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# Backward Walking Training on an Anti-Gravity Treadmill System Combined with Conventional Lumbodorsal Core Training for Non-Specific Low Back Pain: A Post-Print

**Authors:** Tu Jinkang, Li Fangfang, Xiaoqiong Wu, Xi Chong, Qi Shaohua, Jun Chen, Chen Jun

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## Abstract

**Background** In recent years, the incidence of non-specific low back pain has been increasing. Conventional treatments yield short-lasting effects with symptoms prone to rebound, causing substantial physical and psychological impact on patients.

**Objective** To investigate the efficacy of backward walking training on an anti-gravity treadmill system combined with conventional lumbar core training for non-specific low back pain.

**Methods** Forty patients with non-specific low back pain who presented to the Department of Rehabilitation, Zhongshan Hospital Affiliated to Fudan University between July and December 2022 were randomly assigned to an experimental group (n=20) or a control group (n=20) using the random number table method. The control group received conventional lumbar core training, while the experimental group received additional backward walking training using an anti-gravity treadmill system. The Oswestry Disability Index (ODI), Visual Analogue Scale (VAS), and Back Pain Behavior Scale (BPS) scores were evaluated in both groups before treatment and after 4 weeks of intervention.

**Results** No statistically significant differences in ODI, VAS, or BPS scores were observed between the two groups before treatment ($P>0.05$). After 4 weeks of treatment, ODI, VAS, and BPS scores decreased in both groups compared with baseline, with significantly lower scores in the experimental group than in the control group ($P<0.05$). The between-group comparisons of pre-post treatment differences for all scores were statistically significant ($P<0.05$).

**Conclusion** Backward walking training using an anti-gravity treadmill system

effectively improves pain levels and overall lumbar condition in patients with non-specific low back pain, warranting clinical promotion.

## Full Text

# Effectiveness of Backward Walking Based on Anti-Gravity Treadmill Training System Combined with Conventional Low Back Core Training on Patients with Non-Specific Low Back Pain

**TU Jin-kang[1], LI Fang-fang[2], WU Xiao-qiong[1], XI Chong[1], QI Shao-hua[1], CHEN Jun[1]***

[1]Rehabilitation Medicine Center, Zhongshan Hospital, Fudan University, Shanghai 200032, China
[2]VIP Ward, Tongji University Yangzhi Rehabilitation Hospital, Shanghai 201613, China
*Corresponding author: CHEN Jun, Associate Chief Rehabilitation Therapist; E-mail: chen.jun2@zs-hospital.sh.cn

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### Abstract

**Background**
In recent years, the incidence of non-specific low back pain (NLBP) has been increasing. Conventional treatments offer only short-term relief with frequent symptom rebound, causing significant physical and psychological burden on patients.

**Objective**
To investigate the effectiveness of backward walking training based on an anti-gravity treadmill system combined with conventional low back core training for patients with NLBP.

**Methods**
Forty patients with NLBP who visited the Rehabilitation Department of Zhongshan Hospital, Fudan University between July and December 2022 were randomly divided into an experimental group (n=20) and a control group (n=20) using a random number table method. The control group received conventional low back core training, while the experimental group received additional backward walking training on an anti-gravity treadmill system. The Oswestry Disability Index (ODI), Visual Analogue Scale (VAS), and Back Pain Classification Scale (BPS) were assessed before treatment and after 4 weeks of intervention.

**Results**
There were no significant differences in ODI, VAS, or BPS scores between the two groups at baseline ($P>0.05$). After 4 weeks of treatment, both groups

showed decreased ODI, VAS, and BPS scores compared to baseline, with the experimental group demonstrating significantly lower scores than the control group ($P<0.05$). The between-group differences in score changes were also statistically significant ($P<0.05$).

**Conclusion**

Backward walking training using an anti-gravity treadmill system effectively improves pain levels and overall lumbar status in patients with NLBP, warranting clinical promotion.

**Keywords**

Low back pain; Non-specific lumbago; Waist and back core training; Anti-gravity treadmill; Backward walking

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## Introduction

Non-specific low back pain (NLBP) refers to persistent lumbosacral pain and weakness, with or without lower limb radiation, that excludes known diseases or pathological changes [1-2]. Epidemiological studies show that 50-80% of adults experience low back pain during their lifetime, with NLBP accounting for approximately 90% of cases [3-4], significantly impacting patients' functional activities, physical and mental health, and quality of life [5]. The condition is characterized by long duration, frequent recurrence, and progressive aggravation, making it a challenging problem in rehabilitation [6]. Current common treatments include preventive therapy, acupuncture and massage, exercise therapy, physical modalities, and minimally invasive interventions [1]. While most patients experience symptom improvement after treatment, the recurrence rate within one year remains as high as 70% due to incomplete recovery of core functions such as abdominal and lumbar muscle strength, endurance, and proprioception [7].

