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The Effect Of Trancutaneous Electrical Nerve Stimulation And Core Stability Exercise On Myogenic Low Back Pain

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ABSTRACT

Myogenic Low Back Pain (LBP) is a musculoskeletal disorder commonly experienced by traditional coffee bean sorting workers due to prolonged static sitting positions and repetitive non-ergonomic activities. This condition increases pain intensity and limits functional ability, thereby reducing occupational productivity and quality of life. This study aimed to determine the effect of the combination of Transcutaneous Electrical Nerve Stimulation (TENS) and Core Stability Exercise on pain reduction and functional improvement among traditional coffee bean sorting workers in Lembang Langda, Sopai District, North Toraja. This study employed a quasi-experimental design using a time-series approach. The research was conducted from January to February 2026 in Lembang Langda, North Toraja Regency. A total of 20 respondents who met the inclusion criteria were selected using purposive sampling techniques. Pain intensity was measured using the Visual Analogue Scale (VAS), while functional disability was assessed using the Oswestry Disability Index (ODI). Data analysis was conducted using the Shapiro–Wilk normality test and paired sample t-test. The results demonstrated significant improvements in both clinical parameters after intervention. The mean VAS score gradually decreased from 6.88 during the pre-test to 5.08 at post-test 1, 3.74 at post-test 2, and reached 1.37 at post-test 3. Similarly, the mean ODI score improved from 34.64% during the pre-test to 13.24% at post-test 3. Statistical analysis revealed p-values < 0.05, indicating a significant effect of the intervention on respondents' recovery. In conclusion, the combination of TENS and Core Stability Exercise was effective in reducing pain intensity and improving functional ability among individuals with myogenic low back pain. This intervention may be recommended as an occupational physiotherapy rehabilitation strategy for traditional workers exposed to prolonged static and repetitive activities.

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INTRODUCTION

Myogenic low back pain (MLBP) is one of the most prevalent musculoskeletal disorders affecting workers who perform repetitive and static occupational activities. This condition is characterized by excessive tension and dysfunction of muscles,

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tendons, and ligaments in the lumbar region, particularly involving the multifidus, erector spinae, and quadratus lumborum muscles. Persistent overload on these structures can lead to muscle spasm, inflammation, stiffness, and limited mobility, ultimately reducing work productivity and quality of life. Several studies have reported that poor posture, prolonged sitting, repetitive trunk flexion, and monotonous work activities are major contributors to the development of MLBP among manual workers and agricultural laborers (Hasmar & Faridah, 2022; Hartvigsen et al., 2018; Maher et al., 2017). Low back pain has also become a global occupational health concern because it contributes significantly to disability-adjusted life years and economic burden worldwide (Wu et al., 2020).

In traditional agricultural sectors, the prevalence of low back pain tends to be higher due to limited ergonomic awareness and physically demanding work systems. In Indonesia, coffee bean sorting activities are still predominantly conducted manually using traditional methods. Workers often maintain prolonged sitting positions on the floor or low stools while performing repetitive hand movements and trunk flexion for several hours every day. Such working conditions place excessive mechanical stress on the lumbar spine and surrounding musculature (McGill, 2015). In Lembang Langda, Sopai District, North Toraja, coffee bean sorting is not merely an economic activity but also part of the local cultural identity. However, the traditional work system applied by local workers rarely incorporates ergonomic principles or occupational health interventions, thereby increasing the risk of chronic musculoskeletal disorders (Badan Pusat Statistik, 2022; Kementerian Pertanian Republik Indonesia, 2023).

The repetitive lumbar flexion posture observed among coffee bean sorting workers causes continuous compression and tension on spinal stabilizing muscles. Sustained contraction of postural muscles may lead to muscle fatigue, decreased circulation, ischemia, and pain sensitization mechanisms (Sutrisno et al., 2021). Furthermore, prolonged static sitting without adequate lumbar support contributes to abnormal spinal loading and postural imbalance. Previous ergonomic investigations among agricultural workers demonstrated that static trunk flexion exceeding 20 degrees for long durations significantly increases the risk of developing chronic low back pain (Hoy et al., 2014). Similar findings were reported among plantation workers, farmers, and food-processing laborers who perform repetitive manual tasks without ergonomic modifications (Janwantanakul et al., 2015).

