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# Effect of the Base Concept, Core Strengthening and Ergonomic Advice on Mechanical Low Back Pain in Manufacturing Industry Workers - A Randomized Control Trial

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## Abstract

**Background:** Workers in the manufacturing sector are more likely to experience mechanical low back pain. Low back pain (LBP) is common in India; over 60% of people report having severe back pain at some point in their lives. Since musculoskeletal issues impact between 70 and 80 per cent of adults, they are particularly common in developed nations. Back discomfort originating from the spine, intervertebral disks, or surrounding soft tissues is referred to as mechanical low back pain. This comprises spinal compression fractures, lumbar spondylosis, spondylolisthesis, spondylolysis, disk herniation, and acute or chronic traumatic damage. Chronic mechanical low back pain is frequently a result of overuse or repetitive damage, and it frequently develops as a secondary injury at work. **Method:** 125 participants were recruited who fulfilled the inclusion criterion and were divided into two groups Group A and Group B and given intervention for six weeks. Group A received Core strengthening, Stretching and Ergonomic Advice and Training in the form of BASE Concept. Group B received Ergonomic advice. Both groups were advised to take hot fermentation at home. Pre- and post-outcomes were assessed. The data was analysed statistically. **Results:** Both groups showed substantial improvements, though Group A generally exhibited slightly greater improvements in pain reduction, muscle endurance, and strength. Group B showed greater improvement in reducing the disability as compared to Group A.

**Major Findings:** Both groups showed substantial improvements, suggesting that the intervention was highly effective across different metrics. Lastly, the intervention demonstrates a robust capacity to improve pain levels, muscle endurance, strength, and functional ability among manufacturing industry workers.

**Keywords:** Exercise Therapy, Lumbar Stabilization Exercises, Physical Ergonomics, Task Performance and Analysis, Work-Related Musculoskeletal Disorders

## 1. Introduction

Globally, Low Back Pain (LBP) is a significant public health issue. It is the most reported musculoskeletal cause of impairment and the most common reason for which patients seek outpatient physical therapy. LBP is common in India; over 60% of people report having severe back pain at some point in their lives. While LBP usually resolves on its own, 10% of individuals go on to develop chronic LBP, which is defined as lasting more than 12 weeks. Despite the tiny number, the related handicap makes this a substantial socioeconomic burden[1,2].

Pain in the lower back which originates from the spine, intervertebral disks, or surrounding soft tissues is known as mechanical low back pain. This includes disk herniation, spondylolisthesis, lumbar spondylosis,

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spondylolysis, spinal compression fractures, and acute or chronic traumatic injury[3,4]. Chronic mechanical low back pain is frequently a result of overuse or repetitive damage, and it frequently develops as a secondary injury at work. Most people with activity-limiting low back pain eventually endure recurring episodes. Approximately 23% of individuals globally endure chronic low back pain, with 24% to 80% of these patients experiencing a recurrence within one year[5,6]. The manufacturing business under consideration in this study is highly labour-demanding. Most of the jobs are handled manually by the personnel. A typical industrial process includes extremely repetitive tasks that are performed in a sedentary stance. Musculoskeletal Diseases (MSDs) relate to injuries and illnesses that affect various body parts while working[7,8]. Regardless of workload, the prevalence of work-related musculoskeletal disorders symptoms is particularly high when it comes to manual handling, prolonged standing, and working in an awkward posture. Since 70–80 % of adults will experience musculoskeletal issues at some point in their lives, these issues are particularly common in developed nations. Most MSDs impact the lower back, shoulders, and neck[9,10].

There are many physical therapy treatments which are published and effective for mechanical low back pain. Some of the treatments which are published are Stretching, Lumbar stabilization exercises, Ergonomic modifications, Multicomponent exercises, stabilization exercises with neuromuscular electrical stimulation, etc[11].

