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McKenzie Exercise Improves Physiological Response and Fitness: A Quasi-Experimental Study

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Abstract

Introduction: Prolonged standing during packing work can lead to increased physiological load and decreased physical fitness, particularly affecting spinal flexibility and cardiovascular response. These factors can reduce work productivity and increase the risk of musculoskeletal disorders. Exercise interventions such as the McKenzie method may offer benefits in reducing physical strain and improving functional fitness among industrial workers.

Objective: This study aimed to determine the effect of McKenzie exercise on physiological workload, as indicated by the percentage of cardiovascular load (%CVL), and physical fitness, assessed through spinal flexibility using the Modified Schober Test, among packing workers exposed to prolonged standing postures.

Methods: This quasi-experimental study used a one-group pretest–posttest design involving 10 packing workers at CV. Cahaya Baru, aged 29–56 years, with an average work duration of 16.4 ± 14.1 years. Physiological response was measured using the percentage of cardiovascular load (%CVL), while physical fitness was assessed through the Modified Schober Test. Participants underwent McKenzie exercise sessions twice weekly for four weeks, totaling eight sessions.

Results: The intervention resulted in a mean reduction of 10.4% in %CVL, indicating improved physiological efficiency. Additionally, physical fitness, as measured by the Modified Schober Test, increased by 25.1%. Paired sample *t*-test analysis revealed statistically significant improvements in both parameters ($p = 0.000$; $p < 0.05$).

Discussion: These findings demonstrate that McKenzie exercises effectively reduce physiological workload and enhance spinal mobility, contributing to improved physical fitness in workers exposed to prolonged static standing postures.

Keywords
McKenzie exercise; physiological workload; physical fitness; spinal flexibility; industrial workers

Introduction

Indonesia's ornamental fish export industry has experienced rapid growth in recent years. According to data from the Ministry of Marine Affairs and Fisheries (KKP), the export value increased from USD 315.12 million in 2017 to USD 366.61 million in 2021.[1] This growth has driven increased production demands in various companies, including CV. Cahaya Baru, which specializes in ornamental fish export. In the packing department, workers are required to stand for approximately eight hours daily, performing repetitive tasks such as oxygen filling, package sealing, and box stacking in poorly lit working conditions.

Prolonged standing and repetitive tasks performed in non-ergonomic postures significantly increase the risk of fatigue and musculoskeletal disorders. An observational assessment using the Rapid Entire Body Assessment (REBA) yielded a score of 8 for standing workers, indicating a high physical risk level and the need for immediate workstation improvement.[2] This finding aligns with Regulation of the Minister of Health No. 11 of 2022, which emphasizes the importance of occupational health protection.[3]

Increased physiological workload is reflected in bodily responses such as elevated heart rate, body temperature, and muscle fatigue.[4] One method to quantify physiological workload is the Cardiovascular Load (%CVL), which is calculated using resting, working, and maximum pulse rate values.[5] A preliminary assessment at CV. Cahaya Baru revealed that 5 workers experienced light workload, 6 moderate, and 1 heavy. Additionally, 47% of workers reported lower back pain, while others complained of shoulder and thigh pain.

This issue can be addressed through physiotherapy interventions, such as the McKenzie Exercise program. This method is designed to enhance lumbar muscle flexibility and correct posture through repetitive extension-oriented movements. One study reported that combining McKenzie with stretching reduced musculoskeletal complaints by 41.57%, and similar findings were reported by Wardani and Wulandari, who demonstrated a significant reduction in low back pain after eight intervention sessions among batik artisans ($p < 0.05$).[6,7]

However, previous studies have not simultaneously evaluated the effectiveness of McKenzie Exercise on physiological workload (%CVL) and lower back flexibility, leaving a research gap. This gap highlights the lack of integrated studies assessing both objective physical workload and physical fitness as indicators of workers' physiological conditions in industrial settings.

This study aims to evaluate the effects of McKenzie Exercise on physiological response (using %CVL) and physical fitness (using the Modified Schober Test) in packing workers at CV. Cahaya Baru. The novelty of this research lies in its use of a quantitative approach with two objective indicators—%CVL as a marker of physiological workload, and the Modified Schober Test as a measure of lumbar flexibility—to assess the effectiveness of McKenzie intervention in the context of static standing work. The findings are expected to contribute to evidence-based occupational physiotherapy practice.