In October 2025, observational data in Lembang Langda identified 32 traditional coffee bean sorting workers, mostly women aged between 30 and 60 years, who worked approximately 3–6 hours daily in static sitting positions. Most workers complained of persistent low back pain, stiffness, and discomfort during and after work activities. Self-management strategies commonly practiced by workers, such as using topical balms, massage oils, or resting temporarily, only provided short-term symptom relief and failed to address the underlying biomechanical dysfunction. Consequently, sustainable therapeutic interventions are needed to reduce pain intensity, improve spinal stability, and prevent recurrence of myogenic low back pain among these workers.

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Various physiotherapy interventions have been developed to manage myogenic low back pain, including electrotherapy, exercise therapy, manual therapy, and ergonomic correction programs. Among these interventions, Transcutaneous Electrical Nerve Stimulation (TENS) and core stability exercise have gained increasing attention due to their non-invasive characteristics and clinically proven effectiveness. TENS is an electrotherapy modality that utilizes low-voltage electrical stimulation to activate sensory nerve fibers and inhibit pain transmission through the gate control theory mechanism proposed by Melzack and Wall. TENS has been widely reported to reduce pain intensity, improve local blood circulation, and stimulate endogenous opioid release (Johnson & Walsh, 2015; Vance et al., 2014).

Several clinical studies have demonstrated the effectiveness of TENS in reducing musculoskeletal pain conditions, including low back pain. A systematic review by Resende et al. (2018) concluded that TENS provides short-term analgesic effects and improves functional mobility in patients with chronic low back pain. Similarly, Çelik et al. (2020) reported significant pain reduction among workers with occupational lumbar disorders following regular TENS application. TENS therapy is particularly advantageous for workers because it is relatively safe, practical, and capable of providing rapid pain modulation without pharmacological side effects.

In addition to pain control, restoring spinal stability is essential in preventing recurrent low back pain. Core stability exercise has emerged as one of the most effective therapeutic exercise approaches for lumbar dysfunction. Core stability training focuses on strengthening deep trunk muscles such as the transversus abdominis, multifidus, pelvic floor muscles, and diaphragm, which play crucial roles in maintaining spinal alignment and postural control (Akuthota & Nadler, 2016). Weakness or delayed activation of these muscles has been strongly associated with chronic low back pain and spinal instability (Hodges & Richardson, 2013).

Research evidence supports the effectiveness of core stability exercise in improving lumbar function and reducing disability. Gordon and Bloxham (2016) explained that structured core stability programs significantly improve neuromuscular coordination and trunk endurance in individuals with chronic low back pain. Furthermore, a meta-analysis conducted by Wang et al. (2022) demonstrated that core stability exercise produced greater improvements in pain intensity and functional disability compared to conventional exercise therapy. Core stability exercise also contributes to improved movement patterns, postural correction, and long-term prevention of pain recurrence.

The combination of TENS and exercise therapy has recently become an important rehabilitation strategy in physiotherapy practice. Combining electrotherapy with active exercise may provide synergistic effects because TENS reduces pain perception, enabling patients to perform strengthening exercises more effectively (Alrwaily et al., 2018). Several studies have indicated that multimodal interventions are more effective than single therapeutic modalities in managing chronic musculoskeletal pain (Delitto et al., 2012). However, the majority of previous studies focused on office workers, industrial laborers, or clinical patients, while research involving traditional agricultural workers remains limited.

