INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY

RESEARCH ARTICLE

OPEN ACCESS

Received: 30-10-2024

Accepted: 14-11-2024

Published: 18-12-2024

Citation: Kanote R, Sen S, Chawla K (2024) Effects of Spinal De-loading Exercise Program on Spinal Muscle Endurance, Working Posture, and Musculoskeletal Discomfort among University Bus Drivers. Indian Journal of Science and Technology 17(46): 4854-4860. https://doi.org/10.17485/IJST/v17i46.3562

* **Corresponding author**.

neerukanote1234@gmail.com

Funding: None

Competing Interests: None

Published By Indian Society for Education and Environment (iSee)

ISSN
Print: 0974-6846
Electronic: 0974-5645

Effects of Spinal De-loading Exercise Program on Spinal Muscle Endurance, Working Posture, and Musculoskeletal Discomfort among University Bus Drivers

Ravia Kanote[1]*, Siddhartha Sen[2], Karishma Chawla[3]

1 Post Graduation Student (MPT Orthopedics),, Shree Guru Gobind Singh Tricentenary University, Gurugram, Haryana, India
2 Professor, Faculty of Physiotherapy, Shree Guru Gobind Singh Tricentenary University, Gurugram, Haryana, India
3 Assistant Professor, Faculty of Physiotherapy, Shree Guru Gobind Singh Tricentenary University, Gurugram, Haryana, India

Abstract

Objectives: Professional drivers have a significant prevalence of musculoskeletal issues such as LBP as a result of extended sitting and vibration exposure. The purpose of this study was to evaluate the effects of a spinal de-loading exercise program on spinal muscle endurance, working posture, and musculoskeletal discomfort among university bus drivers. **Methods:** 52 subjects who fulfilled the selection criteria were taken and divided into two groups. The experimental group (Group A, n=26) received a spinal de-loading exercise program and the control group (Group B, n=26) received conventional physiotherapy exercises. Each group participated in the intervention thrice a week for six weeks. **Findings:** Statistical analysis showed significant improvement in both the groups, however more so in the experimental group. Comparing Group A to Group B, notable gains were seen. Group A experienced a 45.8% decrease in discomfort, a 56% decrease in pain, and a 42.4% improvement in working posture. In Group A, the transverse abdominis and multifidus muscles' endurance improved by 58.5% and 42.8%, respectively. Compared to Group B, these improvements were noticeably better. **Novelty:** This is the first study to design and assess an exercise program for university bus drivers that explicitly targets spinal de-loading. Compared to traditional physiotherapy exercises, the program substantially improved working posture, spinal muscular endurance, and the reduction of musculoskeletal pain and discomfort.

Keywords: Drivers; Pain; Endurance; Posture; Spine; Discomfort; bus driver; back pain; Deloading exercises

1 Introduction

Professional driving, especially bus driving, is an exhausting profession that demands defensive driving techniques, long hours behind the wheel, and strict respect for traffic regulations. It is a very demanding job because of these duties as well as the requirement to protect other road users and passengers[1]. Work-related musculoskeletal diseases (MSDs) are common among drivers due to a number of ergonomic issues, such as extended sitting, bad posture, twisting motions, and vibration exposure from the vehicle-road interface[2]. According to studies, musculoskeletal pain, especially in the lumbar back, neck, shoulders, knees, and wrists, is reported by up to 80% of professional drivers[3].

Extended sitting, whole-body vibration, and ergonomic mismatches between drivers' body measurements and vehicle design are the main risk factors for these disorders. According to research, professional drivers frequently adopt unappealing positions including lateral leaning and slumped seating, which causes blood vessel constriction and static muscle activation, especially in the thighs, buttocks, and spine. Both general musculoskeletal discomfort and low back pain (LBP) are greatly exacerbated by these postures[4,5].

Long-term axial load and vibration on the spine wear down the back muscles and put greater pressure on the intervertebral discs, increasing the risk of severe spinal injury[6]. Maintaining spinal stability requires muscular endurance, particularly in the multifidus and transverse abdominis muscles. A higher frequency of musculoskeletal problems and more strain on passive tissues are linked to lower endurance levels in these muscles[7]. The effectiveness of spinal de-loading exercises created especially for professional drivers has not been thoroughly studied, despite strong evidence in favour of traditional physiotherapy treatments.

