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Effectiveness Of Red Ginger Herbal Beverage As A Biomarker-Based Occupational Health Intervention On Blood Lactic Acid Levels Among Trans Metro Pekanbaru Bus Drivers With Low Back Pain

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Abstract
Low back pain (LBP) is one of the most common musculoskeletal disorders among transportation workers, particularly bus drivers. Prolonged sitting posture, non-ergonomic working conditions, and continuous exposure to whole-body vibration contribute to impaired muscle perfusion and increased anaerobic metabolism, resulting in elevated blood lactate levels. Red ginger (Zingiber officinale var. rubrum) contains bioactive compounds such as gingerol and shogaol, which possess anti-inflammatory, antioxidant, and vasodilatory properties that may facilitate lactate clearance and reduce muscle pain. To evaluate the effectiveness of red ginger beverage on blood lactate levels among bus drivers with low back pain. This study used a quasi-experimental design with a pretest-posttest control group approach. A total of 60 Trans Metro Pekanbaru bus drivers with LBP were divided into an intervention group (n=30) and a control group (n=30). The intervention group received a red ginger beverage containing 10 g of red ginger in 100 mL of solution, while the control group received a beverage without the active components of red ginger. Blood lactate levels were measured before and after the intervention using the Accutrend® Plus device. Data normality was assessed using the Shapiro–Wilk test. Within-group differences were analyzed using the Wilcoxon signed-rank test, while between-group differences were analyzed using the independent t-test and Mann–Whitney test. Before the intervention, mean blood lactate levels were relatively comparable between the intervention group and the control group, with values of 3.01±0.65 mmol/L and 2.98±0.66 mmol/L, respectively. There was no significant difference in baseline blood lactate levels between the two groups (p=0.841 by Mann–Whitney test). After the intervention, blood lactate levels decreased in both groups. The intervention group showed a greater reduction, from 3.01±0.65 mmol/L to 1.99±0.31 mmol/L, with a mean decrease of 1.02±0.45 mmol/L. In the control group, blood lactate levels decreased from 2.98±0.66 mmol/L to 2.59±0.58 mmol/L, with a mean decrease of 0.39±0.22 mmol/L. The Mann–Whitney test showed a significant difference in post-intervention blood lactate levels between the intervention and control groups (p<0.001), with lower lactate levels observed in the intervention group. The administration of red ginger beverage had an effect on reducing blood lactate levels among TMP bus drivers with low back pain. The reduction in blood lactate levels was greater in the intervention group than in the control group, suggesting that red ginger beverage has the potential to be used as a supportive non-pharmacological intervention to reduce muscle pain among bus drivers with low back pain.

Keywords: ***Red Ginger, Low Back Pain, Blood Lactate, Bus Driver***

INTRODUCTION

Low back pain (LBP) is one of the musculoskeletal complaints commonly found among transportation workers, particularly professional drivers. Bus drivers are a group of workers at high risk of developing musculoskeletal complaints due to prolonged sitting duration, static working posture, poor ergonomic posture, repetitive activities, and exposure to whole-body vibration during driving. A systematic review among professional drivers showed that musculoskeletal complaints have a high prevalence, with the lower back being the most frequently reported body region (Joseph et al., 2020). Among bus drivers, long-term exposure to mechanical vibration has also been reported to contribute to an increased risk of complaints in the lumbar region (Mendes et al., 2021).

Physiologically, prolonged static sitting and exposure to vehicle vibration may increase mechanical load on the lower back muscles. This condition may lead to continuous muscle contraction, interfere with work comfort, and contribute to muscle fatigue. One objective indicator that can be used to assess metabolic responses related to muscle fatigue is blood lactate level. Blood lactate measurement has been widely used to estimate the contribution of anaerobic metabolism to energy expenditure and to help assess fatigue responses after physical activity or intensive muscular work (Theofilidis et al., 2018). Persistent lactate accumulation after strenuous activity may be associated with decreased work capacity and delayed physical recovery (Huang et al., 2025.

