, low-barrier
Villemur et al., 2020	ITAR vs. CT treadmill training	↑ MWD (both), no difference in pain/time	Short duration, effective
Salisbury et al., 2022	Recumbent stepping vs. treadmill	↑ QoL, ↑ 6MWT (both), higher adherence in TBRS	Useful for non-ambulatory

Effects of Exercise Intensity on Walking Performance

Fassora et al., (2022) conducted a meta-analysis of 19 randomized controlled trials to examine how different exercise intensities affect walking ability in patients with PAD. The study compared light-to-moderate and vigorous-intensity exercise, focusing on changes in pain-free walking distance (PFWD) and maximal walking distance (MWD). The results showed that light-to-moderate exercise was more effective in improving both PFWD and MWD. On average, patients improved their MWD by 223 meters with moderate training, compared to 153 meters with vigorous exercise.

PFWD also improved more with moderate training, likely because it was easier for patients to tolerate. What is interesting is that walking, especially at higher intensity, led to the most significant gains in MWD, suggesting that walking remains one of the most effective exercise types for PAD. However, vigorous exercise helped improve cardiovascular fitness (VO_2peak), which did not always result in better walking ability due to pain limitations. In summary, moderate-intensity walking balances functional improvement with tolerability and can be tailored to individual needs (Fassora et al., 2022).

Post-Revascularization Exercise and Vascular Outcomes

A randomized clinical trial was conducted on patients with PAD. All participants had undergone stenting of the femoropopliteal artery. The study examined if walking training could reduce in-stent restenosis (ISR). Forty-four patients were divided into two groups. One group performed walking exercises at least three times per week. Each session took 30–45 minutes. All participants received supervised follow-ups every month. The control group did not receive a structured walking program. After 12 months, the walking group had significantly less restenosis.

ISR occurred in 18.7% of the walking group and 52.4% of the control group. This difference was statistically significant ($p = 0.043$). There was no increase in stent fractures or frequency of adverse events - patients who walked more improved walking distance and ankle-brachial index (ABI). The results indicate that walking training after stenting is safe and effective. It improves physical function and helps maintain vessel patency. Combining endovascular treatment with walking may enhance long-term outcomes in PAD patients (Kato et al., 2022).

Digital and Remote Exercise Interventions

New technologies enter health and medicine. Kim et al. (2021) performed a meta-analysis on mobile health (mHealth)-based exercise interventions in patients with PAD. The review included six randomized controlled trials regarding home-based walking programs supported by mobile technology such as wearable devices, apps, or remote coaching. The results showed that patients in the mHealth groups walked farther and with less pain. They significantly improved pain-free walking, maximum walking distance, and the 6-minute walk test (6MWT). Functional capacity, which was measured using the Walking Impairment Questionnaire, also improved. However, mHealth programs did not significantly improve quality of life (QoL), and the results in this area were mixed. What is essential is that adherence to exercise programs was high in the mHealth groups. Some studies reported over 80% adherence, comparable to supervised exercise therapy (SET). That said, digital tools can help patients stay motivated and consistent with walking programs, improve walking ability, and support long-term self-management of PAD in everyday environments (Kim et al., 2021).

Another example of the use of technology in the treatment of patients with PAD is present in a large randomized controlled trial including 1,982 patients with intermittent claudication. A home-based program called TeGeCoach was tested, which included telephone coaching and remote monitoring using wearable activity trackers. The intervention lasted 12 months and used motivational interviewing, personalized exercise plans, and step tracking. The main goal was to improve walking ability, measured by the Walking Impairment Questionnaire (WIQ). After 12 months, patients in the TeGeCoach group improved their WIQ scores by 8.4 points, compared to 2.1 points in the usual care group. At 24 months, the improvement remained higher in the TeGeCoach group (6.2 vs. 1.6 points). These differences were statistically and clinically significant ($p < 0.0001$).

Patients reported better physical quality of life and higher activation in managing their health. However, daily step count did not increase, showing that walking ability and daily activity are not always linked. TeGeCoach shows that digital and remote walking programs can be an effective alternative if supervised programs are not available (Rezvani et al., 2024).

