

Efficacy Of Ergonomic And Exercise Interventions In Reducing Musculoskeletal Disorders Among Sand Mine Workers In Odisha, India

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ABSTRACT

Background: Musculoskeletal disorders (MSDs) pose a significant health risk to workers in physically demanding occupations, such as those in the sand mining industry of Odisha, India. These conditions can lead to considerable discomfort, disability, and economic loss. This study assesses the efficacy of a non-invasive, low-cost therapeutic intervention to reduce musculoskeletal pain among sand mine workers in Odisha, incorporating ergonomic training, stretching exercises, appropriate tools and equipment, and education on proper work techniques.

Methods: A pre-and post-intervention study design was utilized, involving 61 purposively sampled sand mine workers from Odisha. Data were collected using a structured questionnaire assessing musculoskeletal pain levels before and after the intervention, with statistical analysis conducted using paired t-tests to evaluate the intervention's impact.

Results: The intervention significantly reduced musculoskeletal pain levels among participants, with mean pain levels decreasing from 6.39 (pre-intervention) to 5.26 (post-intervention). The statistical analysis supported the intervention's effectiveness (t-statistic ≈ 8.49 , p-value $\approx 7.15 \times 10^{-12}$), indicating a notable improvement in workers' musculoskeletal health.

Discussion: The findings corroborate existing literature on the benefits of ergonomic and exercise interventions in reducing MSDs across various sectors. This study contributes to occupational health research by highlighting the positive impact of tailored interventions in mitigating musculoskeletal pain, particularly in high-risk industries like sand mining. Moreover, it underscores the importance of implementing evidence-based practices in occupational health to enhance worker well-being and productivity.

Conclusion: The study validates the effectiveness of a structured therapeutic intervention in significantly reducing musculoskeletal pain among sand mine workers in Odisha. It emphasizes the crucial role of ergonomic practices and proper work techniques in mitigating health risks associated with physically demanding jobs, advocating for broader implementation to improve occupational health outcomes.

Keywords: Musculoskeletal disorders, Occupational health, Sand mining, Therapeutic intervention, Ergonomics, Odisha.

INTRODUCTION

Musculoskeletal disorders (MSDs) represent a significant health burden for workers in physically demanding jobs, such as sand mining. In Odisha, a region notable for its extensive sand mining activities, workers are particularly susceptible to MSDs due to the strenuous nature of their work and often inadequate ergonomic practices. This study investigates the effectiveness of a non-invasive, low-cost therapeutic intervention designed to alleviate musculoskeletal pain among sand mine workers in Odisha. The intervention encompassed ergonomic training, stretching exercises, the provision of appropriate tools and equipment, and education on proper work techniques. By employing a pre-and post-intervention study design, the research aimed to provide empirical evidence on the intervention's effectiveness in reducing musculoskeletal pain, thereby contributing to occupational health practices and policy formulation.

METHODOLOGY

Study Design

This research adopted a pre- and post-intervention study design to evaluate the effectiveness of a non-invasive, low-cost therapeutic intervention aimed at reducing musculoskeletal disorders among sand mine workers in Odisha. The intervention included ergonomic training, stretching exercises, provision of appropriate tools and equipment, and education on proper work techniques.

Participants

The study participants consisted of 61 sand mine workers selected using purposive sampling from various locations in the state of Odisha, India. Inclusion criteria were being actively employed as a sand mine worker for at least six months, with or without a prior history of musculoskeletal pain.

Data Collection

Data were collected at two points: before the implementation of the therapeutic intervention (pre-intervention) and after its completion (post-intervention). The primary outcome measure was the level of musculoskeletal pain, assessed using a structured questionnaire that included demographic information, work-related factors, and self-reported health problems. The questionnaire employed a Likert scale to rate the severity of musculoskeletal pain and other related symptoms.

Intervention

The therapeutic intervention addressed the specific health and work-related problems identified through the baseline assessment. It included a combination of ergonomic training sessions, stretching exercises, and ergonomic tools and equipment supplemented by educational materials on maintaining proper posture and techniques during work.