Studies on the benefits of spinal de-loading exercise regimens for enhancing drivers' musculoskeletal health are scarce, and there are few focused interventions that address the unique musculoskeletal issues faced by professional drivers. By creating and assessing a spine de-loading exercise program specifically designed for university bus drivers, this study seeks to close these disparities. In order to improve overall driver health and safety, the goal is to increase spinal muscular endurance, improve working posture, and lessen musculoskeletal discomfort.

2 Methodology

2.1 Ethical Approval

The study's proposal was submitted to the ethical review board for approval, and the departmental Ethical Committee of the Faculty of Physiotherapy at SGT University approved it with letter No. SGTU/FPHY/2022/422. A proper consent form was prepared.

2.2 Study design

The study was performed using a pretest-posttest control group design. The study was conducted in the Biomechanics Lab of the Department of Physiotherapy of SGT University, Gurugram. The sample was chosen as per convenience. It is a sampling technique in which subjects are selected because of their convenient accessibility and proximity to the researcher. Written consent was taken from all the participants. The participants were selected on the basis of the inclusion criteria of the study. All the participants were randomly allocated to the experimental and control group with 26 participants in each group. Group A (Experimental Group) received a spinal de-loading exercise program and Group B (Control Group) received conventional physiotherapy exercises.

2.3 Inclusion and Exclusion Criteria

Bus drivers aged between 25-50 years with low back pain (driving at least 4 hours per day), with at least 2 years of driving experience, and having REBA Score 4 to 7 were included in the study from Shree Guru Gobind Singh Tricentenary University Gurugram, Delhi- NCR by using a convenient sampling method. Drivers with any recent spinal surgery done, previous spinal trauma, or spinal deformity, tumor, or cancer were excluded from the study.

2.3.1 Outcome Measures

Participants' spinal muscle endurance with pressure biofeedback, working posture with the REBA scale, musculoskeletal discomfort with the Cornell musculoskeletal discomfort questionnaire, and pain with NPRS were measured as described below.

2.3.2 Transverse abdominis endurance testing

For the Transverse Abdominis muscular endurance test, subjects were told to lie in a prone lying, with the navel in the center of the pressure cuff, and the lower edge of the pressure biofeedback's cuff lying just below the anterior superior iliac spines (ASIS). The valve was then closed after inflating the pressure cuff to a pressure of 70 mm Hg. The drawing-in maneuver had to be performed by the subjects while maintaining neutral spine alignment and completely relaxing the abdomen. For up to 10 seconds, the subjects were instructed to try and sustain a pressure drop (drawing in) of 6 to 10 mmHg. This was repeated three times and a 10 seconds break was given between each repetition. An average of three measurements was taken for analysis[7].

2.3.3 Endurance testing of Multifidus

For multifidus muscle endurance testing, the subjects were in the supine position, with their knees flexed. All the subjects were instructed to slowly draw in their lower abdomen as if they were holding their urine and then draw up their pelvic floor muscle so that it could contract, together with their lower abdomen, while continuing normal breathing. The end part of the pressure device was placed under the posterior superior iliac spine (PSIS). The initial pressure for PBU was set at 40 mmHg, and the measurements of the pressure reduction were recorded. Subjects were taught about the test before the actual test. The pressure reduction from 0 to 3 mmHg indicates good and fair muscle control. This was repeated three times and a 10 seconds break was given between each repetition. An average of three measurements was taken for analysis[8].

2.4 Measurement of working posture

REBA Scale was used in order to assess the working posture of the individuals in which scoring was given according to the posture. The subjects were in their working posture when a photograph of them was taken. The position of the neck, legs, trunk, forearm, upper arm, and wrist was evaluated by marking angles on the respective areas of the body using the Corel draw application. The reference point for estimating neck angle was the tragus of the ear, for the trunk the axis was L3/L4, the humeral head was the axis for locating the position of the upper arm whereas the lateral epicondyle was the reference point for the lower arm. REBA assessment sheet was filled with the corresponding values which were obtained based on the position of the body segment. A sum of the scores of groups A and B gave a total score that described the posture and the level of risk[9].