The management of LBP and muscle fatigue among bus drivers requires not only ergonomic improvements, appropriate rest scheduling, stretching, hydration, and control of vibration exposure, but may also be supported by safe, simple, and easily applicable non-pharmacological interventions. One herbal ingredient with potential use is red ginger (*Zingiber officinale* var. *rubrum*). Red ginger is widely used in traditional medicine in Asia and is known to contain various bioactive compounds, such as vanilloids, monoterpenes, sesquiterpenes, flavonoids, and other constituents (Zhang et al., 2022). In general, the biological benefits of ginger are largely associated with phenolic compounds, particularly gingerols and shogaols, which possess antioxidant and anti-inflammatory activities (Mao et al., 2019).

The antioxidant and anti-inflammatory activities of red ginger may support muscle recovery by reducing oxidative stress and modulating inflammatory responses related to fatigue and muscle pain. Several previous studies have discussed the potential of ginger in reducing pain and supporting physical recovery; however, studies specifically evaluating the effect of red ginger herbal beverage on blood lactate levels among bus drivers with LBP remain limited. Therefore, this study was conducted to analyze the effect of red ginger herbal beverage administration on blood lactate levels among Trans Metro Pekanbaru bus drivers with low back pain.

RESEARCH METHODS

Research Design

This study employed a quasi-experimental design with a pretest-posttest control group approach. A quasi-experimental design was selected because the study aimed to evaluate the effect of an intervention in a real occupational setting, where full randomization may be difficult to implement. The pretest-posttest control group design allowed the researchers to measure blood lactate levels before and after the intervention in both the intervention and control groups, enabling comparison of within-group changes and between-group differences after the intervention.

The study involved two groups: an intervention group receiving a red ginger beverage and a control group receiving a beverage without the active components of red ginger. Blood lactate levels were measured before the intervention as baseline data and after the intervention to assess changes following treatment. This design enabled the researchers to determine whether the reduction in blood lactate levels was greater in the red ginger group than in the control group.

The research design can be illustrated as follows:

Intervention group : $O_1 \rightarrow X \rightarrow O_2$

Control group : $O_3 \rightarrow C \rightarrow O_4$

O_1 and O_3 represent pretest blood lactate measurements, O_2 and O_4 represent posttest blood lactate measurements, X represents the administration of red ginger beverage, and C represents the control beverage.

Research Location and Time

The study was conducted among Trans Metro Pekanbaru bus drivers in 2025.

Population and Sample

The population of this study consisted of Trans Metro Pekanbaru bus drivers with low back pain. A total of 60 respondents were included and divided into an intervention group and a control group, with 30 respondents in each group. The intervention group received a red ginger beverage, while the control group received a beverage without the active components of red ginger. Both groups underwent blood lactate measurement before and after the intervention using the Accutrend® Plus device. The control group was used to compare natural changes in blood lactate levels and to determine whether the reduction was greater in the red ginger grou

Randomization and Blinding

Participants were allocated into the intervention and control groups using a paired allocation approach based on baseline pain intensity to ensure comparability between groups. This study did not employ formal random sequence generation or allocation concealment; therefore, it was categorized as a quasi-experimental study with a pretest-posttest control group design, rather than a randomized controlled trial. Blinding was applied at the outcome assessment level, in which the blood lactate assessor was unaware of the participants' group allocation.

Inclusion Criteria

The inclusion criteria for this study are bus drivers registered as active drivers of Trans Metro Pekanbaru Bus, present at the time the study is conducted, willing to participate as respondents by signing informed consent, cooperative in following all study procedures, and experiencing low back pain based on assessment using the VAS scale. The respondents included are drivers aged 25–65 years, still actively working or driving, willing to undergo blood lactate level measurements before and after the intervention, and have not consumed red ginger herbal drinks, ergogenic supplements, or energy drinks within the last 24 hours before the study.

Exclusion Criteria

The exclusion criteria for this study are drivers with a history of allergy or hypersensitivity to red ginger; a history of intolerance to red ginger, such as severe nausea, vomiting, diarrhea, or severe epigastric pain after consuming ginger; metabolic diseases such as diabetes mellitus, severe kidney disorders, severe liver disorders, or other metabolic diseases that may affect lactate levels. Drivers are also excluded from the study if they are experiencing an acute illness, such as fever, acute infection, diarrhea, vomiting, or dehydration, have a history of specific or severe spinal disorders or severe neurological disorders, have an acute musculoskeletal injury, regularly take analgesics, anti-inflammatory drugs, muscle relaxants, corticosteroids, or other medications that may affect pain and muscle metabolism, engage in strenuous physical activity before the examination; or are unwilling to complete all study procedures.

