



International Journal of Medical and Exercise Science

(Multidisciplinary, Peer Reviewed and Indexed Journal)

ORIGINAL ARTICLE

EFFECT OF UNWEIGHING HARNESS WITH TREADMILL IN PATIENTS WITH LUMBAR DECOMPRESSION AND FIXATION SURGERY (L2-S1)

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ABSTRACT

Background of the study: Globally, spinal problems such as disc herniation, degenerative spondylo listhesis and lumbar spinal stenosis are among the main causes of disability and decreased quality of life. Nerve compression is often relieved, and spinal stability is restored by surgical procedures including lumbar decompression and fixation. This study aims to investigate the effectiveness of an un-weighing harness combined with treadmill training in improving gait speed and functional independence in patients who have undergone lumbar decompression and fixation surgery (L2-S1). **Methods:** A pre-post study design was used with ten patients who had surgery to treat their lumbar decompression. Gait Speed and Functional Independence Measure (FIM) scores were evaluated on the first and tenth days of therapy. As a component of their post-operative rehabilitation regimen, all individuals engaged in treadmill training with un-weighing harness assistance. T-tests for paired samples were used for statistical analysis. **Results:** Statistically significant improvements were observed in both the outcome measures. Gait speed increased from a mean of 0.248 m/s to 0.778 m/s ($p < 0.001$), and FIM scores improved from a mean of 92.00 to 118.80 ($p < 0.001$). Large effect sizes were recorded for both variables, indicating strong clinical relevance. **Conclusion:** Following lumbar spine surgery, Un-weighing Harness-assisted treadmill training is a well-received and successful technique that dramatically improves gait speed and functional independence in the early post-operative period.

Keywords: Body-weight support, Treadmill training, Lumbar surgery, Gait speed, Functional Independence, Rehabilitation, Dynamometer

Received on 29th October 2025; Revised on 20th November 2025; Accepted on 26th November 2025
DOI:10.36678/IJMAES.2025.V11I04.015

INTRODUCTION

The most common cause of disability globally is low back pain, and as the world's population ages, both the prevalence of low back pain and the resulting burden of disability are predicted to rise. In addition to the high lifetime incidence of low back pain, spinal stenosis and disc prolapse are becoming more frequently diagnosed^{1,2}. Conservative treatment of low back pain is always advised by clinical guidelines; nevertheless, if conservative measures prove ineffective, surgery may be necessary.² As a result, the number of surgical procedures for these disorders is continuously increasing. The most common surgical treatments on the spine are discectomies and nerve root decompression and fixation. Both of these procedures are becoming more common, especially decompression surgery for spinal stenosis, which has been linked to an ageing population.

According to a recent survey, there are significant variations in the limits and recommendations given to patients during the post-operative phase, as well as in the kind and level of rehabilitation, if any, that is offered following spine surgery. It has been proposed that although surgery reduces leg discomfort, functional gains are less pronounced, which may affect quality of life. As a result, although one outcome is considered successful, others are not. This implies that there is room for improvement, especially in terms of the functional result¹.

Physiotherapy is widely employed in the treatment of people having spinal surgery. During an inpatient stay (pre-operative and post-operative), physiotherapy interventions consistently focus on patient's independency with mobility and functional duties, as well as

to educate and counsel patients on post-operative walking and physical activity. Clinical recommendations for the treatment of low back pain regularly advocate for keeping an active lifestyle, as there is evidence that doing so reduces pain and improves functional result².

The cornerstone of successful post-operative rehabilitation is early and progressive mobilisation. On the other hand, pain, a fear of movement, and poor postural control frequently prevent early gait training. Evidence indicates that early and increased walking improves functional success and lowers the rate of post-operative problems in different post-surgical populations. Therefore, more walking right after lumbar spine surgery probably results in similarly better results.

As is well known, a crucial part of the physiotherapy intervention that takes place right after spinal surgery is the evaluation of gait and guidance on walking and returning to physical activity. By determining the amount of walking patients perform now and the effects walking has on long-term functional outcomes in the immediate post-operative period, physiotherapists can tailor patient care to get the best results. It will also assist in identifying individuals who may need more extensive rehabilitation programs since they are unable to walk the minimal amount required for better results³.