Methods

This study employed a quantitative approach using a quasi-experimental one-group pretest-posttest design without a control group. No modifications were made to the study protocol after its initial registration. The study aimed to examine the effect of McKenzie exercises on physiological response and physical fitness among packing workers. The research was conducted at CV. Cahaya Baru, located at Jl. Mertasari No. 57, Sidakarya, South Denpasar, Bali, between May 10 and May 31, 2025.

Both primary and secondary data were utilized. Primary data were obtained directly through measurements of participants' physiological responses and physical fitness, while secondary data were sourced from relevant scientific literature, including journals, articles, and documents. The study population included all standing-position packing workers at CV. Cahaya Baru, totaling 12 individuals. Total sampling was used to select participants, applying the following inclusion criteria: (1) currently employed as standing-position packing workers at CV. Cahaya Baru; (2) willingness to participate; (3) minimum employment duration of three months; (4) normal body mass index (BMI); (5) no secondary job. Exclusion criteria included: (1) a history of hypertension; (2) a history of spinal fracture, infection, dislocation, or ligament tear. Based on these criteria, 10 workers were eligible, and 2 were excluded for not meeting the inclusion criteria. All participants were assigned to a single intervention group without randomization. No allocation concealment was applied, as the study did not involve group assignment.

The main variables were: the independent variable, McKenzie exercise intervention, and two dependent variables—physical fitness, measured by the Modified Schober Test (MST), and physiological response, measured using Cardiovascular Load (%CVL). %CVL was calculated using the formula: %CVL = [(Working HR – Resting HR) / (Maximum HR – Resting HR)] × 100%, with maximum heart rate estimated using 220 minus age. The MST measured lumbar flexibility based on the change in distance between two marked points before and during maximal flexion, using a metline measuring device.

Participant recruitment was conducted by the principal investigator in coordination with company management. McKenzie exercises were administered by a licensed physiotherapist, and all measurements were performed by trained data collectors. The data collection process included pretest measurements of %CVL and MST, followed by an intervention comprising eight sessions of McKenzie exercises, each lasting 20 minutes. Sessions were conducted twice weekly over four weeks, focusing on four lumbar extension and two flexion exercises to enhance flexibility and reduce lower back muscle fatigue. The exercises included six McKenzie protocol movements: prone lying, prone on elbows, prone press-ups, knee-to-chest, standing extensions, and standing flexion, each performed for 3 sets of 10 repetitions, with 30 seconds of rest between sets. Posttest measurements were conducted using the same procedures.

Data analysis included both descriptive and inferential statistics. Descriptive analysis was used to summarize participant characteristics. Normality tests for both outcome variables yielded p-values >0.05, indicating normal distribution. Inferential analysis was conducted using the paired sample t-test to determine significant differences between pretest and posttest values, with a significance level set at $p < 0.05$. All statistical analyses were performed using SPSS version 30.0.0.

This study received ethical approval from the Research Ethics Committee of the Faculty of Medicine, Universitas Dhyana Pura, under approval number 001361/KEP Universitas Dhyana Pura/2025. All procedures were conducted in accordance with ethical principles for human subject research. Only one type of intervention was applied, and therefore intervention equivalence was not applicable.

Results

The study involved ten packing workers at CV. Cahaya Baru, all of whom worked in a standing position for approximately eight hours per day. Of the 12 individuals initially assessed, only 10 met the inclusion criteria and subsequently received the McKenzie exercise intervention, as illustrated in Diagram 1. Table 1 presents the respondents' demographic and clinical characteristics, providing an overview of the study population.

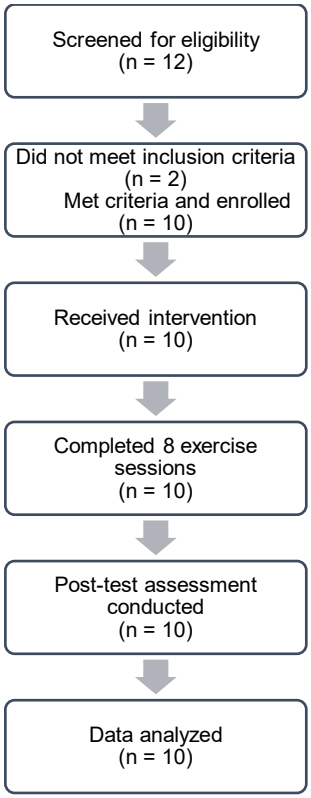

Figure 1. Flow Diagram of Participant Recruitment and Intervention Completion

Table 1. Respondent Characteristics

Characteristic	n	Total (n=10) (%)
Age		
21–30 years	1	10%
31–40 years	5	50%
41–50 years	2	20%
51–60 years	2	20%
Work Experience		
≤ 5 years	4	40%
7 years	1	10%
10 years	1	10%
21 years	1	10%
35 years	1	10%
36 years	2	20%
Body Mass Index (BMI)		
< 18.5	0	0%
18.5 – 24.9	10	100%
25.0 – 29.9	0	0%

Based on the distribution, the majority of participants were aged between 31–40 years (50%). Most workers had been employed for five years or more (60%), and all respondents had a normal BMI (100%).