The therapy plan used in this study was tailored specifically for mechanical low back pain and included stretching, core strengthening, and ergonomic training based on the BASE concept, which is a multidimensional and comprehensive approach. That will focus not just on the workers' muscle strength, but also on their total well-being, which includes ergonomic training, strength training, endurance, and flexibility[12,13]. This comprehensive approach is aimed at assessing the effectiveness of the base concept, core strengthening and ergonomic advice on mechanical LBP in manufacturing industry workers. It includes aspects of health and safety, ergonomics, exercise, and self-efficacy. Furthermore, the overall health condition, preferences, and barriers to participation in health promotion activities are assessed. This study produces practical and goal-oriented recommendations and interventions that meet the demands of the industry and its personnel[14]. These are carried out on-site in real-world workplace settings and involve the introduction of firsthand experience in behavioural modification. This can result in long-term health-promoting behaviours.

## 2. Methodology

A six-week randomized control trial was carried out in Hydro Fabs a manufacturing industry in Bengaluru, involving male workers aged 25 to 45. The Institutional Review Board issued the ethical approval under the reference IEC/IRB/DSU/MPT/2023/021. The clinical trial was registered as CTRI/2024/04/065344 with the Clinical Trial Registry of India. After the participants were screened, those who satisfied the inclusion and exclusion criteria were selected. The inclusion criteria were workers involved in mechanical work such as lifting and transferring heavy objects with Oswestry low back disability questionnaire scores in the range of 0-14 or failing to do the PILE Test. The participants with low back pain due to any cause other than mechanical lifting such as trauma, fractures, malignancy etc were excluded from the study. The research protocol and goals were explained to all the qualifying subjects, and those who were willing to participate and give written consent were included.

### 2.1 Procedure

Participants were randomly assigned to Group A (the BASE concept and ergonomic advice) and Group B (core strengthening and ergonomic advice) using simple random sampling via the sequentially numbered opaque sealed envelope method[15,16]. Assessments were carried out at the start and the end of the six weeks. Subjects' mechanical low back pain was evaluated using the visual analogue scale, the Biering Sorensen test for evaluating the strength in muscles of the lower back, Progressive Iso-Inertial Lifting Evaluation (PILE) was used to determine the endurance of low back muscles, and Oswestry low back disability questionnaire to evaluate the disability levels due to mechanical low back pain.

The visual analogue scale measured the subjective perception of LBP intensity. The scale is a horizontal line numbered from 0 to 10. Which ranges in ascending order from no pain 0 to very severe pain 10. The participants marked the point that they feel represents their perception of their current state. The test-retest reliability is ICC= 0.95[17].

The Biering Sorensen Test measures the strength of the lumbar extensors. The workers will lay prone on a plinth.

The body's trunk extended off the edge of the table at the anterior superior iliac spine level. The buttocks and ankle joints are fixed to the plinth with straps. At the start of the test, the subject will raise his upper body to a horizontal position, crossing the arms in front of their chest, holding the head in a neutral position, and looking down to the floor[18]. Then, the participants are told to hold the position until the maximum duration time of 240 seconds or if they leave the test situation due to fatigue. Another termination criterion was the deviation of the horizontal line by more than 5%. The time that the participants remained in the position without a termination criterion was recorded. The reliability shows ICC values of 0.77–0.83[18].

The PILE-Test recorded the lifting performance, including psychophysical fatigue of the trunk. The workers repeatedly lifted a weight in a box from the floor at the level of their greater trochanter and placed it on a table. The weight was increased by 4.5 kg after an interval of four lifting attempts in 20 seconds, starting with a total weight of 4.5 kg for women and 6.5 kg for men. The test stopped when the participant exceeded the 20-second interval, decided to quit due to muscular fatigue or pain, reached 85% of the maximal heart rate (220 - age), or when (the maximum weight that can safely be lifted has been reached 50% of body weight). The weight that the participants could lift in the given time without a termination criterion was recorded. The relative test-retest reliability was high (ICC= 0.91)[19].

