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# The Effect of Curcumin and Piperine Supplementation as a Recovery Method after Two Consecutive Futsal Matches

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**Abstract** This study aimed to investigate the effect of combined oral consumption of curcumin and piperine on muscle damage in futsal players after 2 consecutive matches. To achieve this, a randomized, double-blinded, placebo-controlled design was used, where 14 days of supplementation of curcumin and piperine, along with a placebo, was administered. A total of 16 amateur futsal players were divided into 2 groups, namely experimental and placebo. Parameters such as blood creatine kinase (CK), aspartate aminotransferase (AST), and alanine aminotransferase (ALT) concentration were assessed at specific time points, including 7 days before the first match, immediately before the first match, 24 h after the first match, 24 h after the second match, 48 h after the second match, and 72 h after the second match. The results showed a significant difference ($p < 0.01$) in the CK, as well as AST ($p < 0.01$) and ALT ($p < 0.01$) values between the CUR and PLA groups 24 h after the second match. Furthermore, 72 h after the second match, the CUR group had a lower CK value compared to PLA ($p<0.05$). Therefore, the supplementation of 200 mg curcumin and 10 mg piperine a day was considered effective in reducing muscle damage and accelerating the recovery of futsal players following 2 consecutive matches.

**Keywords** Futsal, Profile, Curcumin, Piperine, Supplementation, Muscle Damage, Recovery

## 1. Introduction

Futsal is a sport demanding a high level of technical skill and proficiency from players. The matches are characterized by a pattern of intensive physical exertion interspersed with periods of rest and recovery, which range in duration. This study has shown that elite futsal players engage in high-intensity running for 20-30% of the total match duration. As a result, players should possess a combination of sport-specific abilities, cardiovascular endurance, muscular power, and speed in order to achieve success in their careers [1-4].

In futsal, the smaller dimensions of the playing field and the ability to make unlimited substitutions in futsal, contribute to a match dynamic defined by frequent short sprints, sudden changes in rhythm and direction, close control of the ball, and frequent interactions with opponents [3,5-7]. These specific features, alongside the demands of training and competition, have led to the recognition of this sport as possessing a high risk of damage [8,9]. Furthermore, the requirement to participate

in 2 to 4 matches per week exacerbates the stress on players, amplifying their susceptibility to damage and compromising performance due to factors such as fatigue, muscle damage, and inflammation [10].

Muscle damage can be detected through biochemical markers such as creatine kinase (CK) and lactate dehydrogenase (LDH) [11-13]. Several studies examined the impact of futsal on damage markers, including [10] aspartate aminotransferase (AST) and alanin aminotransferase (ALT) [14,15]. For example, de Moura [16] discovered a significant increase in the levels of CK and LDH following elite-level futsal competition [10]. Other studies showed substantial differences in various biomarker indicators, particularly in LDH and IL-6, between goalkeepers and outfield players [16].

A range of strategies has been implemented to mitigate the impact of muscle damage, including both passive and active recovery methods [17], interventions comprising cold water immersion techniques [18], protein consumption [19-21], and the use of herbal-based supplementation [22,23]. However, the adoption of herbal-based supplementation as a form of nutritional intervention has gained significant attention in recent years as a means to reduce or prevent muscle damage among athletes and the general population [23-26]. Previous studies showed that nutritional interventions from a natural compound such as green tea extract, curcumin, and cinnamon, at specific dosages, exert an influence on recovery from damage and alteration in biomarkers among athletes [23,27,28].

Curcumin has been identified as a natural compound with anti-inflammatory properties and a low potential for adverse effects [29]. Several investigations reported positive results for curcumin in aiding exercise recovery [30-35]. Despite the therapeutic potential of this compound, it has a low bioavailability [31,36,37] which can be increased in humans by up to 2000% by the co-administration of piperine, the bioactive constituent of black pepper [38]. Piperine also exhibits antioxidant effects, including scavenging of reactive oxygen species and inhibition of lipid peroxidation [39].

Investigations examining the influence of a curcumin-piperine combination on the recovery process following muscle damage caused by futsal matches are currently limited. Therefore, this study aimed to evaluate the impact of combined curcumin and piperine supplementation on muscle function recovery after 2 futsal matches.