2.5 Measurement of Musculoskeletal Discomfort

Participants were given a brief introduction and were requested to complete the Cornell Musculoskeletal Discomfort Questionnaire independently. Each participant was asked about the clarity and understanding of the questionnaire. Scoring was done from 0 – 5 for each segment and results were calculated. The total discomfort score was interpreted by using the following formula: frequency $\times$ discomfort $\times$ interference = discomfort score[10].

2.6 Measurement of Pain

Participants were given a numeric pain rating scale to rate the pain from 0-10 for back pain. Participants choose an integer value between 0 and 10 that best describes the degree of their pain. The 11-point numerical scale runs from 0 (which represents the least amount of pain, such as ”no pain”) to 10 (which represents the most extreme amount of pain, such as ”severe pain”)[11].

2.7 Intervention Procedure

Group A (Experimental Group) received a spinal de-loading exercise program and Group B (Control Group) received conventional physiotherapy exercises.

In both the groups, baseline measurement of spinal muscle endurance with pressure biofeedback, working posture with REBA scale, musculoskeletal discomfort with Cornell musculoskeletal discomfort questionnaire, and pain with NPRS was done on the 1st day of week one and at the end of the 6th week. Experimental group was getting spinal de-loading exercise program (Overhead Stretch, Prayer Stretch, Dead Bug, Dead Hang, Cat and Camel, Knee to chest, Reclined Twist, Seated Chair Flexion Stretch, Prone Plank Hold, Donkey Kicks, V hold, Russian Twists) and Group B was getting supine lying-Leg lifts, Abdominal crunches in the crook lying position, Prone lying –Leg lifts, Prone lying – Trunk lift.

The intervention session involved 10 minutes of warm-up and 10 minutes cool-down period. The rest of the 15 seconds between each set of exercises and between different exercises 30 seconds was given to the participants. Each session was of about 45 minutes and was given thrice a week.

Table 1. Spinal De-loading exercise program for Group A

Weeks	Exercises			
WEEK 1 & 2	Overhead stretch. 30 sec hold x 3 times	Prayer stretch 30 sec hold x 3 times	Dead bug 12 reps x 2 sets	Dead hang 30 sec hold x 3 times
WEEK 3& 4	Cat and camel 15 reps x 2 sets	Knee to chest 15 reps x 2 sets	Reclined twist 15 reps x 2 sets	Seated Chair flexion Stretch. 30 sec hold x 3 times
WEEK 5 & 6	Prone Plank Hold 30 sec hold x 3 times	Donkey kicks 15 reps x 2 sets	V hold 30 sec hold x 3 times	Russian Twists 15 reps x 2 sets

3 Results and Discussion

The outcomes were assessed at baseline and at the end of the sixth week. Statistical analysis of 52 subjects' discomfort, pain, and working posture was performed using Software IBM SPSS 26 for Windows Version.

Table 2. Demographic comparison between the Groups

Variables	Mean ± SD		Mean ± SD		t value	p-value
	Group A		Group B			
Age (Years)	37.15	4.91	38.03	4.42	0.682	0.498
Weight(kg)	72.30	8.13	73.76	7.64	0.668	0.508
Height(m)	1.688	0.068	1.696	0.058	0.454	0.652
BMI(kg/m^2)	25.28	2.67	25.74	1.98	0.705	0.484
Driving hours	4.65	0.68	4.80	0.80	0.742	0.461
Driving years	11.76	4.43	10.19	3.38	1.441	0.156

The mean value of age, weight, height, BMI, driving hours, and driving years for subjects in Group A and Group B was 37.15 and 38.03, 72.30 and 73.76, 1.688 and 1.696, 25.28 and 25.74, 4.65 and 4.80, 11.76 and 10.19 respectively.

Table 3. Willcoxon Signed Rank Test Within Group – A

Variables	Mean ± SD	Mean ± SD	t value	p-value
	Pre	Post		
EMF	4.14 ± 0.81	5.91 ± 0.79	24.20	0.0001
ETA	3.45 ± 0.71	5.47 ± 0.68	24.35	0.0001

Wilcoxon Signed Rank Test was used to analyze the intra-group differences for Discomfort, Numeric Pain Rating Scale (NPRS), and REBA (Rapid Entire Body Assessment) within Group A and showed significant differences in pre and post with p values 0.0001, 0.0001, 0.0001 respectively.