Supervised Exercise Therapy versus Revascularization

The SUPER study was a randomized trial comparing SET and endovascular revascularization (ER) in patients with intermittent claudication caused by iliac artery obstruction. Two hundred forty patients were randomly assigned to receive SET or ER as their first-line treatment. After one year, both groups improved their walking distance. There was no significant difference between the groups in MWD after one year. However, the ER group had slightly better quality-of-life scores on the VascuQol scale. In this study, compliance with SET was low. Only 50% of patients completed at least six months of the program, and around 29% of patients in the SET group had a revascularisation procedure within the first year.

Despite this, SET still produced meaningful improvements in function and quality of life. Both treatments were also associated with fewer symptoms and improved patient-reported outcomes. After 5.5 years, more patients from the SET group needed further

procedures (49%) compared to the ER group (27%). However, there was no difference in overall survival or major cardiovascular events between groups. The study supports current guidelines recommending starting with SET in patients with mild to moderate symptoms (Koelemay et al., 2022).

Cost-effectiveness is one of the factors that should be taken into account when determining the recommended treatment strategy - an analysis compared SET and ER in patients with intermittent claudication caused by iliac artery obstruction. The study was based on 240 patients in the SUPER randomized controlled trial. Patients were followed for 12 months and assessed for health outcomes and treatment costs. ER led to slightly better results in quality-adjusted life years (QALYs), health-related quality of life (HRQOL), and VascuQol scores. However, these improvements were below the minimum clinically significant difference. The cost of ER was higher than SET. On average, ER costs €4,031 per patient compared to €2,179 for SET. The study showed that SET is more cost-effective, especially considering ER offers only a small clinical benefit (van Reijen et al., 2022).

Cardiovascular and Safety Considerations in Exercise Programs

Slysz et al., (2021) analyzed data from a randomized controlled trial with 210 patients with peripheral artery disease. Participants were assigned to either a SET group based on treadmill training three times per week for six months or an education-only control group. After the program, the SET group showed significant improvements in cardiovascular responses to exercise, including reduced systolic blood pressure by an average of 12 mm Hg, reduced heart rate by seven beats per minute, and decreased pulse pressure during exercise. These changes were statistically significant ($p < .01$). There were no significant changes in diastolic blood pressure. These improvements were linked to better walking performance.

Patients with more substantial reductions in systolic pressure, pulse pressure, and heart rate had more considerable gains in 6MWD and treadmill walking distance. This study shows that SET improves walking ability and cardiovascular responses during physical activity (Slysz et al., 2021).

One of the RCTs focused primarily on the safety profile of home-based walking exercise. The exercise helped many patients with PAD improve their walking performance. More than half of the participants in the exercise group walked at least 20 meters farther in the 6-minute walk. The benefits of exercise were seen in people of all ages, sexes, and backgrounds, which means home-based programs can help many different patients. However, serious side effects were slightly more common in the exercise group. Generally speaking, the risk was similar, but specific subgroups - black participants and those with coronary artery disease or heart failure experienced more serious adverse events (SAEs) with exercise, which may reflect underlying health conditions rather than the exercise itself. The results also show the need to monitor patients with heart disease more closely during training. Tailoring exercise programs to individual risk may improve safety while preserving benefits (Thangada et al., 2025).

Alternative Exercise Modalities and Populations with Limitations

A study was performed to test whether low-intensity resistance training with blood flow restriction (BFR) could be helpful in patients with PAD and claudication. They ran a small randomized controlled feasibility trial with 30 patients. Half of the group did standard low-intensity resistance training, and the other half did the same exercises but with pneumatic cuffs on the upper legs to restrict blood flow. After 8 weeks, both groups improved their 6MWD, but the results in the BFR group were more satisfying. Eighty-six percent of patients in the BFR group improved their walking distance by at least 35.5 meters, compared to only 33% in the control group. Time to claudication pain also improved more in the BFR group.

Pain levels at the end of the walking test were lower for BFR. No adverse events occurred, and adherence to the program was high in both groups. This study shows that BFR training is safe, well tolerated, and possibly more effective than standard resistance training in improving walking performance. It may offer an alternative for patients who cannot tolerate walking or high-intensity exercise due to pain (Parkington et al., 2023).