Oswestry Low Back disability questionnaire measures functional impairment caused by back pain during nine different daily activities: personal care, lifting, walking, sitting, standing, sleeping, sex life, social life, and travelling. The scale ranged from 0 to 50, with higher values representing more significant disability. The functional impairment caused by back pain is then calculated with the minimum value being 0 (no disability) and the maximum value being 50 (complete disability). The correlation coefficient for test-retest reliability is ICC= 0.96[20].

## 2.2 Intervention

The duration of the intervention was twice a week for 30 minutes for 6 weeks for both groups respectively. During this, group A the experimental group received the BASE concept and ergonomic advice and Group B the control group received core strengthening, stretching and ergonomic advice. Groups A and B received a week-wise protocol where in Group A in the 1st-week Video was shown explaining the importance of ergonomics and workers' daily routine and working postures were observed and analysed**.** They were asked difficulty they face in their daily working tasks. 2nd-week body compensatory exercises were given consisting of shoulder shrugs, upper limb active movements, lower limb active movements and a few yoga postures for general stretching like Konasana, Trikonasana, Uttanasana, and Ardha-Uttanasana. In the 3rd-week we started lifting ergonomic training consisting of correct lifting posture was demonstrated and was told to perform and repeated lifting movement was done until it was properly trained as a progression the lifting movement was done on an air cushion to increase the challenge. The 4th-week progression of lifting movement was done with increasing amounts of weights first with a normal surface and then with an air cushion. 5$^{th}$ week Transferring objects was trained with correct posture being demonstrated with a normal surface and then on an air cushion. 5$^{th}$ week consisted of Training all the above postures by adding a rotation movement on the normal surface and then an air cushion.

Group B was given an exercise protocol which was divided into 2 parts. Stretching exercises and core strengthening exercises. Stretching exercises were done for about 5 minutes and there were around 9 stretch poses done for 30 seconds hold and 2 repetitions. There were five levels of core strengthening exercises, with seven fundamental positions: supine, dead bug, side lying, prone, bird dog, bridge, and plank. The degree of instability was progressively increased until the most unstable position was attained. Each participant was assigned to a level with increasing levels of difficulty. Participants were instructed to complete all five exercise positions in each session to challenge the stabilization of all anterior, lateral, and posterior trunk muscles, including the transverse abdominis, rectus abdominis, erector spinae and multifidus, internal oblique abdominals, and quadrates lumborum. For a total of approximately twenty-five minutes, the subjects performed each of the seven postures five times, for approximately thirty seconds each, to the best of their abilities.

To ensure their safety, participants in Groups A and B received assistance during the entire exercise/test. Throughout the process, the exercises and tests were halted periodically while adhering to the termination criteria. Pre- and post-intervention assessments were conducted once the intervention was finished.

### 2.3 Outcome Measures

Visual analogue scale, Biering Sorensen test, Progressive Iso- Inertial Lifting Evaluation (PILE), and Oswestry low back disability questionnaire were administered at the start (pre-intervention) and completion of the 6-week training program (post-intervention).

## 3. Statistical Analysis

The frequency, percentage, mean, and standard deviation of the collected data were compiled using descriptive statistics. The visual analogue scale, Biering Sorensen test, failure weight, reasons for failure, and Oswestry LBP disability were compared between groups as well as within groups using the Paired "t" test. The study employed the Independent Sample "t" test to compare the variables of age, visual analogue scale, Biering Sorensen test, failure weight, reasons for failure, and Oswestry LBP disability between Group A and Group B. The relationship between age, the Visual analogue scale, the Biering Sorensen test, the causes for failure, the failure weight, and the Oswestry LBP disability was determined using the Pearson correlation coefficient ("r"). A p-value of less than 0.05 was deemed significant. SPSS software (SPSS Inc.; Chicago, IL) version 29.0.10 was used to analyse the data.