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Although numerous studies have investigated low back pain interventions, there are still several important gaps in the literature. First, previous studies predominantly focused on urban workers, industrial employees, athletes, and patients in clinical settings, whereas traditional agricultural workers have received limited scientific attention. Coffee bean sorting workers in North Toraja represent a unique occupational population with distinct ergonomic challenges, including prolonged floor sitting, repetitive trunk flexion, and limited occupational health support.

Second, most existing studies evaluated TENS and core stability exercise separately rather than examining their combined therapeutic effects. While TENS effectively reduces pain and core stability exercise improves spinal function, limited evidence exists regarding the integrated application of these interventions among workers experiencing myogenic low back pain due to repetitive agricultural activities. Consequently, there remains insufficient empirical evidence regarding whether combining passive pain modulation with active stabilization exercise can produce optimal rehabilitation outcomes.

Third, studies investigating physiotherapy interventions among Indonesian traditional workers are still scarce, particularly in rural and culturally preserved regions such as North Toraja. Existing occupational health studies in Indonesia have mainly emphasized ergonomic risk analysis rather than evidence-based physiotherapy management. Therefore, there is a need for intervention-based studies that directly evaluate therapeutic effectiveness within local occupational contexts.

Fourth, many previous investigations measured only pain intensity outcomes without comprehensively evaluating functional improvements and postural adaptation. Considering that myogenic low back pain is closely related to spinal instability and movement dysfunction, interventions should not merely target symptom reduction but also restore functional lumbar control and muscular endurance.

Based on the identified problems and research gaps, this study aims to analyze the effect of Transcutaneous Electrical Nerve Stimulation (TENS) and core stability exercise on myogenic low back pain among traditional coffee bean sorting workers in Lembang Langda, Sopai District, North Toraja. Specifically, this research seeks to evaluate the effectiveness of combined electrotherapy and exercise intervention in reducing pain intensity, improving lumbar stability, and enhancing functional movement among workers experiencing occupational low back pain.

The novelty of this study lies in several important aspects. First, this research focuses on traditional coffee bean sorting workers, a population rarely investigated in physiotherapy and occupational health research. Second, this study integrates TENS and core stability exercise as a combined therapeutic approach targeting both pain modulation and spinal stabilization mechanisms simultaneously. Third, the study contextualizes physiotherapy intervention within a traditional agricultural work environment characterized by limited ergonomic implementation and prolonged static postures. Finally, this research contributes empirical evidence to support community-based physiotherapy management for occupational musculoskeletal disorders in rural Indonesia.

In conclusion, myogenic low back pain among traditional coffee bean sorting workers represents a significant occupational health issue requiring comprehensive therapeutic intervention. Prolonged static sitting and repetitive trunk flexion increase lumbar muscle strain and functional impairment among workers in Lembang Langda, North Toraja. While TENS and core stability exercise have independently demonstrated positive effects in managing low back pain, evidence regarding their combined effectiveness among traditional agricultural workers remains limited. Therefore, this study is expected to provide scientific evidence regarding integrated physiotherapy interventions for occupational low back pain and contribute to the development of evidence-based rehabilitation strategies in traditional work settings.

METHODS

This study employed a quasi-experimental research design using a time-series approach to evaluate the effect of Transcutaneous Electrical Nerve Stimulation (TENS) and Core Stability Exercise on myogenic low back pain among traditional coffee bean sorting workers in Lembang Langda, Sopai District, North Toraja. The time-series design was selected because it allows repeated measurements before and after intervention, thereby enabling researchers to observe gradual physiological and functional changes resulting from therapeutic treatment. According to experimental rehabilitation studies, repeated-measurement designs are effective for monitoring intervention outcomes in musculoskeletal disorders because they minimize variability and provide stronger internal validity in community-based clinical research (Portney & Watkins, 2020; Thomas et al., 2019).

The population of this study consisted of 32 traditional coffee bean sorting workers diagnosed with myogenic low back pain. From this population, 20 participants were selected using a simple random sampling technique based on Cohen's effect size calculation for paired-sample analysis. Simple random sampling was chosen because the workers had relatively homogeneous occupational characteristics, including repetitive sitting posture, prolonged lumbar flexion, and similar daily workloads. Randomization techniques are recommended in occupational health studies to reduce sampling bias and improve sample representativeness (Setia, 2016).