Two exercise methods were tested in the ARMEX trial in patients with PAD: treadmill training and arm-ergometry. Both programs lasted 12 weeks and were delivered as supervised sessions. The goal was to see if arm-ergometry could match treadmill training in improving fitness and walking ability. Both groups improved in cardiovascular fitness, measured as VO_2 at the first ventilatory threshold. Peak VO_2 increased only in the arm-ergometry group, but the difference between groups was insignificant.

Breathing efficiency improved more in the arm-ergometry group, but treadmill training led to more significant gains in walking distance. Patients in this group walked 120 meters farther in treadmill tests and 25 meters more in the 6MWT. They also reported feeling better about how far they could walk. These findings suggest that treadmill training is more effective for improving walking

performance. However, arm ergometry may still help improve heart and lung function. It could be a good option for patients who cannot tolerate walking-based programs (Magalhães et al., 2024).

The secondary outcomes from the ARMEX trial focused on these patients' health-related quality of life and mental health. Each group showed significant improvement in physical function and reduced symptoms of anxiety and depression. Treadmill training led to more considerable gains in emotional and physical role function. However, both groups improved similarly in overall physical health scores. No serious adverse events occurred, and adherence to training was high.

Changes in quality-of-life scores were linked to how far patients could walk, especially in the 6MWT. Better self-reported walking ability was also connected to lower levels of anxiety and depression. These results suggest that feeling more mobile in daily life may improve physical and emotional well-being. Different training options may help more patients stay active and benefit from rehabilitation (Magalhães et al., 2025).

The effectiveness of Nordic walking (NW) in patients with peripheral artery disease was evaluated in a recent meta-analysis, which included eight trials and 508 participants. The analysis compared NW with both SET and non-exercise controls. Key outcomes were maximum walking distance (MWD), claudication distance (CD), and exercise duration. No significant differences were observed in MWD or CD when NW was compared directly to SET. SET was more effective than NW in improving exercise duration, with a moderate effect size favoring SET (SMD = –0.41, $p = 0.01$). These results suggest that SET is the more effective way to improve gait performance. However, NW performed better than unsupervised or home-based programs. Although NW does not beat SET, it is still a viable and easy option. Structured instruction and supervision were found to enhance outcomes. NW seems to be worth considering when SET is unavailable or poorly tolerated (Sun et al., 2025).

Two different 4-week supervised exercise programs were tested in patients with intermittent claudication. The study compared interval treadmill training with active recovery (ITAR) to conventional treadmill training (CT) at constant speed and slope. Both programs were delivered five days per week, three hours per day, and included additional physical therapy sessions. Training adherence was excellent, and no adverse events were reported.

All patients in the ITAR group completed 100% of sessions, while a few missed sessions occurred in the CT group. Both training methods led to a significant improvement in MWD. The median MWD nearly doubled, increasing from 415 to 995 meters in the total population. There was no significant difference between the two groups in MWD, claudication test (C-test), or 6MWT. These findings suggest that both training approaches were equally effective in improving walking capacity.

Exercise tolerance was reduced at baseline, indicating moderate to severe impairment in the population studied. The improvements were realized despite comparatively low training intensities (around 50% of VO_2peak). These findings suggest the efficacy and feasibility of short and intense exercise programs in PAD. A 4-week approach with daily training may be as beneficial as longer, lower-frequency programs and could improve patient adherence (Villemur et al., 2020).

Researchers tested treadmill walking (TM) against total body recumbent stepping (TBRS) in a pilot study comparing different supervised exercise modalities for PAD. Nineteen participants completed 12 weeks of training. The goal was to assess whether TBRS is a safe and effective alternative to treadmill exercise. Adherence was higher in the TBRS group (86%) compared to the TM group (71%). Exercise intensity in MET minutes per session was also greater in the TBRS group. Minor adverse events occurred more often with TBRS, but none were serious. Both groups showed improvements in walking performance.

The 6MWT result improved physical function and quality of life in both groups, with no significant differences. These findings suggest TBRS is a feasible and safe alternative to treadmill walking. It may be beneficial for patients who have difficulty performing traditional walking-based training. It is worth considering that further research in larger populations is recommended to confirm these results (Salisbury et al., 2022).

