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Supporting post-exercise recovery in adolescent soccer players: A study of a locally formulated recovery drink

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ABSTRACT

Background: Adolescent athletes are prone to exercise-induced fatigue, making effective recovery strategies essential. Although carbohydrate–protein beverages support recovery, most studies focus on commercial products, while the potential of local ingredients such as *pisang raja* and *gulo puan* in Indonesia remains underexplored. **Research Objectives:** This study aimed to analyze the effects of a homemade recovery drink (HRD) formulated from low-fat milk, cocoa powder, *pisang raja*, and *gulo puan* on the physical recovery of adolescent soccer athletes. **Methods:** A quasi-experimental design was conducted with student-athletes (aged 15–17 years) from Sekolah Olahraga Negeri Sriwijaya Palembang, divided into a control group (placebo, n = 10) and an intervention group (HRD, n = 10). The intervention was administered in a single-blind manner, with two doses provided during a 2-hour recovery window. Data collected included blood pressure, heart rate, and blood glucose. **Finding/Results:** The results showed no significant differences in blood pressure between the HRD and placebo groups ($p > 0.05$). However, significant differences were found in post-recovery heart rate and blood glucose levels ($p < 0.05$). The HRD group showed significantly higher post-recovery blood glucose levels (95 ± 5.77 vs. 88.5 ± 6.49 mg/dL, $p = 0.022$), and heart rate in this group returned closer to baseline compared to the placebo. **Conclusion:** The findings suggest that an HRD formulated from culturally relevant, locally sourced ingredients can effectively support post-exercise recovery in adolescent athletes by maintaining cardiovascular stability and blood glucose levels. This study highlights the potential of traditional Indonesian foods as affordable, accessible alternatives to commercial recovery products.

Keywords: Adolescent athlete; physical recovery; recovery drink

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INTRODUCTION

The recovery phase is essential for the body to restore and replenish components lost during physical training and to prevent rapid fatigue responses, particularly in adolescents undergoing both intense physical activity and active growth phases. Endurance sports, including soccer, are significantly influenced by the body's ability to utilize nutrients during prolonged exercise (Ravindra et al., 2022). Adolescents aged 13-18 years are especially vulnerable to the adverse effects of suboptimal nutrient intake, which may impair physical performance and developmental processes (Desbrow, 2021). Inadequate post-exercise nutrition can result in prolonged fatigue, delayed recovery, and increased risk of overtraining and illness (Bingham & Borkan, 2015). One of the primary physiological responses following exercise is a decline in blood glucose levels, which contributes to fatigue. Carbohydrate intake has been shown to improve glucose availability and reduce fatigue, thereby supporting better recovery outcomes (Flockhart & Larsen, 2023; Russell et al., 2014). These findings underscore the importance of implementing appropriate nutritional strategies to optimize recovery and maintain performance in adolescent athletes.

The recovery process is closely linked to the timely intake of key nutrients. Carbohydrates are crucial for replenishing muscle glycogen that is depleted during prolonged physical activity, while protein supports muscle repair and adaptation following exercise-induced damage. A combination of these macronutrients has been shown to accelerate muscle recovery, reduce soreness, and restore energy levels for subsequent performance. In addition, micronutrients such as vitamins and minerals particularly antioxidants help reduce exercise-induced oxidative stress and inflammation, further supporting physiological recovery (Bonilla et al., 2021; Peake, 2019; Ravindra et al., 2022). Cocoa powder, rich in polyphenols and flavonoids, has also been shown to reduce oxidative stress and improve endothelial function post-exercise (Teixeira et al., 2020). Beverages combining carbohydrates and protein are often preferred due to their rapid digestibility and dual-action benefits. Milk-based recovery drinks are increasingly popular because they deliver both macronutrients and electrolytes that aid rehydration, muscle repair, and glycogen restoration (Alcantara et al., 2019; Amiri et al., 2019; Born et al., 2019; Potter & Fuller, 2015; Rankin et al., 2018; Wadey et al., 2018). Optimal post-exercise nutrition, therefore, plays a multifaceted role in maintaining health and performance in adolescent athletes.