In this context, an Un-weighting harness with treadmill system used in body-weight-supported treadmill training (BWSTT) has become a viable strategy to help early gait retraining in a secure setting.

Both gait research and gait rehabilitation may benefit from the usage of a motorised treadmill. Walking on a treadmill and walking

on the ground have certain differences, but they also share some similarities^{4,5}.

The incapacity to walk or a sluggish, spastic-paretic stride that requires a lot of energy is the most obvious remaining limitation for many individuals. Physiologic studies of the impact of the amount and timing of limb loading during stepping, as well as of stance and swing phase kinematics in spinal transected quadrupeds, have led to the development of a gait training technique known as body weight support on a treadmill^{6,7}.

The therapist can more easily provide manual supervision using body weight-supported treadmill training, which may reduce the risk of manual handling injuries⁸.

Walking on level ground with assistance is also used in neurological rehabilitation and is an alternative to walking on a treadmill. Compared to treadmill training, it can be a more task-specific type of gait training that facilitates the transition from walking in therapy to walking in everyday situations. This is because patients walk on surfaces that are similar to those they walk on in their daily lives. Another reason over ground gait training is popular is because it is low-cost and does not require pricey treadmills. For low- and middle-income nations, this is a very crucial factor^{9,10}.

Wheelchair-dependent people always use upper-body exercises to reach their fitness goals. Even though there is strong evidence that a variety of upper-body exercises can enhance cardiovascular endurance and strength, exercising the legs, which have a larger muscle mass, presents a greater physiological challenge and is likely to produce greater improvements in fitness, cardiovascular function, and metabolic control. Additionally,

we cannot exclude the possible psychological advantages of upright walking exercise for people who rely on wheelchairs. Thus, we must take into account the possible impact of body weight supported treadmill training on a range of health-related outcomes before discounting it as a costly, but possibly inferior, substitute for traditional rehabilitation¹¹⁻¹⁴.

Numerous studies have been conducted on the application of BWSTT in neurological populations, namely in those with incomplete spinal cord injury (SCI). Following systematic treadmill-based therapies, studies have demonstrated notable increases in gait speed, endurance, and functional independence.^{9,10} Although the majority of this research focuses on SCI patients, post-operative orthopaedic rehabilitation, including lumbar spine procedures, can benefit equally from the fundamental ideas of task-specific gait training and decreased mechanical strain.

This study intends to qualify and quantify the effects of treadmill walking with unweighing harness on gait by examining the walking speed and functional independence.

The working hypotheses state that walking on a treadmill has a different gait than walking on the ground and that various body weight support systems and harnesses have an impact on treadmill.

Aims: This study aims to investigate the effectiveness of an un-weighing harness combined with treadmill training in improving gait speed and functional independence in patients who have undergone lumbar decompression and fixation surgery (L2-S1).

Objectives:

- The objectives of the study are:

- To assess the change in Gait speed from Day 1 to Day 10 of rehabilitation using BWSTT.
 - To evaluate improvement in Functional Independence Measure (FIM) scores over the
 - Same period.
 - To determine the feasibility and tolerance of early gait training using an un-weighting
 - harness in post-lumbar surgery patients
3. severe cardiovascular and pulmonary disease, osteoporotic or peripheral nerve injury
 4. Contraindication to weight bearing on lower extremities (pelvic or leg fracture, history of recurrent fracture, chronic joint pain)
 5. Pressure sore stage 2 or higher, located where a harness or treadmill training or standing could affect healing
 6. Patients with a history of psychiatric or psychological disorders
 7. Unlikely to complete the intervention or return for follow

MATERIAL AND METHODS

It is a Pre-Post Study. All research on human subjects was conducted with authorisation at The Northern Railway Central Hospital, and at the Department of Physiotherapy. Written informed consent was given by each participant.