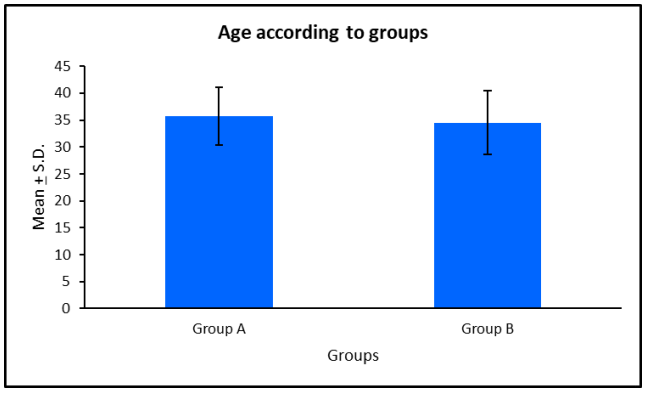
## 4. Results

The Independent sample "t" test was used to compare age according to groups. There was no difference ($p > 0.05$) in age between Group A and Group B (Table 1).

The Paired "t" test was used for the pre to post-test comparison of the visual analogue scale, Biering Sorensen test, failure weight, and Oswestry LBP disability. There was a difference ($p < 0.05$) in the visual analogue scale, Biering Sorensen test, failure weight as well as Oswestry LBP disability from pre-test to post-test irrespective of the groups (Table 2).

The Paired "t" test was used for the comparison of the visual analogue scale, Biering Sorensen test, failure weight, and Oswestry LBP disability within groups. There was a difference ($p < 0.05$) in the visual analogue scale, Biering Sorensen test, failure weight as well and Oswestry LBP within both Groups A and B (Table 3).

The Independent sample "t" test was used to compare the effectiveness (pre-post) in the visual analogue scale, Biering Sorensen test, failure weight, and Oswestry LBP disability between groups. There was a difference ($p < 0.05$) in the visual analogue scale, Biering Sorensen test, failure weight as well as Oswestry LBP disability between Groups A and B (Table 4).




**Graph 1.** Comparison of age according to groups.

**Table 1.** Comparison of age according to groups

| | | Mean | S.D. | "t" | p-value |
|---|---|---|---|---|---|
| Age (Years) | Group A | 35.7 | 5.3 | 1.25 | 0.215 |
| | Group B | 34.5 | 5.9 | | |

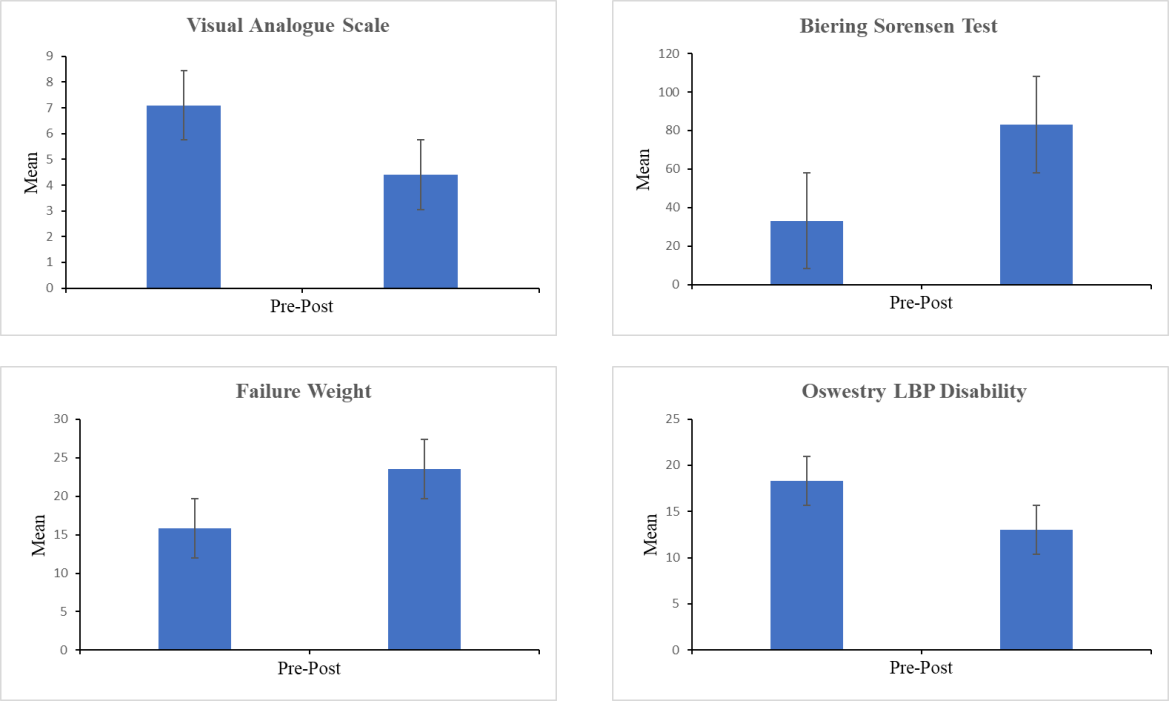
("t" = Independent sample "t" test)