Dropout Criteria

Respondents are considered dropouts if they withdraw during the study, do not complete all blood lactate level measurements, experience complaints after consuming the study beverage such as severe nausea, vomiting, diarrhea, severe abdominal pain, shortness of breath, itching, or allergic reactions, consume analgesics, anti-inflammatory drugs, ergogenic supplements, or energy drinks during the study period, or fail to finish the intervention beverage or control beverage in accordance with the study protocol.

RESULTS AND DISCUSSION

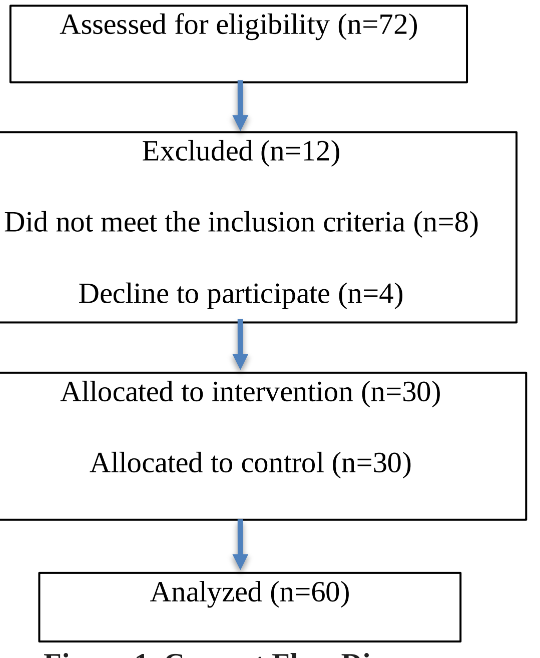

Figure 1. Consort Flow Diagram

Table 1. Lactic Acid Levels in the Intervention Group and Control Group

	Group	Mean	Median	SD	95% CI	Minimum	Maximum	Range
Before Intervention	Intervention	3,01	3,05	0,65	2,77–3,25	2,00	4,50	2,50
After Intervention	Intervention	1,99	1,90	0,31	1,87–2,10	1,50	2,80	1,30
Lactate reduction	Intervention	1,02	1,00	0,45	0,85–1,19	0,30	2,10	1,80
Before Intervention	Control	2,98	2,95	0,66	2,74–3,23	2,00	4,50	2,50
After Intervention	Control	2,59	2,65	0,58	2,38–2,81	1,80	3,60	1,80
Lactate reduction	Control	0,39	0,35	0,22	0,31–0,47	0,10	0,90	0,80

Notes:

Lactic acid concentration unit: mmol/L.

The decrease was calculated by subtracting the lactic acid concentration after the intervention from the lactic acid concentration before the intervention.

The descriptive analysis showed that pre-intervention blood lactate levels were relatively comparable between the intervention and control groups. The mean pre-intervention blood lactate level in the intervention group was **3.01±0.65 mmol/L**, while that in the control group was **2.98±0.66 mmol/L**. After the intervention, blood lactate levels decreased in both groups, with a greater reduction observed in the intervention group. The mean post-intervention blood lactate level in the intervention group was **1.99±0.31 mmol/L**, compared with **2.59±0.58 mmol/L** in the control group.

Table 2. Normality Test of Lactic Acid Levels

Variable	Group	Shapiro–Wilk p-value	Interpretation
Before Intervention	Control	0,399	Normal
Before Intervention	Intervention	0,232	Normal
After Intervention	Control	0,051	Normal
After Intervention	Intervention	0,025	Non-normal

Note:

Data are normally distributed if p > 0.05. Because some data were not normally distributed, bivariate analysis was performed using a nonparametric test.

The Shapiro–Wilk normality test showed that one dataset was not normally distributed, namely the post-intervention blood lactate level in the intervention group, with a p-value of 0.025. Therefore, bivariate analysis was performed using non-parametric tests, namely the Mann–Whitney test to compare blood lactate levels between the intervention and control groups, and the Wilcoxon Signed-Rank Test to compare blood lactate levels before and after the intervention within each group.

