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Effects of Pre-Exercise Banana Beverage Intake on Mood State and Upper-Body Endurance during the Luteal Phase in Female Athletes with Premenstrual Syndrome

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ABSTRACT

Objective: To evaluate banana beverage intake before exercise in relation to mood state and upper-body endurance in female athletes with premenstrual syndrome during the luteal phase.

Methods and Materials: Thirty-six trained female athletes were randomized to banana beverage or placebo (18 allocated per group). Two did not complete the protocol; analysis was per protocol. The banana beverage contained 80 g of banana powder in 360 mL water, and placebo contained 12 g glucose in 360 mL water. Outcomes were the six Brunel Mood Scale subscales and 30-second and 60-second push-up performance.

Findings: In the banana group, 60-second push-up performance increased from 29.00 ± 8.11 to 34.42 ± 9.22 repetitions (within-group $p < .001$); a group × time interaction was reported ($p < .01$). The 30-second test did not change significantly. Nominal within-group reductions were reported for tension, depression, anger, fatigue and confusion, with no significant change in vigour. Mood findings require cautious interpretation because of multiple comparisons and incomplete interaction estimates.

Conclusion: Banana beverage intake was associated with improved 60-second push-up performance and changes in selected negative mood domains under the study conditions. Larger trials with fully specified scoring and complete between-group effect estimates are needed.

Keywords: Banana beverage, Premenstrual syndrome, Female athletes, Mood state, Upper-body endurance.

Introduction

Menstrual-cycle-related symptoms are relevant to the health and performance of female athletes (Carmichael et al., 2021). However, a systematic review found substantial variation and generally limited-quality evidence concerning cycle-phase effects on exercise performance, supporting individualized interpretation rather than a uniform assumption of luteal-phase impairment (McNulty et al., 2020). Premenstrual syndrome (PMS) involves recurrent physical and emotional symptoms before menstruation; severe premenstrual mood disturbance may be associated with substantial functional burden (Pearlstein & Steiner, 2008; Yonkers & Simoni, 2018). Stress reactivity and emotional changes are relevant to PMS (Liu et al., 2017), and mood disturbances have also been studied in soccer players with premenstrual symptoms (Foster et al., 2019). Together, these concerns support the assessment of mood alongside physical performance in female athletes, an area in which further research is needed (Bruinvels et al., 2017).

Dietary intake may influence brain neurochemistry through nutrient availability and neurotransmitter-related pathways (Fernstrom, 2013; Gasmi et al., 2023). Nutritional psychiatry reviews describe associations between diet and mental health while also identifying limitations in causal and intervention evidence (Grajek et al., 2022; Marx et al., 2017). The co-occurrence of physical symptoms, affective responses and behavioral factors also supports a biopsychosocial approach to assessment (Seyed Alitabar, 2025). However, these broad relationships do not establish an acute mood benefit of any specific food, particularly during the luteal phase in athletes.

Carbohydrate availability is important in sports nutrition (Burke et al., 2011; Thomas et al., 2016), although the relevance of a dietary strategy depends on exercise duration and intensity (Burke et al., 2018). Bananas provide carbohydrate and have been evaluated as an energy source during prolonged cycling exercise (Nieman et al., 2012). Tryptophan availability and serotonin synthesis are relevant to nutritional neurochemistry (Strasser et al., 2016), but their involvement in an acute response to banana intake cannot be assumed. Observational research has examined banana consumption and depressive symptoms in adults, with findings that do not establish a simple causal antidepressant effect (Ji et al., 2020). The present trial therefore examined banana beverage intake in relation to mood state and 30-second and 60-second push-up performance among female athletes with PMS during the luteal phase.