Although carbohydrate-protein recovery drinks have been widely studied, most research focuses on commercial formulations like whey shakes (McKinlay et al., 2020; West et al., 2017) or protein bars (Grubic et al., 2019; Jovanov et al., 2021), which may not be accessible or culturally suitable for athletes in low-resource settings. In Indonesia, traditional food components such as *pisang raja* and *gulo puan* offer promising nutritional profiles for recovery applications but have not been systematically investigated. *Pisang raja* contribute fast-absorbing carbohydrates (glucose, fructose, sucrose) and potassium, which support energy restoration and muscle function while helping regulate heart rate (Kumari et al., 2023; Lone et al., 2017; Naderi et al., 2023; Nieman et al., 2018). Compared to other banana types, *pisang raja* offers higher potassium and carbohydrate content, making it especially suitable for adolescent athletes (Wulandari et al., 2018). *Gulo puan*, on the other hand, a traditional South Sumatran sweet made from sugar and buffalo milk, provides an additional source of carbohydrates, protein, and essential minerals such as phosphorus and calcium, enriching the drink's nutritional profile with locally sourced ingredients (Ningsih et al., 2024; Yuliati & Hamzah, 2022). Despite their nutritional potential, these local ingredients have not been utilized in structured recovery interventions for adolescent athletes. This study therefore sought to develop a recovery drink using ingredients native to South Sumatra, not only to leverage their nutritional benefits but also to provide a culturally appropriate, affordable, and accessible option for adolescent athletes in the region. The inclusion of *gulo puan*, a traditional South Sumatran product, reflects the study's commitment to promoting local food heritage while addressing the recovery needs of youth athletes.

Therefore, this study aimed to evaluate the effects of a locally formulated carbohydrate-protein recovery drink composed of low-fat milk, *pisang raja*, cocoa powder, and *gulo puan* on physical recovery indicators in adolescent male soccer players. Specifically, the study assessed changes in blood glucose, blood pressure, and heart rate across recovery phases following exercise. By integrating locally sourced ingredients with known recovery benefits, this research offers a culturally relevant, low-cost alternative to commercial recovery drinks. The formulation of this drink reflects both scientific rationale and local food heritage, making it particularly suitable for youth athletes in South Sumatra and similar contexts. This study contributes to the limited body of literature on functional recovery beverages based on traditional Indonesian ingredients and their impact on post-exercise physiological recovery.

METHOD

Time, Place, Participants

This research was conducted using a quasi-experimental design with a pretest-posttest control group approach. The intervention was administered to two groups: the intervention group, which received the healthy recovery drink, and the control group, which received a placebo. Each group consisted of 10 student-athletes from Sekolah Olahraga Negeri Sriwijaya Palembang, who were selected based on predetermined inclusion and exclusion criteria. The inclusion criteria included male students aged 15-18 years who resided in dormitories, were members of the soccer team, were non-smokers, did not consume alcohol, were not lactose intolerant, and had no allergies to any ingredients in the healthy recovery drink. The total sample size of 20 participants (10 per group) was determined using the Lemeshow formula for sample size calculation in field studies with finite populations. The calculation assumed a 95% confidence level and an estimated proportion based on previous studies of post-exercise recovery in adolescent athletes.

Procedures

The intervention procedure and variable measurements were adapted from Kailaku (2016) and Dow et al. (2019). Subjects were randomly assigned to either the intervention group (healthy recovery drink) or the control group (placebo: low-fat milk + water with the addition of chocolate flavoring, banana flavoring, and dark brown food coloring). The intervention was conducted on a single day after regular school activities had concluded. Subjects were instructed to refrain from consuming any foods or beverages containing milk or dairy products prior to the exercise session, to prevent interference with the recovery drink intervention. Other dietary intake was not restricted. Subjects were required to arrive in a rested state and were instructed to avoid consuming caffeinated beverages such as tea and coffee, as well as B-complex vitamin supplements, for 24 hours before the intervention. The 90-minute training session focused on tactical and strategic components of football, including position-specific drills, small-sided tactical games, and situational exercises directed by the coach. The session reflected the team’s regular weekly training plan and was conducted at moderate to high intensity. To maintain stable hydration status, subjects were required to consume 200 mL of mineral water 20 minutes before the training session. However, hydration status was not objectively measured before or after exercise, which may limit interpretation of cardiovascular recovery outcomes.