Table 3. Comparison of Lactic Acid Levels between the Intervention and Control Groups

Measurement Time	Group	N	Mean Rank	Mann–Whitney U	p-value
Before Intervention	Control	30	30,05	436,5	0,841
	Intervention	30	30,95		
After Intervention	Control	30	39,65	175,5	<0,001
	Intervention	30	21,35		

Note:

The Mann–Whitney test was used to compare blood lactate levels between the intervention and control groups. Before the intervention, there was no significant difference between the two groups. After the intervention, a significant difference was found between the intervention and control groups.

The Mann–Whitney test showed no significant difference in blood lactate levels between the intervention and control groups before the intervention (p=0.841). After the intervention, there was a significant difference in blood lactate levels between the two groups (p<0.001), with lower lactate levels observed in the intervention group.

Table 4. Differences in Lactic Acid Levels Before and After the Intervention Within Each Group

Group	Before Intervention, Mean ± SD	After Intervention, Mean ± SD	Lactate Reduction, Mean ± SD	Statistical Test	p-value
Intervention	3,01 ± 0,65	1,99 ± 0,31	1,02 ± 0,45	Wilcoxon Signed-Rank Test	<0,001
Control	2,98 ± 0,66	2,59 ± 0,58	0,39 ± 0,22	Wilcoxon Signed-Rank Test	<0,001

Note:

The Wilcoxon Signed-Rank Test was used to assess differences in lactic acid levels before and after the intervention within each group.

The Wilcoxon Signed-Rank Test showed that blood lactate levels decreased significantly after the intervention in both the intervention and control groups (p<0.001).

Discussion

The results showed that lactic acid levels before the intervention were relatively comparable between the intervention and control groups. The mean lactic acid level before the intervention was 3.01 ± 0.65 mmol/L in the intervention group and 2.98 ± 0.66 mmol/L in the control group. The Mann–Whitney test also showed no significant difference between the two groups before the intervention, with a p-value of 0.841. This finding indicates that the baseline lactic acid levels of the two groups were relatively comparable, allowing changes in lactic acid levels after the intervention to be compared more objectively.

After the intervention, lactic acid levels decreased in both groups. In the intervention group, the mean lactic acid level decreased from 3.01 ± 0.65 mmol/L to 1.99 ± 0.31 mmol/L, with a mean reduction of 1.02 ± 0.45 mmol/L. Meanwhile, in the control group, lactic acid levels decreased from 2.98 ± 0.66 mmol/L to 2.59 ± 0.58 mmol/L, with a mean reduction of 0.39 ± 0.22 mmol/L. Descriptively, the reduction in lactic acid levels was greater in the intervention group than in the control group. The Wilcoxon test showed that the reduction in lactic acid levels in both groups was statistically significant, with p < 0.001. Blood lactate has been widely used as a biomarker to help characterize the contribution of anaerobic metabolism and the muscle fatigue response, particularly after physical activity or intensive muscular work (Theofilidis et al., 2018; Huang et al., 2025).

The Mann–Whitney test after the intervention showed a significant difference in lactic acid levels between the intervention and control groups, with $p < 0.001$. Post-intervention lactic acid levels were lower in the intervention group than in the control group, at 1.99 ± 0.31 mmol/L compared with 2.59 ± 0.58 mmol/L. This finding indicates that the administration of a red ginger herbal drink was associated with a greater reduction in lactic acid levels among bus drivers experiencing low back pain. This result is consistent with previous research among oil palm harvesters, which showed a reduction in mean lactic acid levels after the administration of a red ginger herbal drink, thereby supporting the potential of red ginger as a herbal-based intervention for workers experiencing physical fatigue (Pratiwi & Utami, 2025).

Physiologically, bus drivers are a group of workers at risk of muscle fatigue and musculoskeletal complaints due to prolonged static sitting, non-ergonomic working postures, and exposure to whole-body vibration from vehicles. A systematic review of professional drivers showed that low back pain was the most frequently reported musculoskeletal complaint, with risk factors including prolonged sitting, whole-body vibration, awkward postures, and repetitive activities (Joseph et al., 2020). Among bus drivers, prolonged exposure to mechanical vibration has also been reported to be associated with an increased risk of complaints in the lumbar region (Mendes et al., 2021). These conditions may cause continuous contraction of the lower back muscles, impair local blood flow, and reduce oxygen supply to muscle tissue. When oxygen supply is insufficient, muscle metabolism may shift toward anaerobic pathways, resulting in increased lactate production. Persistent lactate accumulation may contribute to muscle fatigue, reduced performance, and discomfort after work activities (Theofilidis et al., 2018; Huang et al., 2025).