NLBP primarily manifests as pain and discomfort in the region above the gluteal crease, below the costal margin, and between the bilateral mid-axillary lines [12]. Although diverse treatment approaches exist, high-quality evidence supporting the superiority of any single method is lacking, creating challenges for clinical practice. Evidence suggests that lumbar pain can reflexively inhibit deep core muscle function, compromising lumbar protection and leading to disuse atrophy of core muscles over time, manifested as lumbar soreness, weakness, and poor coordination, ultimately resulting in lumbar instability [13]. Core stability training aims to enhance the motor control capacity of core muscles surrounding the spine during low-load isometric contractions, activating and strengthening core muscle coordination and balance while enhancing lumbar stability to allevi-

ate pain symptoms [13]. WASEEM et al. [14] demonstrated that core stability training is more effective than conventional rehabilitation for improving lumbar stability, core muscle motor control, and pain relief. Studies by LI Zu-hong et al. [15-17] confirmed that core stability training promotes proprioceptive input, activates deep muscle groups, strengthens active and neural control subsystems for lumbar stability, and reduces inflammatory factor secretion to alleviate pain.

Backward walking, widely used as a core strengthening method among athletes, has been proven to effectively improve aerobic endurance, anaerobic capacity, spinal stability, and motor control [18-19]. Unlike simple lumbar muscle contraction, backward walking increases energy utilization compared to forward walking and promotes activation of the motor cortex and skeletal muscles [20-21], with neural regulation enhancing motor unit recruitment capacity and providing greater stimulation to the lumbar region. SUN-HO KIM et al. [22] reported that backward walking training strengthens lumbosacral muscle and ligament strength, reduces lumbar tension, and increases lumbar stability. DUFEK [23] demonstrated that backward walking training effectively reduces lumbosacral pain and increases lumbar mobility, thereby improving quality of life.

The anti-gravity treadmill system, consisting of a pneumatic pressure system and treadmill, is a body weight-supported walking training device that reduces metabolic demand and musculoskeletal load during use [24]. In recent years, it has gained favor among rehabilitation therapists for its significant auxiliary effects in stroke, spinal cord injury, and hip/knee/ankle joint injuries. This study innovatively applied the backward walking mode of the anti-gravity treadmill system to NLBP patients and achieved significant therapeutic effects. Compared with conventional backward walking, anti-gravity treadmill backward walking offers several advantages: (1) walking speed and duration can be set according to patient condition for easy quantification; (2) visual feedback via front-screen monitors helps patients correct abnormal gait patterns and lumbar muscle movement patterns; (3) the air pressure weight-offloading environment effectively reduces lumbosacral muscle tension and pain discomfort during walking; and (4) the airbag enclosure around the waist prevents falls, making patients feel safer during backward walking—particularly beneficial for elderly patients by helping them overcome fear and increase security.

## Methods

**Study Design and Participants** This prospective study enrolled 40 patients with NLBP who visited the Rehabilitation Department of Zhongshan Hospital, Fudan University between July and December 2022. Patients were randomly divided into an experimental group (n=20) and a control group (n=20) using a random number table method. The control group comprised 9 males and 11 females, aged 25-68 years with a mean age of (37.3$±14.8)years.Theexperimentalgroupcomprised7malesand13females,aged24−70yearswithameanageof(40.0±14.5)years.Nostatisticallysignificantdifferenceswerefoundbetweengroupsi P=0.519) or age (t=0.583, P=0.563). This study was approved by the Ethics

Committee of Zhongshan Hospital, Fudan University (B2022-344R).

**Inclusion Criteria**

(1) Age 24-70 years; (2) Met the North American Spine Society (NASS) evidence-based guidelines for NLBP [8]: lumbosacral pain symptoms for $ $3 months, aggravated by activity; negative straight leg raise and 加强试验; pain originating from somatic referred or non-radicular sources (above the knee); (3) VAS score $ $3; (4) Voluntary participation in the study.

**Exclusion Criteria**

(1) Specific low back pain (tumor, infection, metabolic disease, rheumatoid arthritis, fracture); (2) History of lumbar surgery; (3) Spinal deformity (spondylolisthesis, spondylolysis, or scoliosis); (4) Pain below the knee; (5) Extraspinal diseases (e.g., vascular, urogenital system diseases); (6) Low back pain with pain in two or more other regions; (7) Pregnancy; (8) Cognitive dysfunction preventing completion of assessments.