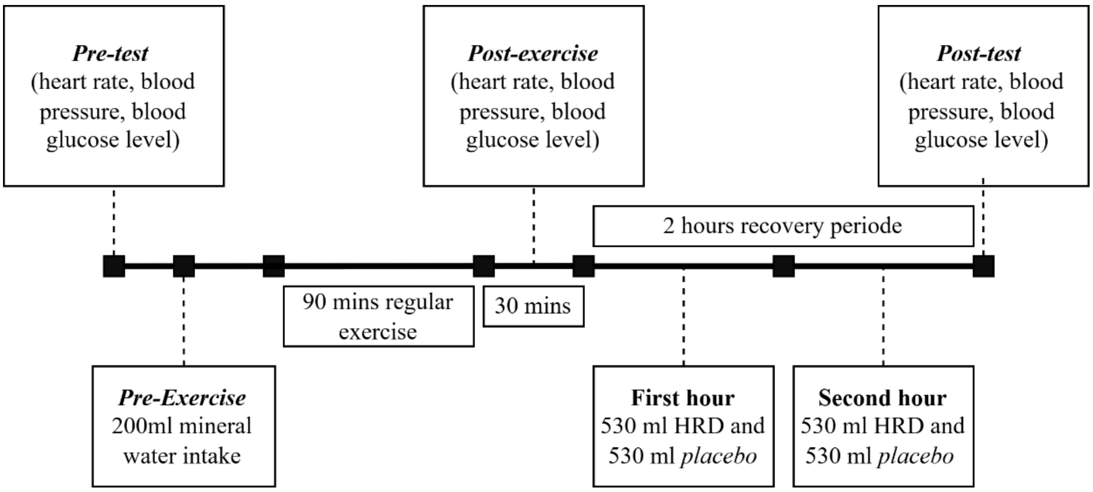

Figure 1. The Intervention Procedure for Administering the Healthy Recovery Drink and Placebo to Study Subjects

The administration of 530 ml of the healthy recovery drink (HRD) to the intervention group and 530 ml of the placebo to the control group was carried out 30 minutes after the training session ended. The beverages were consumed gradually over a 2-hour recovery period, divided into the first and second hours, with each consumption phase lasting 30 minutes. To maintain blinding, the recovery drinks were packaged identically and labeled by a researcher not involved in data collection. Enumerators who collected the outcome data were not informed of group allocation, ensuring that both participants and data collectors were blinded to treatment assignment. The recovery variables measured in this study included blood pressure, heart rate, and blood glucose levels. These parameters were assessed at three time points: before exercise, immediately after exercise, and two hours into the recovery period. Blood pressure and heart rate were measured using a digital Omron® monitor, while blood glucose levels were assessed using a digital glucometer, a portable blood glucose measuring device.

Table 1. Energy and Macronutrient Composition of HRD and Placebo Per Serving

Nutrient Composition	Healthy Recovery Drink (HRD)	Placebo
Energy (kcal)	330.38	186.9
Carbohydrate (g)	52.38	22.1
Protein (g)	24.5	5.1
Fat (g)	2.54	13.6

The nutritional composition of the HRD and placebo drinks was not matched, as the HRD product was specifically formulated to deliver targeted nutritional benefits. However, the placebo was designed to mimic the visual appearance, flavor, and texture of the HRD beverage to minimize participant bias during consumption.

Data Analysis

Statistical analysis was conducted using SPSS version 26.0 for Windows. Descriptive statistics were applied to compare baseline characteristics between groups. Normality was assessed using the Shapiro-Wilk test, with a significance threshold of $p > 0.05$. To evaluate differences across pre-exercise, post-exercise, and post-recovery phases, Repeated Measures ANOVA was performed for normally distributed data, while the Friedman test was used for non-normally distributed data. Between-group differences were analyzed using the Independent-Samples T Test for normally distributed data and the Mann-Whitney U test for non-normally distributed data, with statistical significance set at $p < 0.05$.