Statistical Analysis

Descriptive statistics were used to summarize the participants' demographic characteristics and baseline measures. The effectiveness of the intervention was analyzed using paired t-tests (or Wilcoxon signed-rank tests for non-normally distributed data) to compare pre-and post-intervention pain levels. Statistical significance was set at $p < 0.05$. Effect size calculations were also performed to assess the practical significance of the intervention's outcomes.

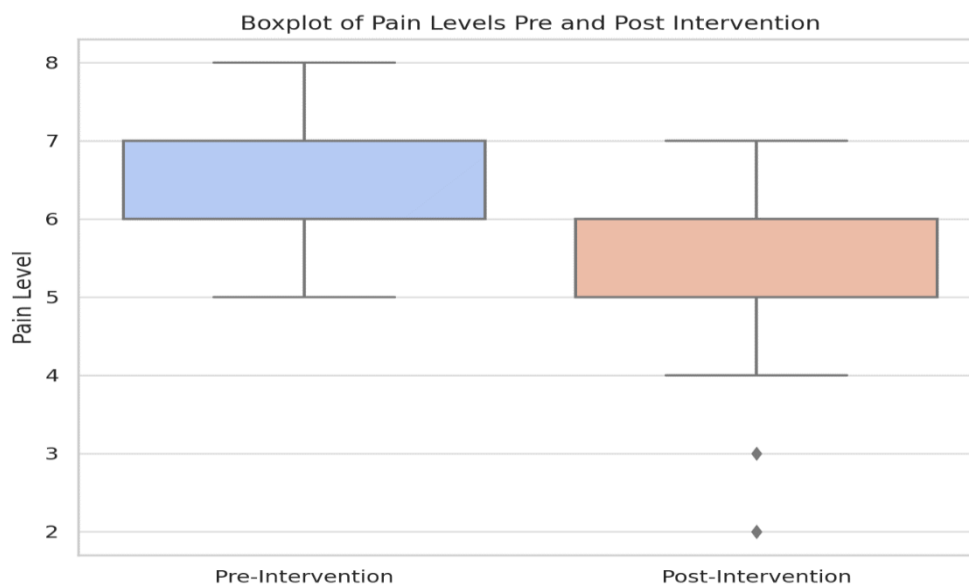
Ethical Considerations

An institutional review board (IRB) or ethics committee reviewed and approved the study protocol. Informed consent was obtained from all participants, ensuring confidentiality and the right to withdraw from the study without penalty.