Methods and Materials

Participants

A total of 36 well-trained female athletes (volleyball, handball, floorball, and hockey) competing at state or national levels were recruited from sports clubs in East Java. All participants reported experiencing dysmenorrhea, premenstrual symptoms, and mood fluctuations. Eligibility screening was conducted through face-to-face interviews, standardized questionnaires, and physical examination by trained personnel to confirm general health status and menstrual history. The recruited population was described as aged 20 ± 2 years with BMI 21 ± 3 kg/m². Eligibility required regular menstrual cycles over the previous five months, a minimum of three years of competitive athletic experience, and regular training of at least three hours per week. Participants were excluded if they had a history of serious medical conditions, were using hormonal contraceptives or medications affecting mood or hormonal balance, had diagnosed eating disorders or endocrine disorders (e.g., hypothyroidism), or were smokers. All participants provided written informed consent after receiving a full explanation of the study procedures, risks, and benefits.

Menstrual Cycle Monitoring

Menstrual cycle phase was monitored to ensure that assessments were conducted during the luteal phase. Participants were instructed to use a home ovulation detection kit based on urinary luteinizing hormone (LH) to identify the LH surge, which was used as the primary indicator of ovulation. Participants performed daily self-testing at home and reported the results to the research team

according to their individual menstrual cycle patterns until the LH peak was detected. The first day of menstruation was defined as day 1 of the cycle, and the luteal phase was estimated as occurring approximately 7–10 days after the identified LH peak (typically between days 21 and 26 of the cycle). To support ovulation identification, participants were also trained to monitor secondary biomarkers, including cervical mucus characteristics (e.g., clear, stretchy, and slippery secretions) and basal body temperature, following standardized guidance. These observations were recorded daily to improve the accuracy of ovulation timing; however, all measurements were based on self-monitoring and participant reporting.

Mood Assessment

Mood state was assessed using the 24-item Brunel Mood Scale (BRUMS), which comprises six subscales: tension, depression, anger, vigour, fatigue, and confusion, with four items per subscale. Each item describes a specific mood descriptor (e.g., tension: anxious, nervous; depression: unhappy, miserable; anger: annoyed, bitter; vigour: energetic, alert; fatigue: tired, sleepy; confusion: mixed-up, unsure), and participants were asked to respond to the question "How do you feel right now?" using a 5-point Likert scale ranging from 0 (not at all) to 4 (extremely) (Brandt et al., 2016). The questionnaire was administered using an online BRUMS platform, and participants completed the assessment under standardized conditions prior to physical testing. All responses were self-reported and recorded electronically. While the use of an online application may introduce variability in administration conditions, participants were instructed to complete the questionnaire in a controlled and consistent environment to minimize potential bias.

Experimental Design

This study employed a randomized, double-blind, pre–post-test control group design involving 36 participants randomly allocated into either a banana drink group (n = 18) or a placebo group (n = 18). Participants were instructed to fast for 6 hours prior to each testing session and to avoid caffeine, energy drinks, and foods high in tryptophan for 24 hours before testing. Randomization was performed by an independent researcher, and beverages were distributed in identical opaque cups with lids to minimize visual identification and support allocation concealment. Both groups completed baseline (pre-test) and post-intervention (post-test) assessments consisting of the BRUMS questionnaire followed by 30-second and 60-second push-up tests. On the pre-test day, all participants received 360 ml of mineral water, while on the post-test day, participants in the experimental group received 360 ml of banana drink and those in the placebo group received 360 ml of sugar water. The intervention beverages were administered 3 hours prior to testing; additionally, participants consumed the assigned beverage at standardized time points (12:00 P.M. and 6:00 P.M.) during the intervention period. The banana drink was prepared by dissolving 80 g of banana powder, produced using a foam mat drying process with egg whites (Noordia et al., 2020), in 360 ml of warm water (40°C), while the placebo drink consisted of 12 g glucose dissolved in 360 ml of water. All beverages were prepared and administered by a separate researcher to maintain blinding. Mood state was assessed using the BRUMS questionnaire administered under standardized conditions prior to physical testing. The study protocol was approved by the Health Research Ethics Committee of the Faculty of Public Health, Universitas Airlangga (No: 55/EA/KEPK/2021). Two participants did not complete the protocol and were excluded from the per-protocol analysis, leaving 34 completers.