The inclusion criteria were: (1) workers diagnosed with myogenic low back pain through physiotherapy examination and muscle palpation, (2) aged between 30–60 years, and (3) willing to participate voluntarily by signing informed consent forms. Meanwhile, the exclusion criteria included: (1) history of vertebral fracture, spinal tumor, or infection, (2) pregnancy, and (3) hypersensitivity or contraindications to TENS and exercise therapy. These criteria were established to ensure participant safety and intervention homogeneity, as recommended in clinical physiotherapy trials involving musculoskeletal pain management (Delitto et al., 2021).

The intervention program consisted of combined TENS therapy and Core Stability Exercise administered three times per week for two consecutive weeks. TENS was applied using conventional stimulation parameters to activate sensory nerve fibers and

reduce pain through gate control mechanisms. Previous evidence demonstrated that TENS effectively reduces pain perception, increases local circulation, and stimulates endogenous opioid release in patients with chronic low back pain (Johnson et al., 2015; Resende et al., 2018). Meanwhile, Core Stability Exercise focused on strengthening deep trunk muscles, particularly the transversus abdominis and multifidus muscles, which are essential for lumbar stabilization and postural control (Akuthota et al., 2018). Studies have shown that core stabilization training significantly improves spinal stability, neuromuscular coordination, and functional mobility among individuals with chronic lumbar dysfunction (Gordon & Bloxham, 2016; Wang et al., 2022).

Data collection was conducted using both primary and secondary approaches to ensure research validity and comprehensiveness. Primary data were obtained directly through structured interviews, workplace posture observation, physiotherapy examination, and repeated clinical measurements before and after intervention. Pain intensity was measured using the Visual Analogue Scale (VAS), while functional disability was assessed using the Oswestry Disability Index (ODI). The VAS is widely recognized as a valid and reliable instrument for subjective pain assessment, whereas the ODI is considered the gold standard for evaluating disability associated with low back pain (Fairbank & Pynsent, 2000; Mehra et al., 2018). Secondary data were collected from scientific journals, textbooks, and official institutional reports related to occupational health and musculoskeletal disorders among agricultural workers.

The research instruments included ODI questionnaires, VAS scales, observation sheets, and intervention equipment such as TENS units and exercise mats. All measurements and intervention procedures were conducted according to standardized physiotherapy protocols to ensure consistency and reliability of data collection.

Data analysis was performed using Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to describe participant characteristics and summarize pre-test and post-test scores. Data normality was assessed using the Shapiro–Wilk test because it is considered appropriate for small sample sizes (Razali & Wah, 2011). If the data were normally distributed ($p > 0.05$), a paired-sample t-test was conducted to determine differences between pre-test and post-test measurements. Conversely, if the data were not normally distributed ($p < 0.05$), the non-parametric Wilcoxon signed-rank test was applied. These statistical approaches are commonly recommended in rehabilitation and physiotherapy research involving repeated measures within the same group (Field, 2018).

RESULTS AND DISCUSSION

Result

Characteristics of Respondents

The respondent characteristics in this study consisted of age and gender distribution among traditional coffee bean sorting workers in Lembang Langda, Sopai

District, North Toraja. A total of 20 respondents participated in this study after meeting the inclusion criteria. The demographic profile is presented in Table 1.