The greater reduction in lactic acid levels in the intervention group may be related to the bioactive constituents of red ginger, such as gingerol, shogaol, paradol, and zingerone. Red ginger (Zingiber officinale var. rubrum) has been reported to contain various bioactive compounds, including vanilloids, monoterpenes, sesquiterpenes, flavonoids, and other compounds that contribute to its biological activities (Zhang et al., 2022). The bioactive compounds in ginger are known to have antioxidant and anti-inflammatory activities that may contribute to reducing oxidative stress and inflammatory responses associated with pain and muscle fatigue (Mao et al., 2019; Crichton et al., 2023). In addition, clinical reviews indicate that ginger may play a role in pain modulation through several mechanisms, such as inhibition of prostaglandin pathways, antioxidant activity, and modulation of inflammatory responses (Rondanelli et al., 2020). Thus, a red ginger herbal drink may have the potential to support muscle metabolic recovery in workers with static workloads, such as bus drivers.

Although the control group also experienced a reduction in lactic acid levels, the magnitude of the reduction was smaller than that in the intervention group. The reduction in the control group may have occurred due to natural physiological factors, such as rest during the measurement period, hydration, adaptation after driving activity, or the body's natural lactate clearance process. Lactate is not merely an end product of anaerobic metabolism but can also be metabolized and reused as an energy substrate during recovery (Huang et al., 2025). In addition, blood lactate levels may be influenced by the timing of sample collection, the sampling site, and activity conditions before testing (Yamagata et al., 2018). This indicates that some reduction in lactic acid levels may occur without the administration of red ginger. However, the significant difference in post-intervention lactic acid levels between the two groups indicates that the reduction in the intervention group was more pronounced than that in the control group.

Overall, the results of this study indicate that the administration of a red ginger herbal drink was associated with a greater reduction in lactic acid levels than in the control group among bus drivers experiencing low back pain. These findings support the potential of red ginger as a biomarker-based, herbal occupational health intervention to help reduce muscle fatigue among transportation workers.

Strengths of the Study

The strength of this study lies in its pretest-posttest control group design, which allowed clearer comparison of changes in lactic acid levels before and after the intervention between the red ginger group and the control group. The use of lactic acid as an objective biomarker of muscle fatigue also strengthened the scientific value of the study, as the outcome was not solely based on subjective complaints. In addition, the study was conducted in a relevant occupational setting among bus drivers with low back pain, supporting its practical implications for occupational health.

Limitations of the Study

This study has several limitations. First, the study was conducted in a single measurement session; therefore, the long-term effects of red ginger drink administration on lactic acid levels and low back pain complaints cannot yet be concluded. Second, the participants' physical activity, dietary patterns, hydration status, sleep quality, and work intensity before measurement could not be fully controlled. Third, this study used only lactic acid levels as a biomarker and therefore could not comprehensively describe the full mechanisms of inflammation and muscle fatigue. Future studies may consider measuring other biomarkers, such as IL-6, TNF-α, creatine kinase, or longitudinal assessments of pain and functional disability.

Implications for Occupational Medicine

The findings of this study have important implications for occupational health, particularly among transportation workers who are at risk of muscle fatigue and low back pain. A red ginger herbal drink may be considered a simple, inexpensive, and easily implemented supportive intervention. However, this intervention should not be regarded as a substitute for ergonomic risk control. Improvements in working posture, regulation of rest periods, muscle stretching, adequate hydration, and control of vibration exposure remain important components in preventing musculoskeletal complaints among bus drivers. This is consistent with evidence that active work breaks and changes in posture may help reduce discomfort and low back complaints among workers (Waongenngarm et al., 2018).

CONCLUSIONS

This study demonstrated that the administration of a red ginger beverage was associated with a greater reduction in lactic acid levels compared with the control group. The intervention group showed a marked decrease in mean lactic acid levels after red ginger administration, while the control group experienced only a smaller physiological reduction. These findings suggest that red ginger beverage may serve as a supportive non-pharmacological intervention to help reduce muscle fatigue among workers, particularly those exposed to static or repetitive workloads. However, its use should complement, not replace, ergonomic improvements, adequate rest, hydration, and occupational risk control. Further studies with larger samples and standardized red ginger formulations are recommended to strengthen the evidence.

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