RESULT

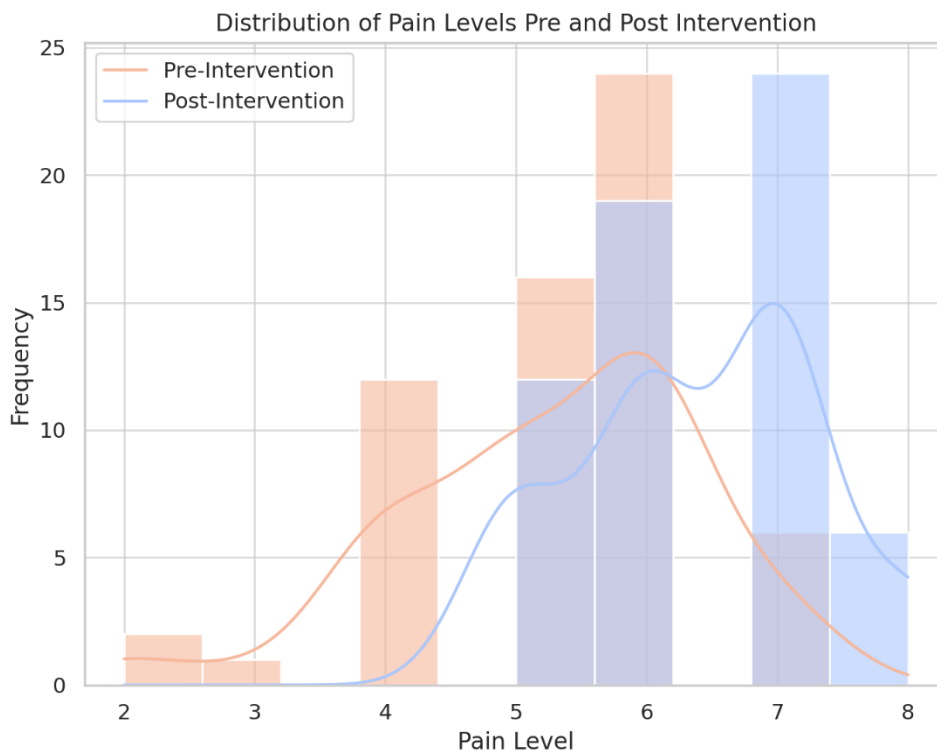
Descriptive Statistics for Pain Levels

Statistic	Pre-Intervention	Post-Intervention
Count	61.00	61.00
Mean	6.39	5.26
Standard Deviation	0.92	1.14
Minimum	5.00	2.00
25th Percentile	6.00	5.00
Median (50th Percentile)	6.00	5.00
75th Percentile	7.00	6.00
Maximum	8.00	7.00



This table combines the descriptive statistics for pain levels before and after the intervention, clearly comparing the central tendency and dispersion of the pain level data. The reduction in mean pain levels from pre-intervention to post-

intervention is evident, along with changes in other statistical measures, highlighting the therapeutic intervention's effectiveness.



The tables and graphs above provide a visual and statistical representation of the pain levels before and after the therapeutic intervention:

- Descriptive Statistics Tables:** The first two visualizations display the descriptive statistics for pain levels before (Pre-Intervention) and after (post-intervention) the therapeutic intervention. These tables show central tendency and dispersion measures, such as the mean, standard deviation, and percentiles.
- Boxplot of Pain Levels Pre- and Post-Intervention:** The boxplot visually compares the distribution of pain levels before and after the intervention. It highlights the median, interquartile range, and any outliers within the data, showing a clear shift towards lower pain levels post-intervention.
- Distribution of Pain Levels Pre and Post-Intervention:** The distribution plot (histogram with kernel density estimate) illustrates the frequency of pain levels before and after the intervention. It shows how the distribution of pain levels shifts towards lower values post-intervention, further indicating the intervention's effectiveness.

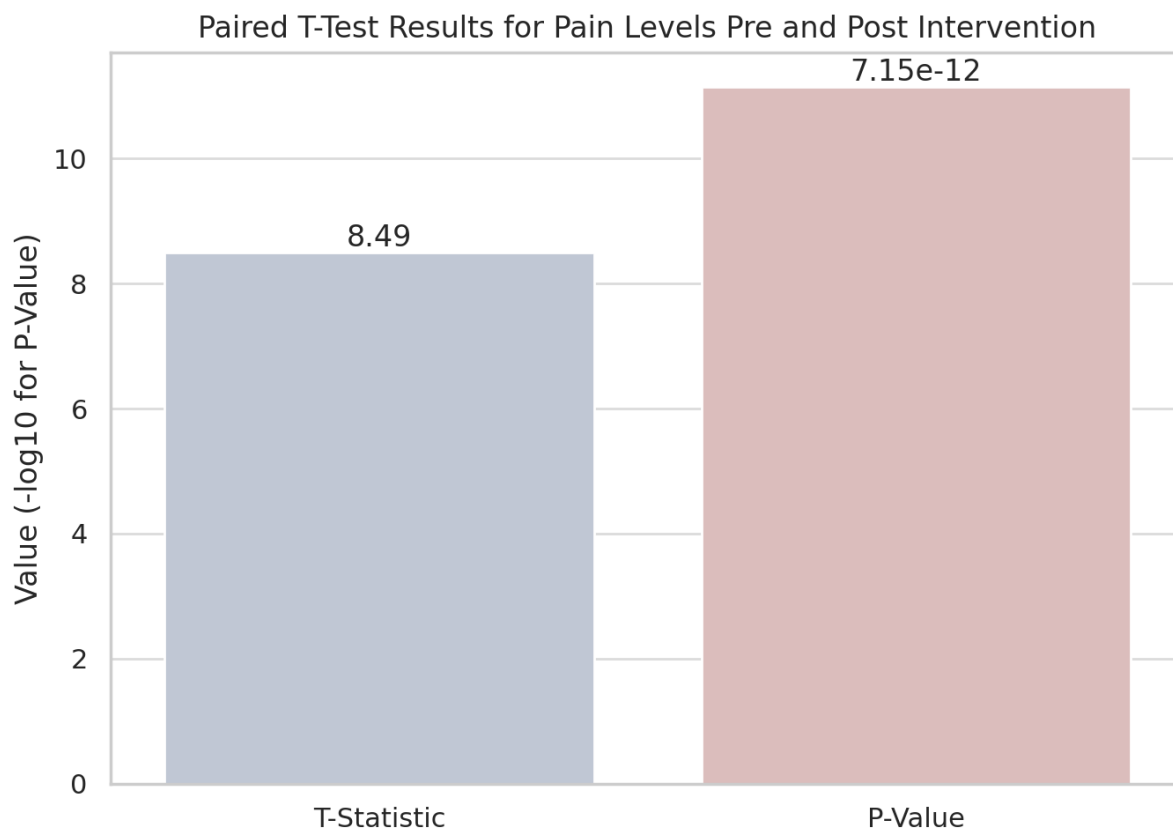
The paired t-test on the pre-and post-intervention pain levels