# 2. Materials and Methods

## 2.1. Participants

This study recruited 16 amateur male futsal players, with age, body mass, and height of 20 ± 0.95 years, 59.40 ± 7.08 kg, and 1.67 ± 0.6 m, respectively. Inclusion criteria for participants were (1) regular futsal players for at least 5 years, (2) training 10 hours per week, (3) absence of musculoskeletal damage, and (4) no vascular diseases. However, exclusion criteria included those who had stopped training for 1 month. Participants were randomly assigned to the CUR (n = 8) and the PLA (n = 8) groups. Before the commencement, participants were informed about the procedures and potential risks, alongside obtaining written informed consent. The study plan was reviewed and authorized by the Institutional Ethics Committee (IEC) number 03/KEPK/EC/IX/2022 at Health Polytechnic Kemenkes Bandung, Indonesia.

## 2.2. Experimental Design

A randomized, double-blinded, placebo-controlled design was used in this 2-week study to examine the effects of curcumin and piperine supplementation on biomarkers in futsal players. During the initial first week, participants engaged in regular exercise for 7 conservative days before the first match, with 2 sessions per day (morning and evening). In this period, opaque capsules containing CUR (Curcumin 100 mg + piperine 5 mg) or PLA (microcrystalline cellulose 105 mg) were ingested twice a day, 2 h before regularly exercising in the morning and going to bed at night. Following the 7-day intervention (first week), participants participated in the first complete futsal match, adhering to FIFA regulations, to induce muscle damage on the 8th day. The match was conducted on an internationally recognized futsal field in Bandung, starting at 02:00 pm, with an average temperature of 28 ± 2 ℃. On the 9th day, the second complete futsal match was played under similar conditions. During the match period in the second week, opaque capsules containing CUR or PLA were ingested twice a day, 2 hours before regularly exercising in the morning and going to bed at night. The curcumin extraction process was based on a prior study [29] and adhered to regulations set by the Indonesian Food and Drug Authority (BPOM) Indonesia. The resulting product, named the Ganesha Fit product, was granted registration license number TR. 223018181.

## 2.3. Blood and Serum Collection

Biological material was collected from participants by nurses following established protocols for collection, transport, and storage. The collection period included 7 days before the first match, immediately before the first match, 24 h after the first match, 24 h after the second match, 48 h after the second match, and 72 h after the second match. A total of 10 ml venous blood was obtained from participants, and put in sterile, labeled tubes without anticoagulant. After the blood samples were collected, serum was stored at a temperature range of 25-30 ℃, while plasma was stored on ice. The laboratory analyses were conducted in 1 h of blood collection, which was the

duration required for the transfer of samples from the field to the laboratory.

### 2.4. Statistical Analysis

The normal distribution of parameters was assessed using the Kolmogorov-Smirnov test. An independent t-test was used to compare participants' characteristics between groups. CK, AST, and ALT levels were analyzed using repeated-measures ANOVA (group × time), followed by Tukey post hoc test for pairwise comparisons. Changes between the assessed times were also presented as the mean ± standard error. The significance level was set at $p<0.05$.

## 3. Results

Table 1 presents the anthropometric characteristics of participants, including their age, height, weight, body mass index, and body fat. The characteristics followed a normal distribution and no significant differences were observed between groups at baseline.

**Table 1.** Anthropometric characteristics of participants

| | CUR (n=8) | PLA (n=8) |
|---|---|---|
| Age (years) | 20.38 ±0.89 | 20.42 ±0.67 |
| Height (cm) | 167.50 ±5.75 | 166 ±6.45 |
| Weight (kg) | 59.65 ±6.21 | 59.16 ±8.06 |
| Body mass Index (kg/m$^2$) | 21.26 ±1.96 | 21.39 ±1.95 |
| Body fat (%) | 11.45 ±2.61 | 10.95 ±1.1 |