**Dropout Criteria**

(1) Receiving other treatments during the study period; (2) Unauthorized withdrawal; (3) Refusal to cooperate with data collection; (4) Treatment interruption due to lumbar injury during the study.

**Interventions** The control group received conventional rehabilitation including massage, neuromuscular electrical stimulation, infrared therapy, and bridge exercises: (1) **Massage and acupressure**: Elbow rolling and palm kneading techniques applied to the lumbosacral region, with thumb pressure on Shenshu, Yaoyangguan, Weizhong, and Chengshan acupoints to patient tolerance, 15 min/session; (2) **Neuromuscular electrical stimulation**: Using an HL-0817B neuromuscular electrical stimulation device (Huali Medical) applied to painful areas with "analgesic and anti-inflammatory" protocol, intensity to patient tolerance, 20 min/session; (3) **Infrared therapy**: Using a 350-type infrared therapy device (Chongqing Xinfeng Medical Equipment Co., Ltd., serial number: 1801009087) on the lumbosacral and gluteal regions at "P-03" setting, with burn prevention measures, 20 min/session; (4) **Bridge exercises**: Including double-leg bridge, single-leg bridge, and ball bridge components. For double-leg bridge, patients lay supine with arms at sides, knees flexed at 90°, feet flat on bed, pelvis lifted to align trunk, pelvis, and thighs. Single-leg bridge involved extending one knee while lifting off the bed, maintaining trunk-thigh alignment with alternating legs. Ball bridge involved placing heels on a yoga ball while lifting the pelvis, maintaining alignment while keeping the ball stable. All exercises were performed for 30 seconds each, 6 repetitions per set, 6-8 sets/day based on individual capacity. Except for bridge exercises, other treatments were administered 2 sessions/week for 4 consecutive weeks.

The experimental group received additional backward walking training on an anti-gravity treadmill based on the control group's regimen. Patients wore appropriate specialized shorts and stood on the AlterG M320 anti-gravity treadmill. Therapists progressively reduced body weight support and adjusted backward walking speed according to patients' physical condition and tolerance. Throughout the process, therapists closely monitored for discomfort, immediately stopping training if patients experienced chest tightness, dizziness, or fatigue and monitoring their subsequent status. Backward walking duration started at 10 minutes and gradually increased to 20 minutes based on patient condition, administered 2 sessions/week for 4 consecutive weeks.

**Outcome Measures** **1.6.1 Oswestry Disability Index (ODI)** [**9-10**]: Assessed before and after treatment to evaluate lumbar function. The index includes 10 items covering pain intensity, self-care ability, walking, standing, and lifting, with each item scored 0-5 (0=no pain, 5=severe pain and functional loss). Maximum score is 50, with lower scores indicating better lumbar function.

**1.6.2 Visual Analogue Scale (VAS)**: Assessed before and after treatment to evaluate low back pain. Scores range from 0 (no pain) to 10 (unbearable pain), with patients self-rating their pain intensity.

**1.6.3 Back Pain Classification Scale (BPS)** [**11**]: Assessed before and after treatment to evaluate low back pain. The scale includes five components: sock-wearing test, object-picking test, body curl test, finger-to-floor test, and lifting test, with each item scored 0-3 (0=complete ability, 3=complete inability).

**Statistical Analysis** SPSS 24.0 software was used for statistical analysis. Gender comparison between groups used the $^{2}$ test. Age and outcome indicators were expressed as M(P25, P75) and analyzed using non-parametric tests. The significance level was set at $\alpha$=0.05.

## Results

**2.1 Comparison of ODI, VAS, and BPS Scores** No significant differences in ODI, VAS, or BPS scores were found between groups at baseline (P>0.05). After 4 weeks of treatment, the experimental group showed significantly lower scores than the control group (P<0.05) . Both groups demonstrated improvement in ODI, VAS, and BPS scores post-intervention, with statistically significant differences in score changes between groups (P<0.05) .