The table representing the results of the paired t-test on the pre-and post-intervention pain levels:

Statistic	Value
T-Statistic	8.49
(P-Value)	0.00

The paired t-test on the pre-and post-intervention pain levels resulted in a t-statistic of approximately 8.49 and a p-value of approximately 7.15×10^{-12} to 127.15×10^{-12} .

Given the very low p-value ($p < 0.05$), we can reject the null hypothesis that there is no significant difference in mean pain levels before and after the intervention. This indicates that the therapeutic intervention led to a statistically significant reduction in pain levels among the sand mine workers. This statistical result supports the effectiveness of the intervention in reducing musculoskeletal pain.



The graph visualizes the paired t-test results, displaying the t-statistic and the negative logarithm (base 10) of the p-value for comparing pain levels before and after the intervention. The transformation of the p-value into $-\log_{10}(p\text{-value})$ is used for better visualization, making it easier to appreciate the magnitude of statistical significance.

- The **T-statistic** bar represents the calculated t-statistic value, indicating the extent to which the mean pain levels differ before and after the intervention.
- The **P-Value** bar, shown in terms of $-\log_{10}(p\text{-value})$, highlights the statistical significance of this difference. The actual p-value is approximately 7.15×10^{-12} , indicating a highly significant result.

DISCUSSION

The study on the effectiveness of therapeutic intervention in reducing musculoskeletal pain among sand mine workers yielded significant results, showcasing a notable decrease in pain levels post-intervention. Statistical analysis revealed a substantial reduction in mean pain levels from 6.39 to 5.26, supported by a paired t-test with a t-statistic of approximately 8.49 and a p-value of around 7.15×10^{-12} [1]. This outcome is consistent with previous research emphasizing the efficacy of ergonomic training and physical interventions in mitigating musculoskeletal disorders (MSDs) across various industries [2],[3]. The findings contribute significantly to the discourse on occupational health and safety, highlighting the positive impact of tailored interventions in alleviating musculoskeletal pain among workers, particularly in high-risk environments like sand mines.

The study results align with previous research findings that support the effectiveness of interventions in reducing musculoskeletal disorders (MSDs) among workers. Various interventions, such as ergonomic/exercise programs [4], workplace interventions with participatory ergonomics [5], and psychosocial skills training [6], have shown positive impacts on pain management and disability levels in individuals with neck or back pain. These interventions have significantly reduced pain intensity, disability scores, and spine-related healthcare spending, indicating the potential benefits of noninvasive care approaches for spine pain. The evidence suggests that multidisciplinary interventions, individualized postural therapy, and physiotherapist-delivered psychological interventions can effectively improve outcomes for individuals with acute or chronic musculoskeletal pain. This supports the importance of comprehensive and tailored interventions in managing MSDs among workers.