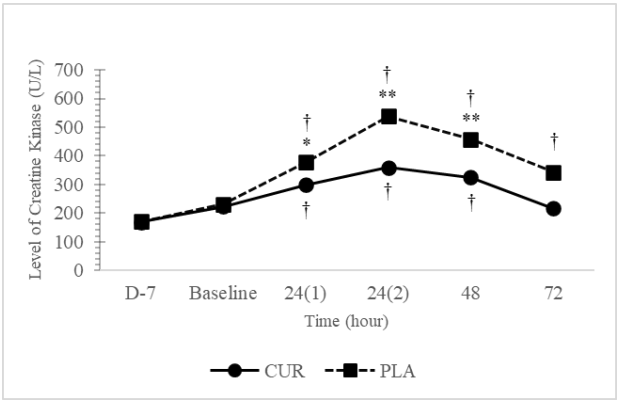


**Figure 1.** Creatine kinase concentration, *Indicates the statistical difference between groups p<0.05. **shows the statistical difference between groups p<0.01. † present statistical difference compared to baseline in the same groups p<0.05. D-7: 7 days before the first match. Baseline: before the first match starts. 24 h (1): 24 hours after the first match. 24 h (2): 24 hours after the second match. 48 h: 48 hours after the second match. 72 h: 72 hours after the second match

Figure 1 shows the concentrations of creatine kinase (CK) at baseline and 72 h post the second match for both CUR and PLA groups. Initially, no significant difference was noted between the groups (CUR 222 ±38 vs. PLA 231 ± 39) (p>0.05). However, at the 72 h mark, there was a discernible distinction in the CK value with the CUR group returning to baseline values, while the PLA group maintained a significantly elevated level compared to baseline (216 ± 46 VS PLA 342 ± 116) (p<0.05). A significant interaction was observed at 24 h (1) after the first match, 24 h (2) after the second match, and remained higher after 48 h compared to baseline in the PLA group (377 ±102; 538 ±148; 458 ±161; p<0.05). Meanwhile, the CUR group had a significant increase at 24 h (1) after the first match. Subsequently, significant differences were observed between the 2 groups at 24 h (1) after the first match (CUR 298 ±64 VS PLA 377 ±62, p<0.05), 24 h (2) after the second match (CUR 360 ±88 VS PLA 538 ±48, p<0.01), and 48 h (CUR 324 ± 56 VS PLA 458 ± 161, p<0.01).

At baseline, aspartate aminotransferase (AST) concentration did not differ between groups (CUR 21.86 ± 2.8 VS PLA 22.14 ± 2.9) (p>0.05). Figure 2 shows the interaction at 24 h (1) after the first match, 24 h (2) after the second match, and continued elevation after 48 h compared to baseline in the PLA group (30.14 ±2.25; 36.07 ±2.38; 32.50 ±2.44; p<0.05). Meanwhile, the CUR group had no significant increase at 24 h (1) after the first match, 24 h (2) after the second match, and 48 h compared to baseline (25.43 ± 3.82; 26.71 ± 3.13; 24.64 ± 3.22; p>0.05). Subsequently, significant differences were observed between 2 groups at 24 h (1) after the first match (CUR 25.43 ±3.82 VS PLA 30.14 ±2.25, p<0.01), 24 h (2) after the second match (CUR 26.71 ±3.13 VS PLA 36.07 ±2.38, p<0.01), and 48 h (CUR 24.64 ±3.22 VS PLA 32.50 ±2.44, p<0.01).

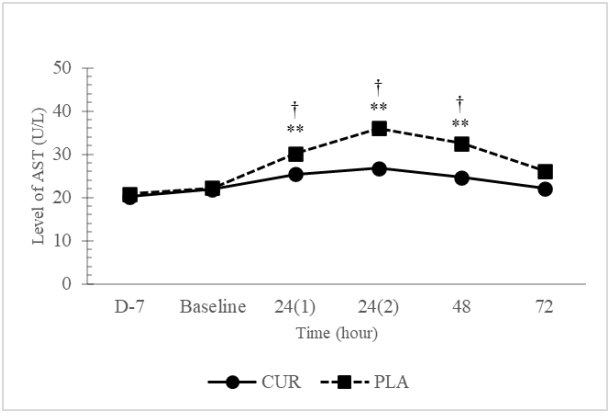


**Figure 2.** Aspartate aminotransferase concentration, *Indicates statistical difference between groups p<0.05. **shows the statistical difference between groups p<0.01. † presents statistical difference compared to baseline in the same groups p<0.05. D-7: 7 days before the first match. Baseline: before the first match started. 24 h (1): 24 hours after the first match. 24 h (2): 24 hours after the second match. 48 h: 48 hours after the second match. 72 h: 72 hours after the second match