Table 4. Paired SampleT-test within Group A

Variables	Mean ± SD	Mean ± SD	Z value	p-value
	Pre	Post		
Discomfort	5.07 ± 1.91	2.75 ± 1.33	4.49	0.0001
NPRS	4.00 ± 1.09	1.76 ± 0.86	4.65	0.0001
REBA	5.26 ± 0.96	3.03 ± 0.91	4.56	0.0001

A paired t-test was used to analyze EMF and ETA within Group A and showed significant differences in EMF and ETA with p values 0.0001, and 0.0001 respectively.

Wilcoxon Signed Rank Test was used to analyze the intra-group differences for Discomfort, Numeric Pain Rating Scale (NPRS), and REBA (Rapid Entire Body Assessment) within Group- B and showed significant differences in pre and post with p value 0.011, 0.025, 0.025 respectively.

A paired t-test was used to analyze EMF and ETA within Group B and showed no significant differences in EMF and ETA with p values 0.134, and 0.237 respectively.

Table 5. Wilcoxon Signed Rank test within the Group B

Variables	Mean ± SD Pre	Mean ± SD Post	Z value	p-value
Discomfort	4.13 ± 1.79	3.85 ± 1.74	2.54	0.011
NPRS	3.73 ± 0.96	3.54 ± 1.02	2.23	0.025
REBA	4.76 ± 1.21	4.58± 1.27	2.23	0.025

Table 6. Paired SampleT-test within Group B

Variables		Mean ± SD Group A	Mean ± SD Group B	Z value	p-value
Discomfort	Pre	5.07 ± 1.91	4.13 ± 1.79	1.56	0.119
	Post	2.75 ± 1.33	3.85 ± 1.74	2.40	0.016
NPRS	Pre	4.00 ± 1.09	3.73 ± 0.96	0.91	0.363
	Post	1.76 ± 0.86	3.54 ± 1.02	5.07	0.0001
REBA	Pre	5.26 ± 0.96	4.76 ± 1.21	1.39	0.164
	Post	3.03 ± 0.91	4.58 ± 1.27	4.17	0.0001

Table 7. Mann Whitney U test Between Group A and Group- B

Variables	Mean ± SD Pre	Mean ± SD Post	t value	p-value
EMF	3.90 ± 0.82	3.95 ± 0.82	1.55	0.134
ETA	3.82 ± 0.56	3.87 ± 0.57	1.21	0.237

Mann-Whitney U-Test was used at baseline and the end of the 6th week, to analyze the inter-group differences in the Discomfort, NPRS, and REBA which showed significant differences in pre and post with p values 0.025, 0.002, and 0.030 respectively.

Table 8. Independent t-test between Group A and Group B

Variables		Mean ± SD Group A	Mean ± SD Group B	t value	p-value
EMF	Pre	4.14 ± 0.81	3.90 ± 0.82	1.55	0.134
	Post	5.91 ± 0.80	3.95 ± 0.82	8.65	0.0001
ETA	Pre	3.45 ± 0.72	3.82 ± 0.56	1.21	0.237
	Post	5.47 ± 0.68	3.87 ± 0.57	9.08	0.0001

Independent Sample T-Test was used at baseline and end of the 6th week to analyze and compare the intra-group differences for the variables EMF and ETA. It showed significant differences in EMF and ETA with p value 0.0001, and 0.0001 respectively.

This study sought to determine how a spinal de-loading exercise regimen affected university bus drivers' spinal muscular endurance. The findings showed a noteworthy improvement in the endurance of the multifidus and transverse abdominis muscles as well as a considerable reduction in pain. Following the intervention, there were also notable decreases in musculoskeletal pain and improvements in posture.

The mechanical process of sitting is controlled by a complex interaction between the soft-tissue components and the skeletal system. Sitting increases the stress on the lumbar region by 40–90% [(12)]. Long periods of sitting put more strain on the ligaments and muscles in the spine, which results in constant axial compressive loading. This results in flattening of the lumbar lordosis and deformation of the disc's elastic components [(13)]. These results are in line with earlier research that demonstrated how bad posture and extended sitting worsen musculoskeletal pain and lead to spinal problems [(14)].