Statistical Analysis

Analyses were performed in SPSS version 23.0, with a nominal significance threshold of $p < .05$. Outcomes comprised push-up performance and the six BRUMS subscales. The Shapiro–Wilk test was used to examine normality; parametric or nonparametric comparisons were applied as appropriate. Group × time effects were examined using two-way repeated-measures ANOVA. Post hoc comparisons were described as using Bonferroni correction for the mood subscales. Analyses were per protocol, with no

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imputation for missing outcomes. Within-group p values are presented separately from interaction evidence and should not be interpreted as equivalent to a between-group treatment effect.

Findings and Results

Participant Characteristics

Thirty-six athletes were randomized, with 18 allocated to each group. Two did not complete the protocol. Baseline demographic and training characteristics are summarized in Table 1. The reported between-group baseline comparisons were not statistically significant.

Table 1

Baseline demographic and training characteristics

Characteristic	Banana beverage	Placebo	p
Age (years)	20.42 ± 0.90	20.89 ± 0.93	0.087
Height (m)	1.59 ± 0.09	1.62 ± 0.05	0.055
Weight (kg)	53.05 ± 5.49	58.31 ± 6.39	0.110
BMI (kg/m²)	21.93 ± 1.74	21.23 ± 1.84	0.280
Waist (cm)	73.26 ± 5.89	74.57 ± 7.65	0.339
Training volume (hours/week)	4.89 ± 0.65	4.94 ± 0.77	0.849
Training experience (years)	7.05 ± 1.64	7.15 ± 1.80	0.894

Note. Baseline values are mean ± SD, with 18 participants allocated to each group. BD = banana beverage; PD = placebo; BMI = body mass index. Two participants did not complete the protocol; the final per-group denominators were not specified.

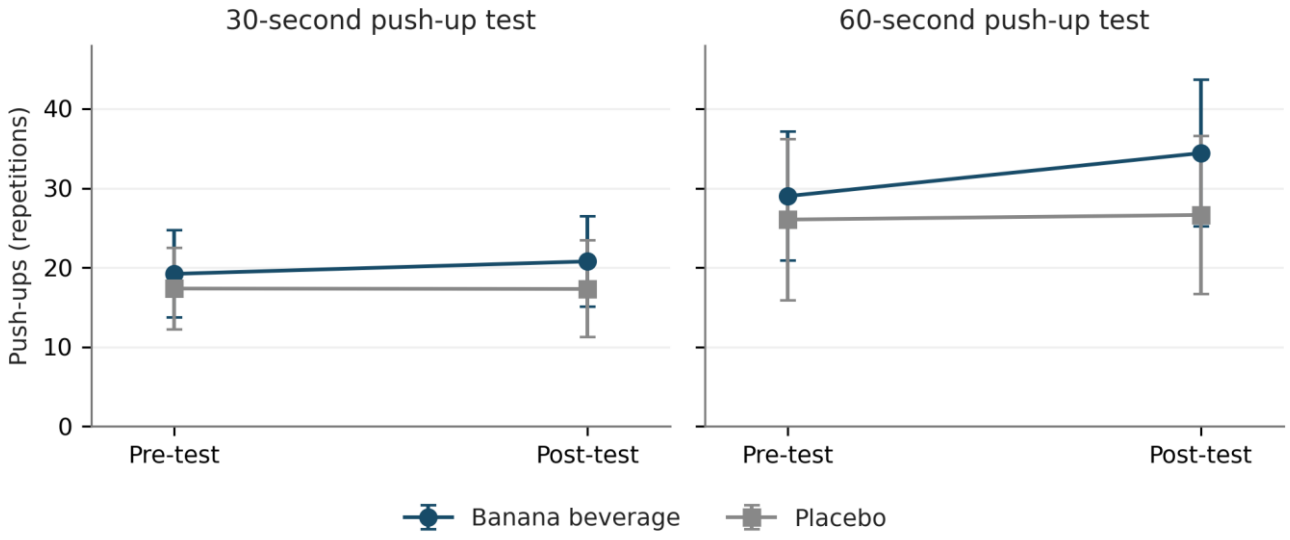


Figure 1

Push-up performance before and after beverage intake

Note. Points indicate means; error bars indicate standard deviations. Values are shown separately for the 30-second and 60-second tests.