## 5. Discussion

The effectiveness of the BASE concept and Core strengthening exercises combined with stretching on mechanical low back pain in manufacturing industry workers. The two above-mentioned protocols are administered to the workers in 2 different groups where Group A received BASE concept and ergonomic advice, and Group B received Core strengthening with stretching combined with ergonomic advice.

In 2018, Yousaf Ayub and Zahid Abbas Shah carried out a study aimed at estimating the risk of work-related musculoskeletal diseases, or WMSDs, among employees in manufacturing companies. They stated in their conclusion that there was a higher likelihood of WMSDs among experienced workers since they reported more pain in various body areas. According to the Nordic questionnaire, 79% of the sample's workers reported experiencing pain in various body areas.

Another study was published in December 2019 by Cristina Cimarras-Otal *et al.* This study aimed to determine whether, in assembly line workers with persistent low back pain, an exercise program tailored




**Graph 2-5.** Pre to post-test comparison of outcome measures irrespective of groups.

**Table 2.** Pre to post-test comparison of visual analogue scale, Biering Sorensen test, failure weight, and Oswestry LBP disability irrespective of groups

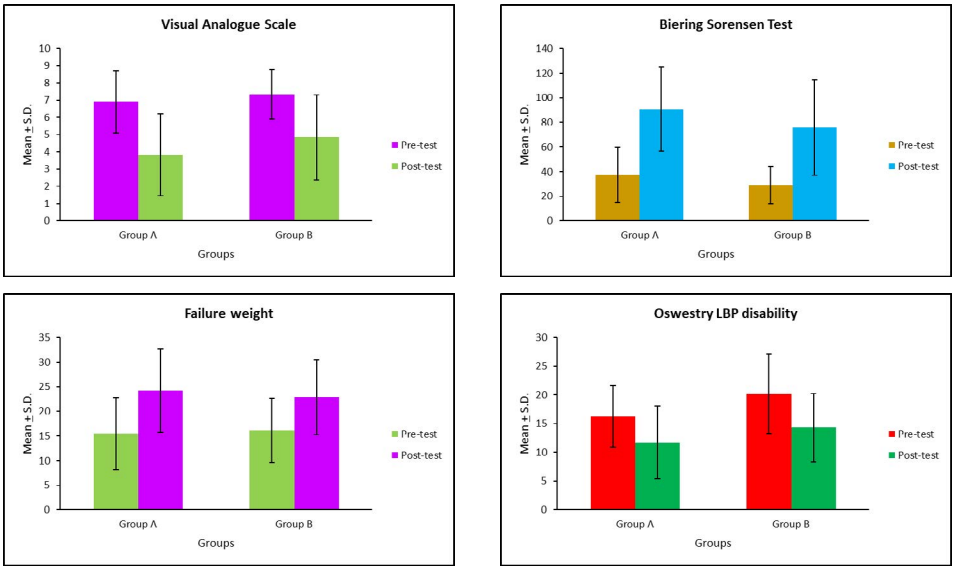
| (Irrespective of groups) | | Mean | S.D. | "t" | p-value |
|---|---|---|---|---|---|
| **Visual Analogue Scale** | **Pre-test** | 7.1 | 1.6 | 15.42 | < 0.001* |
| | **Post-test** | 4.4 | 2.5 | | |
| **Biering Sorensen Test** | **Pre-test** | 33.2 | 19.4 | -17.77 | < 0.001* |
| | **Post-test** | 83.2 | 37.3 | | |
| **Failure weight** | **Pre-test** | 15.8 | 6.9 | -14.90 | < 0.001* |
| | **Post-test** | 23.5 | 8.0 | | |
| **Oswestry LBP disability** | **Pre-test** | 18.3 | 6.5 | 16.60 | < 0.001* |
| | **Post-test** | 13.0 | 6.3 | | |