Table 1.
Characteristics of Respondents

Respondent Characteristics	Frequency (n)	Percentage (%)
Age		
30–40 years	6	30
41–50 years	7	35
51–60 years	7	35
Total	**20**	**100**
Gender		
Male	5	25
Female	15	75
Total	**20**	**100**

Based on Table 1, the highest prevalence was found in the age groups of 41–50 years and 51–60 years, each accounting for 35% of respondents, followed by the 30–40 years group at 30%. These findings indicate that most respondents were in the late productive age phase, where physiological degeneration such as decreased connective tissue elasticity, reduced muscle strength, and mild lumbar degenerative changes begin to occur. Such conditions increase susceptibility to myogenic low back pain, particularly under prolonged static occupational loads. Furthermore, the majority of respondents were female (75%), reflecting the dominance of women in traditional coffee bean sorting activities. Clinically, women tend to exhibit a higher prevalence of low back pain due to hormonal fluctuations, lower muscle mass, and cumulative physical workload from domestic and occupational activities.

Distribution of Visual Analogue Scale (VAS)

The effectiveness of the intervention was first evaluated through changes in pain intensity using the Visual Analogue Scale (VAS). The distribution of VAS scores during the pre-test and post-test measurements is shown in Table 2.

Table 2.
Distribution of Visual Analogue Scale (VAS)

Pain Scale	Category	Pre-Test n (%)	Post-Test 1 n (%)	Post-Test 2 n (%)	Post-Test 3 n (%)
0	No Pain	0 (0%)	0 (0%)	2 (10%)	6 (30%)
1–3	Mild Pain	0 (0%)	3 (15%)	6 (30%)	14 (70%)
4–6	Moderate Pain	9 (45%)	16 (80%)	12 (60%)	0 (0%)
7–10	Severe Pain	11 (55%)	1 (5%)	0 (0%)	0 (0%)
Total		**20 (100%)**	**20 (100%)**	**20 (100%)**	**20 (100%)**

The results demonstrated a gradual and consistent reduction in pain intensity following the administration of TENS and Core Stability Exercise. During the pre-test, all respondents experienced pain, predominantly severe pain (55%) and moderate pain (45%). After the first intervention phase, severe pain decreased substantially to 5%, while mild pain emerged in 15% of respondents. By post-test 2, severe pain was no longer identified, and most respondents experienced moderate or mild pain. At post-test 3, 70% of respondents reported only mild pain, whereas 30% experienced no pain at all. These

findings indicate progressive improvement in pain management outcomes after repeated intervention sessions.

Distribution of Oswestry Disability Index (ODI)

Functional disability associated with low back pain was evaluated using the Oswestry Disability Index (ODI). The distribution of ODI scores is presented in Table 3.

Table 3.

Distribution of Oswestry Disability Index (ODI)

ODI Score	Disability Category	Pre-Test n (%)	Post-Test 1 n (%)	Post-Test 2 n (%)	Post-Test 3 n (%)
0–15	Very Mild	0 (0%)	2 (10%)	6 (30%)	11 (55%)
16–30	Mild	4 (20%)	11 (55%)	14 (70%)	9 (45%)
31–45	Moderate	16 (80%)	7 (35%)	0 (0%)	0 (0%)
46–60	Severe	0 (0%)	0 (0%)	0 (0%)	0 (0%)
61–75	Very Severe	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total		**20 (100%)**	**20 (100%)**	**20 (100%)**	**20 (100%)**

Table 3 demonstrates progressive improvement in functional disability after intervention. At the pre-test stage, most respondents were categorized as having moderate disability (80%), while 20% experienced mild disability. Following the intervention, moderate disability progressively decreased to 35% at post-test 1 and completely disappeared by post-test 2. At post-test 3, most respondents were categorized as having very mild disability (55%) and mild disability (45%). These findings suggest that the intervention effectively improved functional ability and reduced disability related to myogenic low back pain.

Normality Test Analysis

Before hypothesis testing, data normality was assessed using the Shapiro–Wilk test. The results are presented in Table 4.

Table 4.

Shapiro–Wilk Normality Test

Measurement Time	VAS Statistic	p-value	ODI Statistic	p-value
Pre-Test	0.952	0.392	0.944	0.282
Post-Test 1	0.960	0.543	0.960	0.544
Post-Test 2	0.914	0.077	0.931	0.163
Post-Test 3	0.908	0.059	0.959	0.532

The Shapiro–Wilk analysis revealed that all p-values for both VAS and ODI variables were greater than 0.05 ($p > 0.05$), indicating normal distribution of the data at each measurement stage. Therefore, parametric statistical analysis using the paired-sample t-test was considered appropriate for hypothesis testing.