**Table 1** Comparison of ODI, VAS, and BPS Scores Before and After Treatment Between Groups ($\bar{x}\pm s$, points)

| Group | ODI Score | VAS Score | BPS Score |
|---|---|---|---|
| Control (n=20) | 8.0 (5.0, 11.8) | 4.0 (2.3, 6.8) | 5.0 (3.0, 6.0) |
| Experimental (n=20) | 2.0 (1.0, 3.0) | 4.5 (2.0, 8.0) | 3.0 (1.0, 5.8) |

| Group | ODI Score | VAS Score | BPS Score |
|---|---|---|---|
| P-value | <0.001 | <0.001 | <0.001 |

Note: ODI=Oswestry Disability Index, VAS=Visual Analogue Scale, BPS=Back Pain Classification Scale; a indicates P<0.05 compared to control group.

**Table 2** Comparison of Score Changes Before and After Treatment Between Groups ($\bar{x}\pm s$, points)

| Group | n | ODI Change | VAS Change | BPS Change |
|---|---|---|---|---|
| Control | 20 | -4.0 (-5.0, -2.0) | -2.0 (-3.0, -1.0) | -2.0 (-2.0, -1.0) |
| Experimental | 20 | -7.0 (-13.8, -4.0) | -4.0 (-5.0, -2.0) | -4.0 (-6.8, -2.0) |
| P-value | | <0.001 | <0.001 | <0.001 |

## Discussion

This study demonstrated that both conventional lumbar core training and backward walking training can improve pain levels and lumbar behavioral status in NLBP patients, with backward walking showing significantly superior rehabilitation efficacy. Several mechanisms may explain these findings. NLBP primarily manifests as pain and discomfort in the region above the gluteal crease, below the costal margin, and between bilateral mid-axillary lines [12]. While various treatment approaches exist, high-quality evidence supporting superior effectiveness of any single method remains limited, creating clinical challenges. Evidence indicates that lumbar pain reflexively inhibits deep core muscle function, compromising lumbar protection and leading to disuse atrophy, weakness, and poor coordination, ultimately causing lumbar instability [13]. Core stability training enhances motor control of core muscles during low-load isometric contractions, activating and strengthening coordination and balance while improving lumbar stability to alleviate symptoms [13]. WASEEM et al. [14] confirmed that core stability training more effectively improves lumbar stability, motor control, and pain relief compared to conventional rehabilitation. Studies by LI Zu-hong et al. [15-17] demonstrated that core stability training promotes proprioceptive input, activates deep muscles, strengthens active and neural control subsystems, and reduces inflammatory factors to alleviate pain.

Backward walking, widely utilized among athletes for preventing low back pain, effectively improves aerobic endurance, anaerobic capacity, spinal stability, and motor control [18-19]. Unlike simple lumbar muscle contraction, backward walking increases energy expenditure compared to forward walking and promotes motor cortex and skeletal muscle activation [20-21], with neural regulation enhancing motor unit recruitment and providing greater lumbar stimulation. SUN-HO KIM et al. [22] found that backward walking strengthens lumbosacral muscles

and ligaments, reduces lumbar tension, and increases stability. DUFEK [23] demonstrated that backward walking effectively reduces lumbosacral pain and increases lumbar mobility, thereby improving quality of life.

The anti-gravity treadmill system, comprising pneumatic and treadmill components, reduces metabolic demand and musculoskeletal loading during body weight-supported walking training [24]. Its significant benefits in stroke, spinal cord injury, and lower extremity injuries have made it increasingly popular among rehabilitation therapists. This study's innovative application of anti-gravity treadmill backward walking to NLBP patients yielded significant therapeutic effects. Compared with conventional backward walking, this approach offers distinct advantages: (1) speed and duration can be precisely set and quantified according to patient condition; (2) front-screen visual feedback helps correct abnormal gait and lumbar muscle movement patterns; (3) the weight-offloading environment reduces lumbosacral muscle tension and pain during walking; and (4) the waist-enclosing airbag prevents falls, increasing patient security—particularly beneficial for elderly patients by reducing fear.

This study has several limitations, including a small sample size, single-center recruitment, lack of follow-up, and no comparison of different weight-offloading percentages. These aspects will be addressed in future research.

In conclusion, backward walking training using an anti-gravity treadmill system combined with conventional lumbar core training effectively improves pain and functional status in NLBP patients and warrants clinical promotion.

### Author Contributions

TU Jin-kang, LI Fang-fang, QI Shao-hua, and CHEN Jun conceptualized the study and designed the research protocol. XI Chong, WU Xiao-qiong, and TU Jin-kang implemented the research procedures. TU Jin-kang and LI Fang-fang performed data collation and statistical analysis. TU Jin-kang drafted the manuscript and revised the final version. CHEN Jun is responsible for the overall manuscript.

### Conflict of Interest Statement

The authors declare no conflicts of interest.

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