Instrumentation: un-weighting harness with treadmill

Inclusion criteria:

1. age between 35-75 years old
2. had decompression and fixation surgical procedure at (L2-S1) level
3. unable to ambulate over ground at randomisation without at least moderate assistance
4. medically stable and permitted to take part (i.e., each spinal surgeon was contacted to obtain consent for this study)

Exclusion Criteria:

1. Symptomatic orthostatic hypotension or >30-mm Hg drop when upright in the BWS apparatus
2. the presence of unhealed decubitus, existing infection

Recruitment and Randomisation: Following surgery, patients were referred to Physiotherapy department at the Northern Railway Central Hospital and subsequently recruited. A total of 10 patients agreed to participate in the study and provided informed written consent. The study was approved by the ethical and research committee of the Northern Railway Central Hospital.

Procedure: Following surgery, an exercise regimen was initiated the next day, and on the third/fourth day, gait training began.

The conventional inpatient and outpatient rehabilitation therapies for mobility and self-care skills were administered to all individuals, and the main component of their mobility training was 10 days of Treadmill with Un-weighting harness.

For Treadmill with Un-weighting harness, subjects wore a parachute type harness, adjusted to be tight across the lower pelvis. Training on the treadmill was scheduled for 10 minutes per day for 10 days after 20 minutes of exercise. After being secured with the harness, the individual stood on the

treadmill while support was applied. The therapist began the treadmill and assisted the patient with verbal cues and manual help. The subject was permitted to sit and rest after walking until he complained of being tired, after which he was assisted in walking further. The therapists kept track of the time spent walking each session, the assistance given, the treadmill speed, and the support required.

Based on research investigations conducted especially for lumbar decompression and fixation procedures, an exercise regimen was designed. Exercises focussing on (i) isometric muscle activation, (ii) range of motion, (iii) neurodynamics, and (iv) movement control were the key themes.

Outcome Measures: Outcome was measured by a blinded, independent assessor at baseline and after 10 training days. Gait speed was the primary outcome, and functional independence was the secondary. Gait speed was assessed using the 10-meter walk test and Functional independence was assessed using the FIM. 10-meter walk test is used which is a sensitive and trustworthy walking capacity assessment

tool. When combined with the maximum and preferred speeds, it offers more details regarding the recovery of walking ability¹⁵⁻¹⁸.

Research indicates that both intermediate and long-term outcomes are linked to higher FIM values recorded at the time of rehabilitation discharge. Short-term, a higher FIM score is linked to a higher likelihood of residing in the community as opposed to an institution. In the long run, a higher FIM at rehabilitation discharge is linked to better function at follow-

up (i.e., higher FIM scores at follow-up), longer survival, less care burden (i.e., fewer hospitalisations, institutionalisations, and hours of both paid and unpaid help), and a higher likelihood of having paid employment¹⁹.

Data Analysis: The standard deviations and group mean for the descriptive data were computed. We used Paired T- Test to assess the differences between the groups' pre-test and post-test gait speed and functional independence values. A 95% confidence interval threshold of 0.05 for alpha was deemed significant. Every analysis was performed using IBM SPSS software (ver. 30.0).

RESULT

The patients after surgery and proper assessment were checked to fulfil the inclusion criteria of the research. The patients in the study underwent gait training using Un-weighting harness with treadmill. All of the patients were given a standard exercise protocol to be followed. The study duration was 10 days, with treatment sessions conducted every day.

The data collected was statistically analysed using IBM SPSS software (ver. 30.0). Change scores for gait speed and functional independence were calculated by subtracting post-treatment values from pre-treatment values. Descriptive statistics were used to summarise the data, and appropriate statistical tests were applied based on the distribution of the data. Paired t-tests were used for within group comparisons.

The following were the results of these analyses: T-Test

Paired Sample T-Test

For both outcome measures, pre- and post-test data were compared using paired sample t-test. Table 1 provides a summary of the findings.