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Physical Performance

As shown in Figure 1, 30-second push-up performance changed from 17.36 ± 5.15 to 17.31 ± 6.09 repetitions in the placebo group (Δ = −0.05; p = .275) and from 19.21 ± 5.51 to 20.78 ± 5.68 in the banana group (Δ = 1.57; p = .139). For the 60-second test, values changed from 26.05 ± 10.14 to 26.63 ± 9.98 in the placebo group (Δ = 0.58; p = .899) and from 29.00 ± 8.11 to 34.42 ± 9.22 in the banana group (Δ = 5.42; p < .001). A group × time interaction was reported for 60-second performance (p < .01). The reported banana-group change corresponded to Cohen's d ≈ 0.62, with a 95% confidence interval of 1.4 to 9.4 repetitions for the mean change.

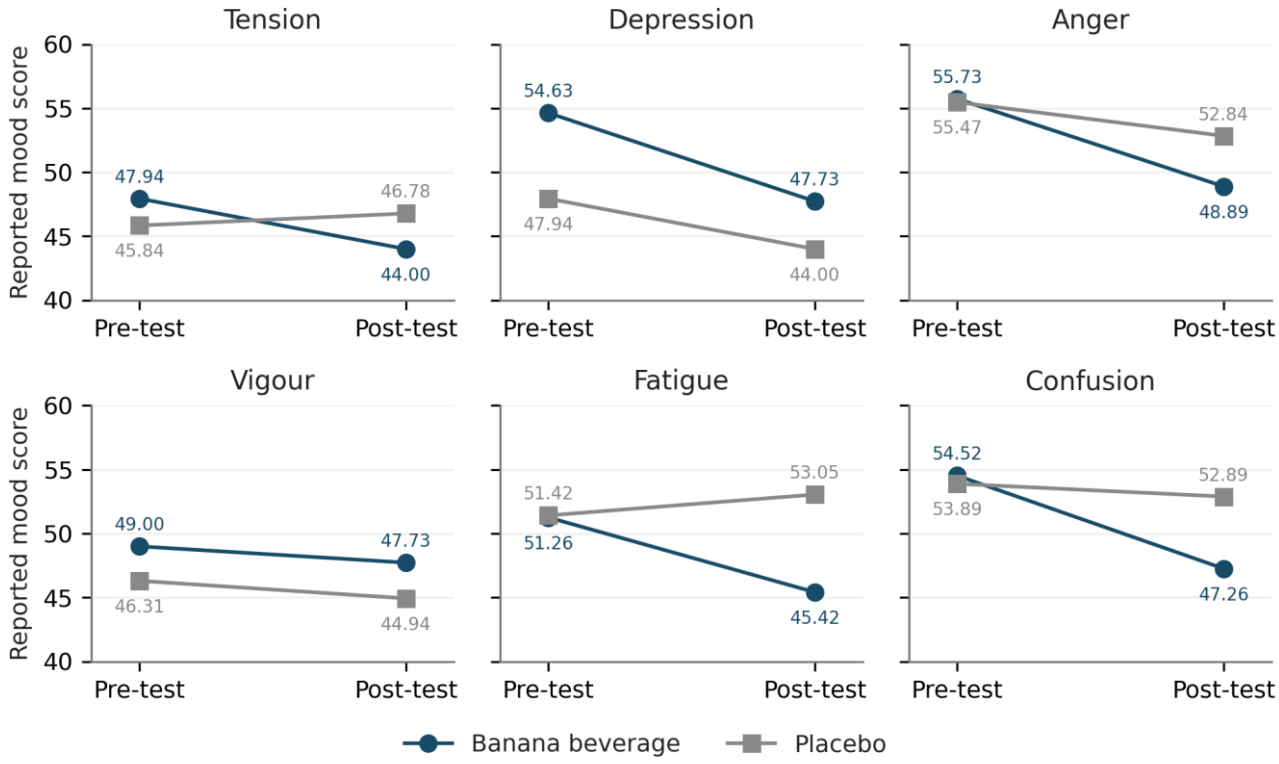


Figure 2

The reported subscale means

Mood State

In the placebo group, nominal within-group p values were .468 for tension, 1.000 for depression, .052 for anger, .288 for fatigue, .608 for confusion and .347 for vigour. In the banana group, nominal reductions were reported for tension (p = .024), depression (p < .001), anger (p = .001), fatigue (p = .001) and confusion (p = .003), whereas vigour did not change significantly (p = .309). These comparisons describe change within each group; they do not establish a treatment effect for each mood domain. Complete group × time estimates and clearly identified multiplicity-adjusted p values were not available for the mood outcomes. No composite total mood disturbance index was calculated. Figure 2 shows the reported subscale means.

Discussion and Conclusion

Physical Performance

Menstrual-cycle symptoms and exercise responses vary between individuals. Narrative and meta-analytic evidence suggests that physiological and psychological factors should be interpreted together, with attention to study quality and individual symptom patterns (Carmichael et al., 2021; McNulty et al., 2020). The present findings concern athletes

with reported PMS symptoms and should not be generalized to all eumenorrheic women.

The results of the present study showed a significant improvement in the 60-second push-up test in the banana beverage group compared with the placebo group, whereas no significant difference was observed in the 30-second push-up test. This finding suggests that the consumption of a banana beverage prior to exercise may be associated with improvements in upper-body muscular endurance performance under the conditions tested in this study. From a nutritional perspective, carbohydrate availability has been recognized as an important factor influencing exercise