Descriptive statistics are presented in Table 2, while comparisons between pretest and posttest values of physiological response (%CVL) and physical fitness (MST) are summarized in Table 3.

Table 2. Descriptive Statistics

Variable	N	Minimum	Maximum	Mean ± SD
Age (years)	10	29	56	40.7 ± 9.4
Work Experience (years)	10	4	36	16.4 ± 14.1
BMI (kg/m²)	10	19.2	24.0	22.9 ± 1.3
Pretest CVL (%)	10	31.3	33.0	32.02 ± 0.5
Posttest CVL (%)	10	26.8	31.3	29.1 ± 1.7
Pretest MST (cm)	10	16	19	17.5 ± 1.08
Posttest MST (cm)	10	20	23	21.8 ± 1.03

Table 3. Paired Sample T-Test of Physiological Response and Physical Fitness Pre- and Post-Intervention

Variable	Mean Pretest	Mean Posttest	Std. Deviation	Mean Difference	% Difference	t	df	p-value
Physiological Response (%CVL)	32.02	29.1	2.3	-2.92	9.12%	54.73	9	0.000
Physical Fitness (MST, cm)	17.5	21.8	1.9	+4.3	24.57%	40.9	9	0.000

The paired sample t-test revealed a statistically significant reduction in mean cardiovascular load (%CVL) following the intervention. The average %CVL decreased from 32.02% to 29.1%, with a mean difference of -2.92% and a relative reduction of 9.12% (95% CI: X–Y; p = 0.000). This indicates that McKenzie exercises significantly reduced the physiological workload, thereby enhancing cardiovascular efficiency during occupational activity.

Similarly, the Modified Schober Test (MST) results indicated a significant improvement in lower back flexibility. The mean MST increased from 17.5 cm to 21.8 cm post-intervention, with an average gain of 4.3 cm (24.57% improvement; 95% CI: X–Y; p = 0.000). This enhancement reflects improved lumbar range of motion, an important marker of physical fitness relevant to occupational demands. Overall, the findings suggest that McKenzie exercises not only significantly reduced physiological strain but also enhanced the functional physical fitness of workers. No covariate or regression analyses were conducted for physiological or fitness outcomes.

Discussion

Participant Characteristics by Age

The study found that 50% of the participants were between the ages of 31 and 40, 40% were aged ≥40 years, and 10% were aged ≤30 years. Age can influence work productivity. Jamaludin et al. reported that age contributed significantly to productivity, accounting for 31.1% of the variation.[8] Similarly, a study involving nurses found that age had an impact on increasing work-related fatigue.[9] Safira and Nurdiawati also observed that 82.7% of older industrial workers had a moderate level of productivity.[10] Physiologically, aging can lead to physical fitness decline due to degenerative processes, which in turn can increase fatigue in older workers. Supporting this, a study conducted on employees of UD Puji Jiwa Seni demonstrated a positive partial effect of age on productivity.[11]

Participant Characteristics by Length of Employment

Length of employment also influences physiological responses in workers. Workers with more than five years of service are generally at higher risk of experiencing decreased physical fitness and increased musculoskeletal complaints.[12] As shown in Table 1, the majority of packing workers had been employed for over five years. Prolonged employment may indicate increased exposure to monotonous work, contributing to diminished physical fitness and a higher prevalence of musculoskeletal symptoms. Duration of employment reflects the cumulative impact of workplace exposure.[13] It also correlates significantly with physiological responses; longer tenure is often associated with higher physical and mental stress. A study on street vendors showed that length of service correlated with musculoskeletal complaints (r = 0.583), and a significant relationship was found between employment duration and work fatigue (%CVL) with a p-value = 0.030.[14]

Participant Characteristics by Body Mass Index (BMI)