Paired Samples Test

| | | Paired Differences | | | 95% Confidence Interval of the Difference |
|--------|---|--------------------|----------------|-----------------|---|
| | | Mean | Std. Deviation | Std. Error Mean | Lower |
| Pair 1 | Gait Speed -Pre test - Gait Speed-Post test | -.53000 | .17981 | .05686 | -.65863 |
| Pair 2 | FIM-Pre test - FIM-Post test | -26.800 | 12.479 | 3.946 | -35.727 |

Table 1: Paired sample test

| | | Mean | N | Std. Deviation | Std. Error Mean | p |
|--------|----------------------|--------|----|----------------|-----------------|---|
| Pair 1 | Gait Speed-Pre test | .2480 | 10 | .03853 | .01218 | |
| | Gait Speed-Post test | .7780 | 10 | .21447 | .06782 | |
| Pair 2 | FIM-Pre test | 92.00 | 10 | 17.963 | 5.680 | |
| | FIM-Post test | 118.80 | 10 | 6.596 | 2.086 | |

Table 2: Paired test within Group A and B

| | Upper | t | df | p | p |
|---|---------|--------|----|-------|-------|
| Pair 1 Gait Speed-Pre test - Gait Speed-Post test | -.40137 | -9.321 | 9 | <.001 | <.001 |
| Pair 2 FIM-Pre test - FIM-Post test | -17.873 | -6.791 | 9 | <.001 | <.001 |

Table 3: Paired test between two Groups, 95% Confidence Interval of the Difference, One-Sided Two-Sided

These results imply a significant and statistically significant improvement in functional independence and gait speed following the intervention.

DISCUSSION

After spinal surgery, successful postoperative rehabilitation is thought to be crucial for assisting patients in regaining their usual function and reaching their recuperation objectives²⁴⁻²⁷. Furthermore, despite the fact that physical exercise is crucial for lowering the

long-term risk of various lifestyle co-morbid disorders like obesity, diabetes, and cardiovascular disease, it has been found that physical activity levels stay low after lumbar spine surgery²⁰⁻²³.

In several post-surgical populations, there is evidence that walking more and earlier

enhances functional success and reduces the incidence of post-operative complications. Consequently, it is increased walking immediately following lumbar spine surgery most likely yields equally improved outcomes.

In this study, a total of 10 patients who underwent Lumbar decompression and fixation surgery (L2-S1) were recruited. Patients received Un-weighting harness with treadmill training for gait training combined with a well-designed exercise protocol after lumbar surgery. The treatment was administered for a duration of 10 days (excluding Sundays), ensuring consistency in the intervention provided to patients. The primary outcome measures were to assess Gait Speed by using 10MWT and FIM Scores. These measurements were recorded before and after the intervention period for all the patients to evaluate the impact of the treatments.

The current study showed that patients recovering from lumbar decompression and fixation surgery showed significant gains in both gait speed and functional independence after a 10-day intervention that included treadmill training with an un-weighting harness. The substantial effect sizes found suggest that, despite its brief duration, the intervention had a strong influence on patients' functional results. The notable improvement in gait speed is indicative of improved mobility and self-assurance in walking, which are sometimes hindered after surgery because of discomfort, weakness, or movement anxiety. The improvement in FIM scores lends credibility to the idea that towards the end of the training, patients found it simpler and more controllable to do functional tasks and daily living activities. By lowering the strain on the spine and promoting early mobilisation, the use of body-weight support during treadmill training

probably assisted patients in safely retraining their walking mechanics.

Gait Speed and Functional Gains:

An important measure of locomotor recovery and functional mobility, gait speed increased statistically significantly after the intervention. This aligns with earlier research that highlights the benefits of aided treadmill training for walking endurance and efficiency in individuals with neurological impairments. In research by Protas et al. (2001), after 12 weeks of aided treadmill ambulation training, individuals with partial spinal cord injuries showed notable gains in gait speed and endurance. The potential advantages of early intervention were highlighted by the gains that were still noticeable despite the reduced research period. Wilson et al.⁵ (2000) corroborated our findings that even brief training produces quantifiable functional benefits by reporting increased gait speed and decreased energy expenditure after treadmill-based rehabilitation. Additionally, Field-Fote (2001) noted that walking ability improved more when BWSTT and FES were combined than when BWSTT was used alone. According to this synergy, adding FES to BWSTT treatments may improve rehabilitation results and provide a more reliable method of regaining locomotor function³².