capacity, particularly by supporting energy availability for working muscles during physical activity (Spriet, 2014). Carbohydrate ingestion prior to exercise may increase glucose availability and support muscle energy metabolism during exercise (Nieman et al., 2012). However, it should be noted that much of the existing literature on carbohydrate supplementation has been conducted in the context of prolonged endurance exercise, and these findings may not be directly comparable to the relatively short-duration upper-body endurance task used in the present study.

Previous studies have also investigated the effects of banana consumption during exercise. For example, Nieman et al. (2012) reported that banana ingestion during prolonged cycling exercise provided carbohydrate availability comparable to that of sports drinks. However, the experimental conditions in that study involved long-duration endurance exercise, which differs substantially from the short push-up test protocol used in the present research. Therefore, while these findings provide some contextual support for the potential role of carbohydrate-rich foods such as bananas in exercise settings, caution should be exercised when interpreting these comparisons.

Bananas contain dopamine and other bioactive compounds that have been investigated for antioxidant activity (Kanazawa & Sakakibara, 2000). Peripheral serotonin has metabolic roles (El-Merahbi et al., 2015), and dietary serotonin can transiently affect circulating 5-hydroxyindoleacetic acid (5-HIAA) concentrations (Tohmola et al., 2015). Banana ingestion during exercise has also been evaluated using metabolomics (Nieman et al., 2012). However, peripheral measurements do not establish increased central serotonergic activity, and this trial measured neither neurotransmitters nor metabolic or inflammatory markers. Mechanistic explanations for the performance findings therefore remain hypotheses.

Furthermore, improvements in push-up performance could partly reflect factors unrelated to nutritional intake, such as familiarization with the test procedure or short-term variability in physical performance. In addition, expectancy effects associated with consuming a beverage perceived to enhance energy or performance may also have influenced participant responses. Placebo and expectancy effects have been widely documented in sports and exercise research and may influence both psychological and performance outcomes (Beedie et al., 2018). Therefore, these factors should be considered when interpreting the observed performance differences between conditions.