RESULTS AND DISCUSSION

Table 1 presents the physical recovery parameters, including diastolic blood pressure, systolic blood pressure, heart rate, and blood glucose levels in both the intervention group (HRD) and the control group (placebo) across three phases: pre-exercise, post-exercise, and post-recovery.

Table 2. The Effect of HRD and Placebo Beverage on Physical Recovery during Pre-Exercise, Post-Exercise, and Post-Recovery

Physical Recovery Parameters	Pre-Exercise	Post-Exercise	Post Recovery	p-value
Diastolic BP				
HRD	64.1 ± 7.65^{a}	67.9 ± 11.6^{a}	69.5 ± 7.07^{a}	0.393
Placebo	70.95 ± 8.05^{a}	66.75 ± 7.74^{a}	68.4 ± 10.03^{a}	0.128
p-value	0.067	0.797	0.780	
Systolic BP				
HRD	113.5 ± 9.75^{a}	103.6 ± 9.43^{a}	109.3 ± 9.14^{a}	0.120
Placebo	114.8 ± 9.35^{ab}	108.2 ± 7.63^{a}	115.7 ± 9.06^{b}	0.022
p-value	0.687	0.241	0.131	
Heart Rate				
HRD	81.6 ± 13.07^{a}	90.5 ± 13.69^{b}	84.7 ± 8.62^{ab}	0.009
Placebo	75.45 ± 10.48^{a}	78.3 ± 9.71^{a}	69.05 ± 12.57^{a}	0.497
p-value	0.326	0.064	0.005*	
Blood Glucose Level				
HRD	$110{,}1 \pm 18.86^{a}$	90.5 ± 9.49^{b}	95 ± 5.77^{ab}	0.021
Placebo	103 ± 16.63^{a}	89.8 ± 10.10^{a}	88.5 ± 6.49^{a}	0.067
p-value	0.472	0.820	0.022*	

Explanation of the results from the *Repeated Measures ANOVA*, *Friedman* test, and *Independent-Samples Mann-Whitney U test*
^{a,b}Similar letter notation indicates no significant difference ($p > 0.05$) within the same group
*Indicates a significant difference ($p < 0.05$) between groups

No significant differences were observed in diastolic blood pressure within or between groups after the recovery period ($p > 0.05$). Post-recovery diastolic blood pressure did not differ significantly between groups ($p = 0.393$), and the effect size was small (Cohen's d = 0.13). A similar trend was found in systolic blood pressure, where although the placebo group showed a greater increase compared to the HRD group after recovery, the intergroup difference was not statistically significant ($p > 0.05$). Although systolic blood pressure differed between groups in the placebo condition ($p = 0.022$), the effect size comparing post-recovery systolic BP between HRD and placebo was moderate (Cohen's d = -0.70). Both groups demonstrated similar recovery patterns across time points.

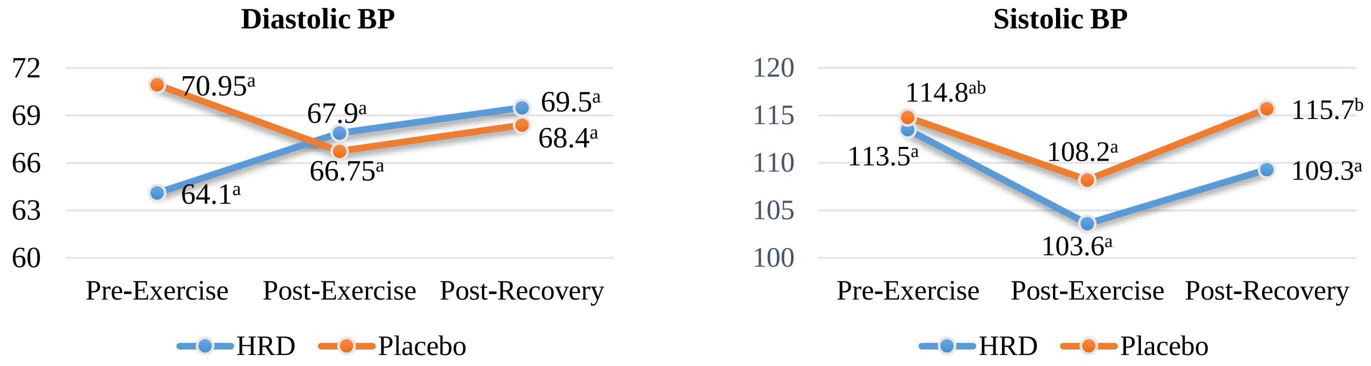

Figure 2. Trends in Blood Pressure Across Recovery Phases between HRD and Placebo Groups