Exercise raises intra-abdominal pressure, which creates negative pressure inside the disc and facilitates nutrition exchange and rehydration, according to similar research. As a result, there is less strain on the joints and less compression on the spine, which is associated with less discomfort [(15)]. Group III (A-delta) and IV (C) primary afferents in skeletal muscle are activated by muscle contractions. This can activate the endogenous opioid system and help reduce pain [(10)]. Furthermore, it has been demonstrated that exercises can successfully lessen discomfort in those with generalized low back pain [1].

However, according to certain research, the kind, length, and intensity of the workouts can affect how well they reduce pain and increase muscle endurance. For example, whereas exercise regimens can enhance muscle function, they might not always significantly reduce pain in all groups, according to a study by Macedo et al. (2020) [16]. This emphasizes the necessity of individualized fitness regimens catered to each person's unique requirements and circumstances.

The transverse abdominis and multifidus spinal muscle endurance significantly improved following the spinal de-loading exercise program, according to the study's findings. Exercise increases the skeletal muscles' oxidative capacity and metabolic efficiency, which raises capillary density and mitochondrial biogenesis. This delays the onset of muscle exhaustion during prolonged exercises by assisting the body's ability to distribute and use oxygen to generate energy [13]. Exercise increases endurance, which improves muscular durability against loading, according to studies [12]. Muscle endurance is improved by training-induced skeletal muscle adaptations, which are manifested in an increased capacity of muscle homogenates and the mitochondrial fraction [15].

The results also showed that drivers' working posture significantly improved after completing a spinal de-loading exercise program. Maintaining appropriate form and body alignment is the major goal of the exercises [15]. Frequent exercise improves proprioception, or bodily awareness, which helps people maintain proper posture while going about their daily lives [12]. By increasing muscle endurance and strengthening the back and core muscles, one can better support the spine and maintain normal alignment, which lowers the risk of developing bad posture [10]. According to research, exercise helps people with musculoskeletal discomfort by promoting better posture, balance, and relaxation. Better posture is a result of increased endurance [13].

Additionally, after the intervention, bus drivers reported significantly less discomfort. Exercise improves blood flow and the muscles' and tissues' ability to receive oxygen and nutrients. Muscle relaxation results from increased circulation, which also lessens inflammation, improves tissue repair, and more effectively eliminates waste products [12]. These results are corroborated by a study that found that after six weeks of intervention, there were notable decreases in discomfort and an increase in muscle endurance [17].

4 Conclusion

This study showed that the experimental group of university bus drivers' well-being was considerably enhanced by a spine de-loading exercise program. Group A showed improvements in working posture of 42.4%, pain reduction of 56%, and discomfort reduction of 45.8%. Furthermore, there was an improvement of 42.8% and 58.5% in the endurance of the multifidus and transverse abdominis muscles, respectively. These outcomes were significantly superior to those of Group B. The results demonstrate how well-targeted exercise interventions can improve posture and muscle endurance while lowering pain and discomfort. Professional drivers' health and quality of life can be greatly enhanced through bringing such programs into practice.

Future studies should concentrate on assessing the exercise program's long-term adherence and sustained benefits, assessing the intervention's efficacy in different occupational groups and environments, and examining the physiological processes that underlie the noted increases in pain relief and muscle endurance. By adopting these suggestions into practice, bus drivers' general health and quality of life can be enhanced and musculoskeletal diseases related to their jobs can be considerably decreased.