("t" = Paired "t" test; * Significant)

to the specifics of the workplace is a helpful addition to conventional exercise guidelines. They concluded that a modified exercise regimen would be a useful treatment for assembly line workers who have persistent lower back pain. Thus, this study concludes that rather than a general exercise regimen, a customized individual exercise program based on the work mechanics and work profile of workers in a particular industry is always advised and useful.

A study by Jee Hyun Suh *et al.* in 2019 conducted a randomized controlled trial, after examining the participants were randomly put into 1 of 4 groups: flexibility exercise, Walking Exercise (WE), Stabilization Exercises (SE), and Stabilisation with Walking (SWE) groups. Participants performed each exercise for 6 weeks. This study shows that lumbar SE and WE should be given to patients with chronic LBP as they not only help to relieve back pain but also chronic back pain through the increase of muscle endurance. Here the study correlated the effectiveness of core strengthening exercises with chronic low back pain and proves it to be effective.

Another study by Bettina Wollesen *et al.* in 2016 conducted a study where they gave the BASE concept to workers. They also said that the BASE concept was developed to support it as a preventive strategy within companies. It includes elements of exercise, ergonomics, self-efficacy, and health protection. A thorough examination will identify the strain, such as musculoskeletal pain from certain body positions or psychological tension. Additionally, evaluations are conducted regarding the general state of health, preferences, and obstacles to engaging in health promotion initiatives. Practical, goal-oriented recommendations and actions that meet the objectives of businesses and employees are the result of this investigation. These are implemented on-site in actual work environments and involve providing first-hand knowledge of behavioural




**Graph 6-9.** Comparison of outcome measures within the groups.

**Table 3.** Comparison of visual analogue scale, Biering Sorensen test, failure weight, and Oswestry LBP disability within the groups

| Mean | | Group A | | | | Group B | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | S.D. | "t" | p-value | Mean | S.D. | "t" | p-value | |
| **Visual Analogue Scale** | **Pre-test** | 6.9 | 1.8 | 12.98 | < 0.001* | 7.3 | 1.4 | 9.29 | < 0.001* |
| | **Post-test** | 3.9 | 2.4 | | | 4.9 | 2.5 | | |
| **Biering Sorensen Test** | **Pre-test** | 37.5 | 22.3 | -14.91 | < 0.001* | 29.1 | 14.9 | -10.81 | < 0.001* |
| | **Post-test** | 90.8 | 34.3 | | | 75.7 | 38.8 | | |
| **Failure weight** | **Pre-test** | 15.5 | 7.3 | -11.53 | < 0.001* | 16.1 | 6.5 | -9.74 | < 0.001* |
| | **Post-test** | 24.2 | 8.4 | | | 22.9 | 7.6 | | |
| **Oswestry LBP disability** | **Pre-test** | 16.3 | 5.4 | 12.52 | < 0.001* | 20.2 | 6.9 | 11.81 | < 0.001* |
| | **Post-test** | 11.8 | 6.3 | | | 14.3 | 6.0 | | |

("t" = Paired "t" test; * Significant)

modification. As a result, the employees' acceptance and self-efficacy for health promotion are increased by this practical method. This study suggests that ergonomic training can be effective in improving work-life by reducing work-related musculoskeletal disorders and reducing absenteeism.