This finding suggests that the consumption of the healthy recovery drink (HRD), composed of low-fat milk, banana, cocoa powder, and *gulo puan*, and the placebo (low-fat milk) did not produce significantly different recovery effects in male adolescent soccer players. This aligns with a study by Upshaw et al. (2016), which reported no significant difference in performance recovery between chocolate milk and low-fat milk after the recovery period. Blood pressure fluctuations during and after exercise are normal physiological responses. During physical activity, epinephrine increases cardiac output, but vasodilatation helps prevent excessive rises in blood pressure (Ustafia et al., 2017). In the post exercise, plasma volume may drop due to fluid loss, leading to a temporary decrease in blood pressure. In this study, both systolic and diastolic pressures rose again during the 2 hour recovery period, suggesting fluid absorption from the HRD. According to Rahmawati et al. (2023), effective rehydration helps restore plasma volume and circulation, supporting the normalization of blood pressure. Although the differences between groups were not statistically significant, both showed a similar recovery trend.

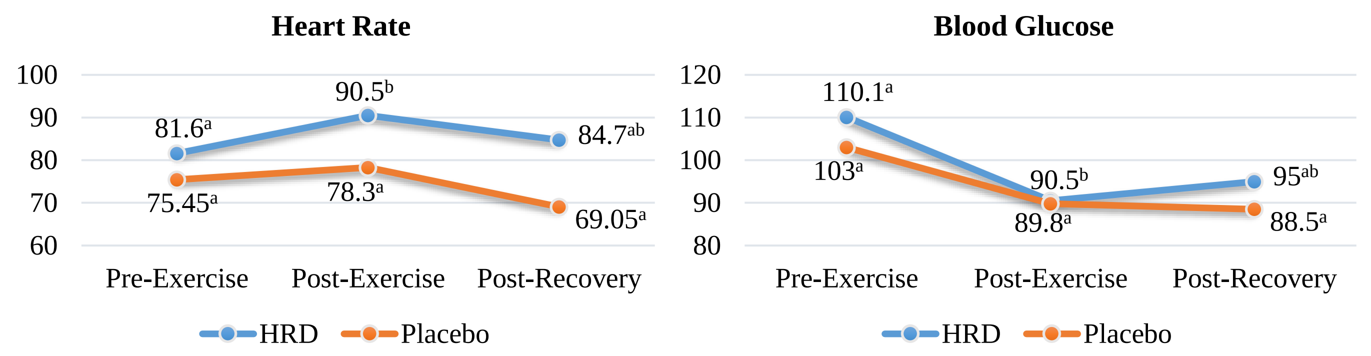

Figure 3. Trends in Heart Rate and Blood Glucose Levels Across Recovery Phases between HRD and Placebo Groups

Regarding heart rate, a significant difference in post-recovery heart rate was observed between groups ($p = 0.005$), with a large effect size (Cohen's d = 1.45), with the HRD group showing a mean heart rate of 84.7

± 8.62 bpm, although this was higher than that of the placebo group (69.05 ± 12.57 bpm). Within the HRD group, significant differences were found across time points, particularly between pre-exercise and post-exercise, indicating the expected cardiovascular response to physical exertion. This response may be associated with hypohydration, which increases cardiovascular workload and elevates heart rate (Perez-Castillo et al., 2024; Webb et al., 2016). After the recovery period, heart rate in the HRD group returned to near-baseline levels. In contrast, the placebo group showed no significant differences across time points, but demonstrated a lower post-recovery heart rate compared to both their own pre-exercise values and the HRD group. The decrease in heart rate from post-exercise to post-recovery in the intervention group indicates a physiological recovery process, although the post-recovery value had not yet fully returned to the pre-exercise baseline. This pattern may reflect a stronger parasympathetic rebound, potentially linked to central fatigue or lower metabolic demands post-recovery (Coote & White, 2015; Miyatsu et al., 2023). Although participants received water prior to exercise to minimize the risk of dehydration, the absence of objective hydration assessment may have impacted cardiovascular outcomes, particulary heart rate and blood pressure.