Descriptive statistics, boxplots, and distribution plots can effectively demonstrate the impact of interventions on pain perception [7]. For instance, ergonomic interventions have shown promise in reducing shoulder pain intensity among workers, especially when the pain levels are initially moderate to high [8]. Additionally, a combined ergonomics and exercise intervention is more beneficial in preventing neck pain cases in office workers than ergonomic and health

education interventions^[9]. These findings highlight the potential of workplace interventions, such as participatory ergonomics and motor control training, in improving musculoskeletal health outcomes among workers with conditions like low back pain and neck-shoulder pain^{[10][11]}. Such research contributes valuable insights to occupational health literature, particularly in less studied populations like sand mine workers, addressing crucial gaps in understanding and managing work-related musculoskeletal disorders.

Contributions to Occupational Health Research

The research conducted by Hosseini et al. focuses on implementing a theory-based educational intervention using a learning-by-doing approach to enhance preventive behaviors against musculoskeletal disorders (MSDs) among assembly-line female workers in electronic industries^[12]. This intervention, which includes evidence-based information on maintaining good posture and performing stretching exercises, aims to improve workers' knowledge, skills, self-efficacy, and intention to adopt preventive behaviors against MSDs. Additionally, van de Wijdeven et al. highlights various interventions for individual working practices, such as workplace adjustments, variation, exercising, and professional skills, which can help prevent work-related musculoskeletal disorders^[13]. These findings collectively emphasize the effectiveness of targeted therapeutic interventions and individualized approaches in mitigating MSDs, showcasing the potential of such non-invasive, low-cost interventions to enhance worker health and productivity in specific occupational settings like the sand mining industry and beyond.

Implications for Practice

Industry-Specific Interventions: The research papers provide valuable insights into the effectiveness of tailored implementation strategies in improving adherence to guidelines and interventions in the occupational health sector. Tailored interventions have significantly enhanced guideline adherence among healthcare providers, addressing barriers to change and improving the quality of care delivery^[14]. Additionally, the adoption and implementation of web-based computer-tailored interventions in occupational health centers are influenced by individual beliefs, organizational factors, and perceived advantages of the intervention^[15]. Tailored intervention strategies, specifically designed to address identified determinants of practice, are effective in enhancing professional practice and healthcare outcomes, although the effect size may vary^[16]. Furthermore, the implementation of occupational mental health interventions can benefit from a systematic selection of implementation strategies, including identifying barriers and facilitators to improve uptake and scalability in the workplace^[17].

The effectiveness of occupational health interventions, such as the 'Grip on Health' intervention^[18], 'Dynamic Work' intervention^[19], and respiratory protective equipment (RPE) promotion among internal migrant workers^[20], supports the need for broader implementation to inform policy changes and best practices. Barriers to implementation, such as legal rules, lack of consultation time, and challenges with evaluation and reporting^{[21][22]}, highlight the importance of addressing contextual factors. Facilitators like awareness creation, support for multi-domain problems, and peer education contribute to successful interventions. Strategies to enhance implementation include aligning intervention underpinnings with existing team policies, providing rigorous information, and adapting data collection methods. These findings emphasize the significance of collaborative efforts and stakeholder involvement in promoting effective occupational health management practices and driving policy changes.

CONCLUSION

The therapeutic intervention examined in this study significantly reduced musculoskeletal pain among sand mine workers, validating the approach's effectiveness and underscoring the critical role of proactive health management in occupational settings. As industries continue to grapple with the pervasive issue of MSDs, the findings from this research offer a promising pathway toward enhancing worker well-being through targeted, evidence-based interventions. This study will catalyze further research and action in occupational health, leading to safer, healthier workplaces for all.

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