The above-mentioned studies are the foundation articles on which this study is been formulated, as there were no studies on improving the WMSD's in manufacturing industry workers. This study is done to add to the previous information and fill the research gap. Therefore, according to this study, after the intervention being held for 6 weeks and after statistical analysis, the results which came are as follows:

All the tables in the result summarise that the study demonstrated significant improvements across all measured outcomes, with reductions in pain (visual analogue scale) and disability (Oswestry LBP disability index), and increases in muscle endurance (Biering Sorensen test) and strength (failure weight), all showing statistically significant changes ($p < 0.001$). Both groups benefited from the intervention, with Group A showing slightly greater improvements in pain reduction, muscle endurance, and strength, while Group B had a marginally greater reduction in disability. These results indicate the intervention's overall effectiveness in enhancing worker health and productivity, supported by consistent and reliable findings across balanced group sizes. The future scope of the study lies in advancing research methodologies, exploring innovative interventions, integrating technology, and collaborating across sectors to enhance the health and well-being of manufacturing industry workers. By addressing these areas, future studies can contribute to developing effective strategies

**Table 4.** Comparison of effectiveness (pre-post) in visual analogue scale, Biering Sorensen test, failure weight, and Oswestry LBP disability between groups

| Effectiveness (Pre-Post) | | Mean | S.D. | "t" | p-value |
|---|---|---|---|---|---|
| **Visual Analogue Scale** | **Group A** | 3.1 | 1.8 | 1.61 | < 0.001* |
| | **Group B** | 2.5 | 2.1 | | |
| **Biering Sorensen Test** | **Group A** | -53.3 | 27.7 | -1.19 | < 0.001* |
| | **Group B** | -46.6 | 33.7 | | |
| **Failure weight** | **Group A** | -8.7 | 5.9 | -1.93 | < 0.001* |
| | **Group B** | -6.8 | 5.4 | | |
| **Oswestry LBP disability** | **Group A** | 4.5 | 2.8 | -2.24 | 0.027* |
| | **Group B** | 5.9 | 3.9 | | |

("t" = Independent sample "t" test; * Significant)

that optimize worker health, productivity, and quality of life in diverse industrial settings.

## 6. Conclusion

The study evaluated the effectiveness of an intervention on two groups, Group A and Group B, across several measures relevant to pain, muscle endurance, strength, and disability. The balanced distribution of participants between the groups ensures a reliable comparison of outcomes. The intervention demonstrates a robust capacity to improve pain levels, muscle endurance, strength, and functional ability among manufacturing industry workers. Implementing such interventions in workplace health programs could lead to significant benefits in worker health and productivity. By addressing the physical demands and health challenges faced by manufacturing workers, companies can foster a healthier, more efficient, and safer work environment.

## 7. Limitation

The limitation of this study was that some outcome measures, such as pain levels (visual analogue scale) and disability (Oswestry LBP Disability Index), rely on self-reporting by participants. This introduces potential biases due to subjective interpretations or motivations to report favourable outcomes. While the study provides valuable insights into the effectiveness of interventions aimed at improving health outcomes among manufacturing industry workers, these limitations should be considered when interpreting and applying the findings. Future research could address these limitations by employing larger sample sizes, longer follow-up periods, randomized controlled trial designs, and more comprehensive outcome measures to enhance the robustness and applicability of the findings to diverse occupational health contexts.

## 8. Ethical Approval

Ethical clearance has been obtained by the College of Physiotherapy, School of Health Sciences, Dayananda Sagar University. Ramanagara Dt.- 562112, Karnataka

**Reference number:** IEC/IRB/DSU/MPT/2023/021

**Trial Registration Clinical Trial:** CTRI/2024/04/065344

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