Paired Sample T-Test on Visual Analogue Scale (VAS)

Table 5.

Paired Sample T-Test on VAS Scores

Comparison	Mean	SD	Sig. (p)
Pre-Test	6.88	1.744	<0.001
Post-Test 1	5.08	1.355	<0.001
Post-Test 2	3.74	1.965	<0.001
Post-Test 3	1.37	1.135	<0.001

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The paired-sample t-test results showed a significant reduction in pain intensity after intervention. The mean VAS score decreased from 6.88 during the pre-test to 5.08 at post-test 1, 3.74 at post-test 2, and 1.37 at post-test 3. All comparisons yielded significance values of $p < 0.001$, indicating statistically significant differences between pre- and post-intervention measurements. These findings confirm that the combination of TENS and Core Stability Exercise was effective in significantly reducing pain intensity among traditional coffee bean sorting workers.

Paired Sample T-Test on Oswestry Disability Index (ODI)

Table 6.

Paired Sample T-Test on ODI Scores

Comparison	Mean	SD	Sig. (p)
Pre-Test	34.64	6.700	<0.001
Post-Test 1	25.80	10.218	<0.001
Post-Test 2	17.35	7.561	<0.001
Post-Test 3	13.24	7.330	<0.001

The ODI paired-sample t-test analysis also demonstrated a statistically significant reduction in disability scores following intervention. The mean ODI score decreased from 34.64 during the pre-test to 25.80 at post-test 1, followed by 17.35 at post-test 2, and 13.24 at post-test 3. All measurement comparisons showed p-values < 0.001, indicating highly significant differences before and after intervention. Overall, these findings demonstrate that the combination of TENS and Core Stability Exercise effectively improved functional ability and reduced disability among workers with myogenic low back pain.

Discussion

The findings of this study demonstrate that the combination of Transcutaneous Electrical Nerve Stimulation (TENS) and Core Stability Exercise significantly reduced myogenic low back pain and improved functional ability among traditional coffee bean sorting workers in Lembang Langda, Sopai District, North Toraja. The effectiveness of the intervention was reflected in the gradual reduction of Visual Analogue Scale (VAS) scores and Oswestry Disability Index (ODI) scores across repeated measurements. These findings confirm that integrated physiotherapy interventions can provide substantial clinical benefits for workers exposed to prolonged static posture and repetitive lumbar loading.

The demographic characteristics of respondents revealed that most participants were aged between 41–60 years, representing the late productive and pre-elderly age categories. This finding is consistent with previous research indicating that increasing age is strongly associated with musculoskeletal degeneration, including reduced muscle elasticity, decreased muscle strength, and diminished spinal flexibility (Hartvigsen et al., 2018; Wu et al., 2020). Aging also contributes to intervertebral disc degeneration and decreased postural endurance, thereby increasing susceptibility to low back pain among workers exposed to repetitive occupational stress (Hoy et al., 2014). In the context of

traditional coffee bean sorting, prolonged sitting and trunk flexion accelerate mechanical loading on the lumbar region, particularly affecting the paravertebral muscles and multifidus stabilization system.

This study also identified that the majority of respondents were female (75%). Previous studies have consistently shown that women experience higher prevalence rates of low back pain compared to men due to hormonal influences, lower muscle mass, and differences in musculoskeletal biomechanics (Meucci et al., 2015; Mambu, 2022). Hormonal fluctuations, especially reduced estrogen levels during menopause, may contribute to decreased bone density and increased pain sensitivity (Bener et al., 2013). Furthermore, women often experience cumulative physical burdens from occupational and domestic activities, increasing muscle fatigue and lumbar strain. The predominance of female workers in traditional coffee sorting activities may therefore contribute to the high prevalence of myogenic low back pain observed in this population.