Alanine Aminotransferase (ALT) concentration as shown in Figure 3 did not differ between groups (CUR 17.86 ±3.74 VS PLA 18.86 ±2.68) at baseline (p>0.05). A

significant interaction was observed at 24 h (1) after the first match, 24 h (2) after the second match, and remained higher after 48 h and 72 h compared to baseline in the PLA group (26.64 ±2.65; 30 ±2.68; 24.64 ±1.88; 22.21 ±2.01, $p<0.05$). Meanwhile, CUR group had no significant increase at 24 h (1) after the first match, 24 h (2) after the second match 48 h, and 72 h compared to baseline (19.86 ± 3.36; 20.64 ± 4.41; 17.93 ± 3.47; 17.86 ± 3.20, $p>0.05$). Subsequently, there were significantly different between the 2 groups at 24 h (1) after the first match (CUR 19.86 ± 3.36 VS PLA 26.64 ± 2.65, $p<0.01$), 24 h (2) after the second match (CUR 20.64 ± 4.41 VS PLA 30 ± 2.68, $p<0.01$), 48 h (CUR 17.93 ± 3.47 VS PLA 24.64 ± 1.88, $p<0.01$), and 72 h (17.86 ±3.20 VS 22.21 ±2.01, $p<0.01$).

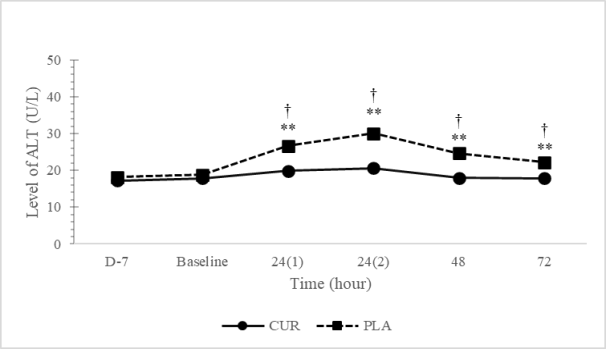


**Figure 3.** Alanin aminotransferase concentration, *Indicates the statistical difference between groups $p<0.05$. **shows the statistical difference between groups $p<0.01$. † Indicates statistical difference compared to baseline in the same groups $p<0.05$. D-7: 7 days before the first match. Baseline: before the first match starts. 24 h (1): 24 hours after the first match. 24 h (2): 24 hours after the second match. 48 h: 48 hours after the second match. 72 h: 72 hours after the second match

## 4. Discussion

The primary objective of this study was to investigate the impact of a newly developed curcumin and piperine supplementation on biomarkers in futsal players. Previous literature has offered limited insight into the effect of the supplementation on delayed onset muscle soreness (DOMS) following futsal matches. This study was the first randomized, double-blind, and placebo-controlled trial to evaluate the chronic effects of curcumin and piperine on inflammation and muscle damage induced by 2 consecutive futsal matches.

This study demonstrated a significant increase in CK activity 24 hours after the first match in both the CUR and PLA groups compared to the baseline. The results were in line with previous reports showing increased CK levels post-futsal match [10, 16]. The CK levels peaked at approximately 400 U/L, which was typically observed after badminton [40], football [41,42], rugby [43,44], or long-distance events [45]. Furthermore, a considerable elevation was discovered in CK activity after the second match in both groups compared to the first match. At the 72 h mark, following the conclusion of the second-day match, there was a discernible distinction in the parameter between the CUR and PLA groups. The CUR group exhibited a return to the baseline value, while the PLA group sustained a significantly elevated level.

Changes in CK activity were commonly used as indirect indicators of match intensity and myocyte damage incurred during physical activity [46,47]. Due to the demanding nature of a futsal match, which includes frequent explosive activities such as jumps, duels, shots, dribblings, accelerations, decelerations, changes of direction (COD), sprints, as well as periods of jogging, walking, or standing, significant loads on active musculature, lead to microdamage of muscle fibers, and release of CK and other proteins from the cytosol [16,41,47].