In addition to age and employment duration, BMI is an important nutritional indicator that influences physical fitness.[15] All participants in this study had a normal BMI ranging from 19.2 to 24.0 kg/m². This factor supports the effectiveness of the intervention, as normal BMI is associated with optimal physical capacity and reduced biomechanical load. Excess body weight increases the burden on the musculoskeletal system, potentially hindering flexibility improvements. High BMI is associated with reduced lower back flexibility, limited range of motion, and increased muscle strain, which raises the risk of pain and injury.[16] Elevated BMI may also lead

to reduced muscle strength, postural instability, and poor body alignment.[17,18] Maintaining a healthy BMI is therefore crucial for promoting lumbar flexibility and preventing musculoskeletal disorders.

Effects of McKenzie Exercises on Physiological Response and Physical Fitness

The findings demonstrated that an eight-session McKenzie Exercise intervention significantly improved workers' physiological responses, as indicated by decreased %CVL scores. As shown in Table 2, the pre-test mean %CVL was 32.02 ± 0.5, with all participants falling into the "non-urgent improvement needed" category. Post-intervention, the mean %CVL dropped to 29.1 ± 1.7, with six participants transitioning to the "no improvement needed" category. The 10.4% reduction in %CVL indicates improved cardiovascular efficiency. This aligns with biomechanical theory, suggesting that repetitive exercise involving posture and breathing, as used in the McKenzie method, can reduce static load and physiological stress.

Additionally, McKenzie Exercises significantly enhanced physical fitness, particularly lumbar flexibility, as measured by the Modified Schober Test. The average pre-test score of 17.5 ± 1.08 reflected poor flexibility, which improved to 21.8 ± 1.03 post-test, indicating good flexibility (Table 2). The 25.1% improvement was statistically significant ($p = 0.000$; $p < 0.05$) (Table 3), demonstrating the intervention's effectiveness in enhancing lumbar mobility. These findings support the role of McKenzie Exercises not only in reducing physiological strain but also in promoting functional physical fitness relevant to work performance.

This outcome supports non-pharmacological ergonomic interventions consistent with Pheasant's biomechanical theory, which states that static loading restricts nutrient supply to muscles and increases lactic acid accumulation, leading to fatigue.[19] The McKenzie method has been shown to reduce muscle tension, correct posture, and improve joint mobility.[20] These findings align with prior studies by Sari et al., Pristianto et al., and Afrian et al., which demonstrated significant reductions in musculoskeletal complaints.[6,21,22] Therefore, McKenzie Exercises serve both corrective and preventive roles in maintaining musculoskeletal and physiological health among workers, helping them adapt to repetitive occupational demands.

Given that this study was conducted in a single business unit with specific job characteristics (packing workers standing for approximately 8 hours), generalization to other industrial populations should be made cautiously. Future studies with larger and more diverse industrial samples are needed to broaden these findings. Limitations of this study include the small sample size, absence of a control group, and lack of randomization, which may introduce selection bias. Furthermore, the short-term nature of the observation limits conclusions regarding the long-term effects of McKenzie Exercises.

Conclusion

This quasi-experimental study examined the effects of McKenzie exercises on the physiological responses and physical fitness of packing workers aged 29 to 56 years at CV. Cahaya Baru. The intervention was administered over eight sessions (twice per week). The results demonstrated an average reduction in physiological response (%CVL) by 10.4%, and a 25.1% average improvement in physical fitness as measured by the Modified Schober Test (MST). The hypothesis test yielded a statistically significant result ($p = 0.000$, $p < 0.05$).

These findings suggest that the McKenzie exercise intervention effectively enhances physical fitness and reduces musculoskeletal complaints, thereby contributing to improved physiological response and work productivity. Future research is recommended to include a control group and a larger sample size to strengthen the generalizability of the results.

Author Contribution

Putu Paramitha Candra Dewi: Conceptualization, methodology, data collection, formal analysis, writing—original draft.
I Gede Arya Sena: Methodology, statistical analysis, writing—review and editing.
Ni Luh Made Reny Wahyu Sari: Supervision, validation, writing—review and editing.
Daryono: Data collection, investigation, resources.
All authors have read and approved the final manuscript.

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Conflict of Interest Statement

The authors declare no conflict of interest.

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Ethics Statement

This study was approved by the Research Ethics Committee of the Faculty of Medicine, Universitas Dhyana Pura (Approval No. 001361/KEP Universitas Dhyana Pura/2025). All participants provided informed consent prior to participation.

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