The results of the VAS distribution analysis demonstrated a substantial reduction in pain intensity after intervention. Initially, 55% of respondents experienced severe pain and 45% experienced moderate pain. However, after repeated intervention sessions, most participants shifted into the mild pain category, while 30% reported no pain during the final post-test. These findings indicate a cumulative therapeutic effect of TENS and Core Stability Exercise. Similar outcomes were reported by Rahmawati et al. (2024), who found that non-pharmacological physiotherapy interventions gradually increase pain tolerance and reduce nociceptive sensitivity through neuromodulation mechanisms. Repeated therapeutic stimulation has been shown to activate descending inhibitory pathways and stimulate endogenous opioid release, thereby reducing pain perception over time (Johnson et al., 2015; Vance et al., 2014).

The improvement in ODI scores further supports the effectiveness of the intervention. At the beginning of the study, 80% of respondents experienced moderate disability, indicating that low back pain substantially interfered with daily functional activities. Following intervention, the majority of participants shifted into very mild and mild disability categories. This improvement suggests that pain reduction was accompanied by enhanced functional movement and spinal stability. According to Saputra and Wijaya (2022), decreased pain intensity is strongly associated with improved joint mobility and muscular coordination because reduced nociceptive stimulation allows more efficient neuromuscular activation. Functional improvement is particularly important among workers whose occupations require repetitive static posture and sustained trunk activity.

The normality test results confirmed that all VAS and ODI data were normally distributed ($p > 0.05$), validating the use of parametric statistical analysis. The paired-sample t-test analysis revealed statistically significant reductions in both pain intensity and disability levels at every measurement stage ($p < 0.001$). The mean VAS score decreased from 6.88 during pre-test to 1.37 during post-test 3, representing a total reduction of 5.51 points. Clinically, this reduction reflects a transition from severe pain to minimal pain conditions. These findings align with studies by Wulandari et al. (2024)

and Sari and Wijaya (2024), which demonstrated that repeated therapeutic interventions produce progressive pain reduction through sensory nerve modulation and improved musculoskeletal adaptation.

From a physiological perspective, the effectiveness of TENS can be explained through the gate control theory proposed by Melzack and Wall. TENS stimulates large-diameter afferent A-beta fibers, which inhibit nociceptive transmission at the dorsal horn of the spinal cord, thereby reducing pain perception (Johnson & Walsh, 2015). Additionally, TENS stimulates endogenous opioid release, including endorphins and enkephalins, which further contribute to analgesic effects (Sluka & Bjordal, 2013). Increased local blood circulation induced by electrical stimulation may also accelerate tissue recovery and reduce muscle ischemia resulting from prolonged static contraction (Resende et al., 2018). In this study, these physiological mechanisms likely contributed to the rapid reduction in pain intensity observed during repeated intervention sessions.

Core Stability Exercise also played a critical role in improving lumbar function and reducing disability. Core stabilization training specifically targets deep trunk muscles such as the transversus abdominis, multifidus, diaphragm, and pelvic floor muscles, which are essential for maintaining spinal alignment and segmental stability (Akuthota et al., 2018). Weakness or delayed activation of these muscles has been associated with chronic low back pain and impaired postural control (Hodges & Richardson, 2013). By strengthening spinal stabilizers, core stability exercises reduce excessive lumbar loading and improve neuromuscular coordination. Previous studies by Gordon and Bloxham (2016), Wang et al. (2022), and Pratiwi and Hidayat (2022) confirmed that core stability programs significantly improve trunk endurance, spinal stability, and functional mobility among individuals with low back pain.