Functional Independence and Quality of Life:

The Functional Independence Measure (FIM) showed significant improvements in patients' capacity to carry out everyday tasks. Increases in FIM scores were consistent with the body of research showing that BWSTT improves performance in everyday living tasks in addition to facilitating locomotor recovery. According to Hicks et al.²⁵ (2005), individuals with chronic SCI who received BWSTT for a

year reported feeling more satisfied with their lives and physical function, with improvements lasting for up to eight months after the intervention.

Even though the current study was brief and focused on patients recovering from lumbar surgery rather than SCI, the similarity in improved outcomes indicates that weight-supported training is a useful mechanism for lowering physical burden, promoting patient autonomy, and encouraging early mobilisation.

Physiological and Psychological Impacts of BWSTT:

BWSTT has been linked to increases in psychological well-being and cardio metabolic health in addition to functional metrics. In the SCI population, Hicks and Martin Ginis¹⁰(2008) examined the beneficial effects of upright locomotor training, like BWSTT, on cardiovascular health, muscle mass, insulin sensitivity, and health-related quality of life. Our lumbar postsurgical patients who experience mobility constraints after surgery may benefit psychologically from "seeing oneself walk again," as mentioned in their study. In addition to improving longterm recovery and lowering the risk of post-surgical problems including depression and deconditioning, these favourable emotional effects may also increase therapy adherence and serve as a motivating factor. In a pilot study, Effing et al¹⁸. (2006) assessed how BWSTT affected the functional health status and quality of life of people with chronic incomplete SCI. The results showed that participants' psychological health and physical function both improved. According to these findings, BWSTT has a comprehensive benefit that improves mental health, physical healing, and general quality of life. According to

research by Faure et al. (2011), protein kinase C activation caused by tumour necrosis factor-alpha (TNF- α) can decrease sodium currents in skeletal muscle, resulting in a decrease in muscle excitability. Given the prevalence of muscular weakness in critical disease polyneuromyopathy, this conclusion is especially pertinent. By encouraging muscle activation and strength, BWSTT may be able to reverse such neuromuscular deficits during recovery.

Role of Unweighing Harness:

The application of the un-weighing harness was pivotal in this study since it allowed patients to participate in gait training early in their rehabilitation process and supported their body weight. Harness use dramatically changes trunk acceleration and stability during treadmill walking, according to Aaslund and Moe-Nilssen⁴(2008). This suggests mechanical and neuromuscular adjustments that may help patients with spinal compromise move more safely and effectively. In a randomised study, Dobkin et al.⁶(2006) examined the effects of over ground mobility treatment and body weight-supported treadmill training (BWSTT) on patients with acute incomplete spinal cord injury (SCI). The results of the study showed no discernible changes in walking outcomes between the two therapies, indicating that both approaches may be useful for enhancing post-injury mobility. Based on patient preferences, available resources, and particular treatment objectives, this finding suggests that the decision between BWSTT and over ground training can be customised but another study by Field-Fote and Roach¹⁹(2011) concluded that, BWSTT should be incorporated into long-term rehabilitation plans for long-term functional improvement. This is consistent with our results, which showed that patients

increased their confidence and postural control over the course of ten days while tolerating treadmill training without experiencing any negative side effects. Body weight-supported treadmill training (BWSTT) and body weight-supported over ground training was also compared in a pilot randomised experiment by Senthilvel kumar et al¹³. (2015) for people with partial tetraplegia. According to the study, BWSTT significantly increased walking distance and speed, indicating that treadmill-based therapies may be more beneficial for gait rehabilitation than over ground techniques.

In 2008, Lee and Hidler examined the differences in kinematic and temporal gait variables between walking on a treadmill and on the ground in healthy people. The study discovered significant variations in muscle activation patterns and joint kinematics, indicating that walking on a treadmill might not accurately mimic over ground locomotion. When evaluating the applicability of treadmill-based rehabilitation results to actual walking situations, this distinction is crucial. Also the fact that over ground gait training is inexpensive and doesn't require expensive treadmills is another factor contributing to its popularity. This is an extremely important consideration for low- and middle-income countries²⁶⁻²⁸. However, we cannot rule out the potential psychological benefits of exercise that involves upright walking for individuals who use wheelchairs. Therefore, before dismissing body weight assisted treadmill training as an expensive, but perhaps inadequate, alternative to conventional rehabilitation, we must consider the potential effects on a variety of health-related outcomes^{10, 25}.