A significant difference in blood glucose levels between the HRD and placebo groups was observed following the recovery period ($p < 0.05$). Post-recovery blood glucose levels differed significantly ($p = 0.022$), also with a large effect size (Cohen's d = 1.06). As shown in Table 1, both groups experienced a decline in blood glucose levels post-exercise, which aligns with the physiological role of glucose as the primary energy substrate during endurance exercise (Hulton et al., 2022). However, in the post-recovery phase, the HRD group exhibited a higher blood glucose level (95 ± 5.77 mg/dL) compared to the placebo group (88.5 ± 6.49 mg/dL), suggesting that HRD may support more effective glucose replenishment in male adolescent soccer players. Although baseline glucose levels were not significantly different between groups, the HRD group began with a higher mean value (110.1 vs. 103 mg/dL), which may have partially influenced the post-recovery outcomes and should be taken into account when interpreting the results. This finding is consistent with recommendations by Born et al. (2019), who highlighted that post-exercise carbohydrate-protein intake is more effective in optimizing recovery among athletes. Similarly, Wadey et al. (2018) found that consuming chocolate milk during recovery significantly influences blood glucose levels compared to plain water. Additionally, although baseline glucose levels were not significantly different between groups, the HRD group had a higher mean value (110.1 mg/dL vs. 103 mg/dL), which may have partially influenced post-recovery outcomes. Future studies are encouraged to use statistical methods such as ANCOVA to control for baseline differences in outcome variables.

Research has also demonstrated that recovery beverages containing both carbohydrates and proteins enhance glycogen resynthesis and glucose homeostasis more effectively than water or low-nutrient alternatives (Dow et al., 2019; James et al., 2019). Furthermore, the banana content in HRD may contribute to these effects, as bananas provide a blend of glucose, fructose, and sucrose, supporting both immediate and sustained glucose replenishment (Naderi et al., 2023; Nieman et al., 2018). While both HRD and placebo contained milk-based carbohydrates and protein, HRD included additional components such as banana, cocoa powder, and *gulo puan*, each contributing distinct nutritional properties. Banana is rich in potassium, which plays an important role in neuromuscular function and cardiovascular regulation. *Gulo puan*, a traditional caramelized milk-sugar product, contributes not only carbohydrates but also fat, calcium, and phosphorus, which may support energy replenishment and electrolyte balance. These additional ingredients may explain the enhanced recovery responses observed in the HRD group beyond the effects of milk alone. These findings suggest that HRD may support post-exercise recovery in male adolescent soccer players aged 15-17 years. While promising, these findings should be interpreted within the context of the specific sample, and further research is needed to confirm the applicability to broader athletic populations. Several limitations should be acknowledged. The small sample size (n = 10 per group) may have reduced the statistical power and limited the generalizability of the results. In addition, hydration status was not objectively measured, which may have influenced cardiovascular recovery outcomes such as heart rate and blood pressure. Finally, the study did not conduct a sensory validation to ensure that the placebo and HRD were indistinguishable in taste or appearance, which could have affected participant perception and expectations.

CONCLUSION

This study suggests that a healthy recovery drink (HRD) composed of low-fat milk, *pisang raja*, cocoa powder, and *gulo puan* may support post-exercise recovery in male adolescent soccer players, particularly by supporting heart rate stabilization and post-recovery blood glucose replenishment. While no significant effects were observed on blood pressure, the overall findings indicate that HRD could serve as a practical, culturally relevant recovery option in resource-limited settings. However, the results should be interpreted with caution due to the small sample size, absence of hydration status assessment, lack of sensory validation to ensure placebo similarity, and the imbalance in baseline glucose levels between groups. Future studies should consider using ANCOVA to control for baseline variation and employ larger, more diverse samples to confirm the effectiveness of HRD and refine its application in athletic recovery.

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CONFLICT OF INTEREST

There are no competing interest associated with this research.

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