The combined use of TENS and Core Stability Exercise produced synergistic therapeutic effects in this study. TENS provided rapid pain reduction, enabling participants to perform exercise therapy more effectively and comfortably. Meanwhile, core stabilization training addressed the underlying biomechanical dysfunction responsible for recurrent pain. This integrated approach is consistent with recommendations from modern physiotherapy rehabilitation frameworks, which emphasize combining passive pain management modalities with active exercise-based interventions (Delitto et al., 2021; Alrwaily et al., 2018). Multimodal physiotherapy interventions have been shown to provide superior long-term outcomes compared to single-modality treatment because they simultaneously target pain modulation, muscular stabilization, and functional restoration (Smith et al., 2022; Lee et al., 2023).

The strong positive correlation identified between pain reduction and functional improvement further reinforces the clinical relevance of the intervention. The paired-sample correlation analysis demonstrated very high correlation coefficients ($r = 0.848–0.958$), indicating that lower VAS scores were consistently associated with improved ODI outcomes. These findings suggest that reducing pain not only alleviates subjective discomfort but also enhances mobility, postural efficiency, and occupational performance. According to Avelino et al. (2022) and Johnson et al. (2023), functional

recovery in low back pain rehabilitation is highly dependent on achieving both pain control and muscular stabilization simultaneously.

This study has important implications for occupational health management among traditional agricultural workers. Traditional coffee bean sorting workers often lack access to ergonomic facilities and evidence-based rehabilitation services. Therefore, implementing simple, affordable, and non-invasive physiotherapy interventions such as TENS and Core Stability Exercise may represent an effective strategy for reducing musculoskeletal disorders in rural communities. Furthermore, regular monitoring through repeated post-test assessments proved valuable in evaluating intervention effectiveness and ensuring sustained rehabilitation outcomes. As emphasized by Pratiwi (2023), continuous therapeutic monitoring is essential for maintaining long-term pain reduction and preventing recurrence of occupational low back pain.

Overall, the findings of this study confirm that the combination of TENS and Core Stability Exercise provides significant physiological, functional, and clinical benefits for individuals with myogenic low back pain. The intervention effectively reduced pain intensity, improved spinal stabilization, and enhanced functional ability among traditional coffee bean sorting workers. These results contribute valuable empirical evidence supporting the integration of electrotherapy and exercise therapy in occupational physiotherapy rehabilitation programs, particularly for traditional workers exposed to prolonged static and repetitive physical activities.

CONCLUSION

Based on the results and discussion of this study, it can be concluded that the combination of Transcutaneous Electrical Nerve Stimulation (TENS) and Core Stability Exercise had a highly significant effect on reducing myogenic low back pain among traditional coffee bean sorting workers in Lembang Langda, Sopai District, North Toraja. The intervention demonstrated a consistent and progressive reduction in pain intensity throughout the treatment period. This finding was supported by statistical analysis showing that the mean Visual Analogue Scale (VAS) score decreased substantially from 6.88 during the pre-test to 1.37 at post-test 3, with a significance value of $p < 0.001$. These results indicate that the combined intervention effectively reduced pain perception and improved the respondents' tolerance to occupational musculoskeletal stress caused by prolonged static posture and repetitive lumbar flexion activities.

In addition to reducing pain intensity, the intervention also significantly improved the functional ability of the respondents. This improvement was reflected in the decrease of the mean Oswestry Disability Index (ODI) score from 34.64 at the pre-test stage to 13.24 at post-test 3, with statistical significance of $p < 0.001$. The gradual decline in disability scores indicates that the intervention not only alleviated pain symptoms but also restored physical mobility and functional performance in daily activities. The repeated and structured application of TENS and Core Stability Exercise produced

cumulative therapeutic effects, contributing to better spinal stability, muscular coordination, and postural control.

From a clinical perspective, the integration of TENS and Core Stability Exercise proved to be an effective physiotherapy approach for managing myogenic low back pain in traditional workers. The intervention provided both short-term analgesic effects and long-term functional improvements by enhancing core muscle stability and reducing mechanical stress on the lumbar spine. Consequently, respondents were able to perform daily and occupational activities more effectively without significant movement limitations, ultimately improving their overall quality of life and occupational productivity.

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