Mood Response

The banana group showed nominal within-group reductions in five negative mood domains and no significant change in vigour. These findings should be treated as exploratory because multiple mood outcomes were examined and complete interaction estimates were not available. The findings do not demonstrate a generalized improvement in mood or establish superiority over placebo for every domain. Research on emotional interventions in premenstrual dysphoric disorder also highlights the value of assessing distinct affective outcomes, although that population and intervention differ from the present trial (Eshaghi Hasanabadi & Sajjadian, 2026).

Nutrient and phytochemical pathways offer possible explanations that require direct testing. Magnesium is involved in neurological function, and its relationship with mental disorders has been reviewed (Botturi et al., 2020). Dietary electrolyte intake has also been examined in relation to mood (Torres et al., 2008), while tryptophan and serotonin remain relevant to nutritional neurochemistry (Strasser et al., 2016). Phenolic profiling studies have identified antioxidant compounds in banana and plantain

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tissues (Bashmil et al., 2021; Passo Tsamo et al., 2015). These studies support biological plausibility but do not show that the tested beverage produced an acute central nervous system effect.

Despite these observations, the present study did not directly assess biochemical markers related to oxidative stress, inflammation, or neurotransmitter activity. Therefore, the potential physiological pathways linking banana consumption to mood responses cannot be established based on the current data. It is also possible that psychological factors, including participants' expectations about the effects of the beverage, may have influenced reported mood responses. Previous research has demonstrated that expectancy effects may influence subjective outcomes in sports and exercise settings (Beedie et al., 2018).

Overall, the findings of the present study suggest that pre-exercise consumption of a banana beverage may be associated with changes in certain mood states and improvements in upper-body endurance performance as measured by the push-up test. However, the mechanisms underlying these responses remain unclear, and the results should be interpreted with caution given the exploratory nature of the present investigation.

Study Limitations

Several limitations of the present study should be acknowledged. First, the relatively small sample size may limit the statistical power of the analysis and restrict the generalizability of the findings beyond the specific population of trained female athletes included in this study. Although a placebo-controlled design was employed, the effectiveness of the blinding procedure may not have been fully robust because the sensory characteristics of the banana beverage could potentially differ from those of the placebo drink, which may have influenced participants' expectations regarding the intervention. In addition, physical performance was evaluated using only a single field-based test, namely the push-up test, and therefore does not comprehensively represent overall athletic performance. The study also did not include biochemical measurements that could clarify the physiological mechanisms underlying the observed responses, such as biomarkers related to neurotransmitters, inflammation, antioxidant status, or metabolic responses. Furthermore, the menstrual phase of participants was determined based on reported cycle timing rather than hormonal assays, which may not fully capture individual variability in hormonal status during the luteal phase. Several external factors that may influence mood and exercise performance were also not strictly controlled, including daily dietary intake, sleep patterns, training load prior to testing, and the severity of PMS symptoms among participants. In addition, the analysis involved multiple mood variables, which may increase the risk of type I statistical error. Finally, a small number of participants initially recruited did not complete the study protocol, which should be considered when interpreting the final sample size used in the analysis. Future studies with larger samples, stricter control of potential confounding factors, and more comprehensive physiological measurements are needed to further clarify the effects of banana beverage intake on mood responses and exercise performance in female athletes. The carbohydrate and energy content of the banana beverage was not sufficiently characterized to confirm equivalence with the glucose placebo. In addition, the mood scores displayed in the figure exceed the raw BRUMS subscale range; the scoring transformation and reference norms were not specified. These reporting limitations, together with incomplete mood interaction estimates, restrict interpretation of the mood findings.

Conclusion

Under the study conditions, banana beverage intake was associated with a larger improvement in 60-second push-up performance than placebo, with no significant change in the 30-second test. Nominal within-group changes in selected negative mood domains warrant further study but do not establish a broad mood benefit. Larger trials with characterized and appropriately matched beverages, fully specified mood scoring and complete between-group estimates are needed to confirm the findings.

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Declaration of Interest

The authors declare no conflicts of interest.

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