In this study, it was observed that the CUR group had a lower concentration of CK compared to the PLA group, suggesting reduced muscle damage at 24 h after the first and second matches. Theoretical explanations propose that the combined administration of curcumin and piperine, exerted inhibitory effects on NF-Kb and COX-2, potentially mitigating post-match inflammation [38,48]. Furthermore, curcuminoids were known for their strong free radical scavenging properties, and when combined with anti-inflammatory action, curcumin supplementation was hypothesized to reduce secondary muscle damage [48]. While some strategies primarily focus on recovery after muscle damage, the current supplementation approach presents a preventive effect. In addition, this effect could be attributed to the ability of curcumin to inhibit the production of histamine and prostaglandin, which are associated with increased vascular permeability. According to reports, this natural compound can affect membrane structure depending on the concentration in the blood. This may also help to attenuate CK elevation and promote faster recovery [35]. The results were in line with other experimental studies showing the effectiveness of the compound in reducing CK concentration following physical stress, indicating that curcumin may have a protective effect against muscle damage. According to previous studies, curcumin supplementation can reduce muscle soreness immediately [30], 24 h [49], and 3 days after exercise in healthy individuals [35].

The results of increased AST and ALT levels 24 h after the first and second match in the PLA group were in line with previous studies showing a similar effect after acute aerobic exercise [50]. However, the CUR group did not exhibit a significant increase in these parameters after both matches. This suggests that the supplementation taken by the CUR group may have prevented the rise. These were consistent with previous studies indicating that CUR interventions can limit the increase in AST and ALT levels in active players. Several plausible mechanisms suggest a favorable effect of curcumin on liver function. This compound may improve hepatic steatosis and inhibit the progression of fatty liver disease by blocking the synthesis of fatty acids, including unsaturated types such as stearic acid, oleic acid, and linoleic acid [51]. It can also enhance

mitochondrial activity, facilitate β-oxidation, and decrease lipogenesis. Additionally, oxidative stress and immune system dysfunction were known to contribute to liver dysfunction [52].

Curcumin has been shown to have potential benefits in reducing oxidative stress by decreasing the production of reactive oxygen species, reducing protein expression in the liver, and decreasing pro-inflammatory cytokines and chemokines such as interferon (IFN) γ, interleukin-1β, and IFN γ-inducible protein [53,54]. Furthermore, it has the potential to hinder liver damage in steatohepatitis by decreasing the movement of high mobility group box 1 (HMGB1) in the cytosol and nucleus, as well as inhibiting nuclear factor kappa B (NF-κB), while stimulating peroxisome proliferator-activated receptor-gamma (PPAR-γ) [14,15]. The ability of curcumin to act as an antioxidant was linked to its capacity to stimulate the production of various antioxidant enzymes such as heme-oxygenase-1, catalase, and glutathione transferase [54].

Despite meticulous efforts to design and implement a study with effective methodology, certain limitations should be acknowledged. A cross-over design would have been preferred, but it was deemed unsuitable due to the potential introduction of a training effect and reduction of DOMS during the cross-over phase. This design would have necessitated a lengthy washout period, extending the study duration by several months. Additionally, since this was the first investigation into the effects of curcumin and piperine supplementation on muscle function, the optimal dosage for efficiently attenuating muscle damage remains unknown. It would be valuable to compare the effects of different doses of this combined supplementation on muscle function and recovery kinetics following the same high-intensity exercise task.

In terms of sports, various recovery strategies are often employed without considering potential conflicting effects. For instance, a recent study highlighted that the antioxidant capacity of red fruits diminishes when consumed alongside milk, a protein-rich beverage [55]. Therefore, it becomes imperative to evaluate the repercussions of implementing multiple recovery strategies concurrently on muscle function and recovery kinetics post-exercise-induced muscle damage. It has been established that post-exercise oxidative and inflammatory stress significantly influence the training adaptation process. Furthermore, antioxidant supplementation may potentially prevent these adaptations. However, in certain situations, maximizing performance was essential for athletes, specifically during tournaments. The question of whether combined curcumin and piperine supplementation could adversely impact chronic muscle adaptations subsequent to strenuous exercise remains uncertain and warrants further investigation.

## 5. Conclusions

In conclusion, the results strongly suggested that a 14-day supplementation regimen of curcumin and piperine effectively mitigated the rise in concentrations of CK, AST, and ALT among futsal players engaged in 2 consecutive matches. Consequently, the supplementation appeared to be a viable strategy for optimizing recovery in futsal players and other trained individuals. Future studies should prioritize investigating the prolonged effects of curcumin and piperine (spanning more than 24 days) on recovery enhancement and performance following futsal matches.

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