Home-Based and Monitored Exercise Programs

In 2021, a systematic review and meta-analysis compared home-based exercise programs (HEPs) with supervised exercise programs (SEPs), basic walking advice, or no exercise. They included 23 studies with 1907 participants. The results showed that SEPs were generally more effective than HEPs for improving walking distance. However, when HEPs included monitoring (like pedometers or step counters), the difference between HEPs and SEPs was insignificant. HEPs with monitoring were nearly as effective as SEPs in some studies. Compared to basic advice or no exercise, HEPs were better. Patients improved both pain-free and maximum walking distance.

In some cases, quality of life improved, primarily when HEPs were structured and included goal setting, feedback, and patient education. The most effective programs used walking 3–5 times per week, for mild or moderate pain, for up to 60 minutes. The authors concluded that HEPs are useful when SEPs are unavailable. A clear prescription and patient support are needed to make HEPs effective (Pymer et al., 2021).

The SUNFIT trial compared three treatment strategies for patients with intermittent claudication: supervised exercise therapy (SEP), home-based structured exercise (HSEP), and walking advice (WA). All 166 patients received the best medical care, free Nordic walking poles, and advice to walk regularly. They were randomized and followed for 12 months. The primary goal was to test if HSEP was non-inferior to SEP. The change in maximum 6MWT between SEP and HSEP was 11.6 meters, which stayed within the pre-defined non-inferiority margin of 50 meters, confirming that HSEP was not worse than SEP.

In this study, three groups showed significant improvement in pain-free walking distance and muscle endurance, yet no significant differences were observed between the three groups after 12 months. These results suggest that even basic walking advice and the best medical care may lead to functional improvements. The reason behind these results might be the adherence to the training programs. Only 24% of HSEP and 26% of SEP participants completed the program. These findings support using home-based walking programs when supervised therapy is unavailable. However, future programs may need to focus more on improving adherence to achieve better outcomes (Sandberg et al., 2023).

A recent network meta-analysis compared different types of SET for patients with intermittent claudication. Eighteen studies with 1,135 participants were included. The analysis focused on walking capacity, measured by both MWD on a treadmill and the 6MWD. Combined aerobic and resistance training produced the most significant improvements in walking capacity. These patients increased their treadmill MWD by 122 meters, more than intermittent walking (107 meters). For the 6MWD, combined training led to gains of 57 meters, slightly more than underwater training (56 m) and intermittent walking (39 m). These differences were clinically meaningful, exceeding published thresholds for improvement. The results suggest that combining intermittent walking with resistance exercises may offer the best outcome for patients. Underwater exercise also showed promising results, but was tested in only two studies. The quality and reporting of the included studies varied, and many lacked information on exercise volume or adherence (Tremblay et al., 2023).

4. CONCLUSIONS

Exercise therapy remains an integral part of management in PAD patients. Walking is especially advantageous compared to other exercises and should be a first-line approach. After stenting, normal walking reduces in-stent restenosis and improves physical function. The practice is safe and does not increase the number of complications or stent fractures. Supported walking by mobile technologies at home can effectively improve walking function and functional performance. Wearable monitors, apps, and remote guidance increase compliance and engage patients in training. Although the effects on the quality-of-life mix, mHealth interventions remain promising and feasible. SET is more cost-effective than revascularization and improves walking distance and cardiovascular function. Home programs with formal monitoring are equal to supervised training. Resistance training performed with blood flow restriction is a safe and well-tolerated alternative for patients unable to exercise due to pain.

Other modalities like recumbent stepping and arm-ergometry can be helpful, especially in mobility-impaired patients. High-intensity, brief exercise regimens can improve walking ability significantly and possibly increase compliance. Positive cardiovascular adaptations brought about by exercise include lowered heart rate and blood pressure while exerting effort. More significant improvements in walking function are linked to these adaptations.

Consequently, increased mobility provides a higher quality of life and improved mental health. For training programs to be safe, effective, and ultimately successful, they must be customized. It might be possible to reach more patients by combining scheduled walking with non-modalities or other digital technologies. Program optimization, improved adherence, and patient-specific intervention customization will need to be the main topics of future research.

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Acknowledgments
Not applicable.

Informed Consent
Not applicable.

Ethical approval
Not applicable.

Funding
This study has not received any external funding.

Conflict of interest
The authors declare that there is no conflict of interests.

Data and materials availability
All data sets collected during this study are available upon reasonable request from the corresponding author.

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