References

1) Rezaei E, Shahmahmoudi F, Makki F, Salehinejad F, Marzban H, Zangiabadi Z. Musculoskeletal disorders among taxi drivers: a systematic review and meta-analysis. *BMC Musculoskelet Disord*. 2024;25(1):663–663. Available from: https://doi.org/10.1186/s12891-024-07771-w.
2) Nabi MH, Hawlader M, Naz F. Low back pain among professional bus drivers: a cross-sectional study from Bangladesh. *BMC Public Health*. 2023;23:1172–1172. Available from: https://doi.org/10.1186/s12889-023-16018-7.
3) Kumar P, Sakthivel H, Shankar G, S. Prevalence of work-related musculoskeletal disorders among occupational bus drivers of Karnataka, South India. *Work*. 2020;66(1):73–84. Available from: https://doi.org/10.3233/WOR-203152.
4) Chen YL, Alexander H, Hu YM. Self-reported musculoskeletal disorder symptoms among bus drivers in the Taipei metropolitan area. *Int J Environ Res Public Health*. 2022;19(17):10596–10596. Available from: https://doi.org/10.2486/indhealth.mswbvi-02.
5) Lalit, Soni R, Garg S. The prevalence of musculoskeletal disorders among bus drivers in Tricity. *Int J Physiother*. 2015;2:850–854. Available from: https://doi.org/10.15621/ijphy/2015/v2i5/78244.
6) Arippa F, Leban B, Pau M. Postural strategies of bus drivers during a regular work shift in urban area: A pilot study. *Hum Factors Ergon Soc*;2019:779–786. Available from: https://doi.org/10.1177/1071181319631429.
7) Patel GH, Chitte SJ, Bhagat CA, Bhura PA. Correlation between transverse abdominis muscle endurance and body mass index among college students. *J Sci Soc*. 2022;49:125–132. Available from: https://doi.org/10.4103/jss.jss_40_22.
8) Fallahasady E, Rahmanloo N, Seidi F, Rajabi R, Bayattork M. The relationship between core muscle endurance and functional movement screen scores in females with lumbar hyperlordosis: a cross-sectional study. *BMC Sports Sci Med Rehabil*. 2022;14(1):182–182. Available from: https://doi.org/10.1186/

s13102-022-00567-2.

9) Kee D. Systematic comparison of OWAS, RULA, and REBA based on a literature review. *Int J Environ Res Public Health*. 2022;19(1):595–595. Available from: https://doi.org/10.3390/ijerph19010595.
10) Darvishi E, Osmani H, Aghaei A, Moloud EA. Hidden risk factors and the mediating role of sleep in work-related musculoskeletal discomforts. *BMC Musculoskeletal Disorders*. 2024;25(1). Available from: https://doi.org/10.1186/s12891-024-07387-0.
11) Nugent SM, Lovejoy TI, Shull S, Dobscha SK, Morasco BJ. Associations of Pain Numeric Rating Scale Scores Collected during Usual Care with Research Administered Patient Reported Pain Outcomes. *Pain Medicine*. 2021;22(10):2235–2241. Available from: https://doi.org/10.1093/pm/pnab110.
12) Houle M, Tétreau CE, Châtillon C, Marchand AA, Descarreaux M. Effectiveness of a 6-week specific rehabilitation program combining education and exercises on walking capacity in patients with lumbar spinal stenosis with neurogenic claudication: a randomized controlled clinical trial protocol. *Trials*. 2022;23:1046–1046. Available from: https://doi.org/10.1186/s13063-022-07011-3.
13) Özden F, Tümtürk İ, Yuvakgil Z, Sarı Z. The effectiveness of physical exercise in patients with lumbar spinal stenosis: a systematic review. *Sport Sci Health*. 2022;18:1129–1140. Available from: https://doi.org/10.1007/s11332-022-00895-3.
14) Joseph L, Standen M, Paungmali A, Kuisma R, Sitilertpisan P, Pirunsan U. Prevalence of musculoskeletal pain among professional drivers: A systematic review. *J Occup Health*. 2020;62(1):12150–12150. Available from: https://doi.org/10.1002/1348-9585.12150.
15) Percuoco K, Dunaj-Compo M, Olson M. Extension end-range loading for lumbar spinal stenosis: a case report. *J Contemp Chiropr*. 2023;6(1):56–61. Available from: https://journal.parker.edu/article/78099-extension-end-range-loading-for-lumbar-spinal-stenosis-a-case-report.
16) Macedo LG, Maher CG, Latimer J, Mcauley JH. Motor control exercise for chronic low back pain: a systematic review and meta-analysis. *Cochrane Database Syst Rev*. 2020;1(1). Available from: https://doi.org/10.1002/14651858.CD012004.
17) Villanueva A, Rabal-Pelay J, Berzosa C, Gutiérrez H, Cimarras-Otal C, Lacarcel-Tejero B, et al. Effect of a long exercise program in the reduction of musculoskeletal discomfort in office workers. *Int J Environ Res Public Health*. 2020;17(23):9042–9042. Available from: https://doi.org/10.3390/ijerph17239042.