Clinical relevance of the study:

This study highlights the clinical effectiveness of Un-weighting harness with treadmill training with exercises after Lumbar decompression and fixation surgery showing increased gait and speed and improved functional independence score. The findings support a gait training treatment approach, where un-weighting bodyweight on treadmill during walking enhances speed and functional autonomy³⁰⁻³².

For physiotherapists and healthcare providers, these results emphasize the importance of body weight supported gait training with therapeutic exercises for optimal walking speed and functional improvements. The study reinforces evidence-based physiotherapy practices, reducing disability and functional limitations and promoting long-term musculoskeletal health. These results provide credibility to the inclusion of un-weighting harness with treadmill systems in early rehabilitation regimens for individuals who have had spinal surgery since they provide a secure and efficient way to hasten functional recovery. Future research with larger sample sizes and longer follow-up periods can further validate the sustained benefits of Un-weighting harness with treadmill^{33, 34}.

Limitations of the study:

There are several constraints in this study that need to be acknowledged. The findings limited generalisability due to the small sample size of only 10 participants might yield more trustworthy results from a bigger study group. Furthermore, since the study only examined immediate post-treatment results without follow-up, the 10-day treatment period might not be enough to evaluate long-term impacts. Variability in patient characteristics, such as pain chronicity, occupation, and posture, was not extensively analysed, which could influence individual treatment responses, also lack of a

control group makes it difficult to attribute changes solely to the intervention.

Scope for future research:

This study aims to evaluate the effectiveness of Un-weighing harness with treadmill training combined with exercises in patients with Lumbar decompression and fixation surgery. It explores the impact of this gait training on walking speed and functional independence, providing valuable insights into the role of physiotherapy rehabilitation after a successful surgery.

But the study was constrained by its brief intervention duration and small sample size. There was no follow-up to ascertain whether the advantages would be maintained over time. Future studies need to investigate:

Efficacy in comparison is to alternative rehabilitation techniques. Long-term has psychological and functional results. Long-term has patient adherence and cost-effectiveness.

CONCLUSION

With a focus on two crucial rehabilitation outcomes, gait speed and functional independence, the current study sought to assess the impact of un-weighing harness combined with treadmill training on patients after lumbar decompression and fixation surgery. Both measures showed notable improvements following a 10-day, controlled intervention that included body-weight support gait training along-with exercises. These results demonstrate the beneficial effects of early, assisted mobilisation in spinal rehabilitation following surgery.. The improvement in gait speed and functional independence seen in a comparatively brief period of time highlights how this strategy may

hasten healing and enhance quality of life for patients recuperating after lumbar spine surgery.

The results of this study are supported by an expanding corpus of research showing that bodyweight-supported treadmill training (BWSTT) is beneficial for a variety of neurological and musculoskeletal disorders. This technique has been related to improvements in psychological well-being, confidence, locomotor function, and even cardiovascular health. Crucially, when administered under proper supervision and with the assistance of a therapist, the technique is both practicable and well-tolerated in clinical settings.

The protocol emphasises early mobilization and functional autonomy, aiming to enhance patients' work efficiency and minimise the number of lost workdays. Although the results of this study are positive, there are several limitations. The findings' long-term relevance and generalisability are restricted by the small sample size and brief duration. Comparative study against established rehabilitation techniques is not possible due to the lack of a control group. In order to assess the sustainability of functional benefits, future studies should overcome these limitations by conducting longer follow-up periods and bigger, randomised controlled trials.

Nevertheless, the findings of this research provide compelling initial support for the inclusion of treadmill training based on un-weighing harnesses in the early post-operative rehabilitation of patients who have had lumbar decompression and fixation. Its use can lower the risk of postoperative problems, encourage independence, facilitate early mobilisation, and possibly shorten hospital stays.

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