



Kencur Supplementation Modulates Interleukin-6 (IL-6) and C-Reactive Protein (CRP) in Response to Muscle Damage Following Eccentric Exercise

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Abstract

Background. Intense or unaccustomed exercise can cause muscle damage and tissue injury, leading to temporary muscle dysfunction and the release of pro-inflammatory cytokines and free radicals. These factors may result in muscle protein breakdown, impaired nutrient absorption, and hindered recovery.

Objectives. This study aimed to evaluate the effects of Kencur supplementation on plasma IL-6 and CRP levels following eccentric exercise.

Materials and methods. A randomized controlled trial (RCT) with a double-blind, placebo-controlled design was conducted with 40 male recreational students from the State University of Surabaya — Universitas Negeri Surabaya (age: 19.65 ± 1.09 years, BMI: 21.10 ± 1.16 kg, body fat percentage: $22.14\% \pm 2.14\%$). Participants were randomly assigned to either the Kencur group (200 mg/day) or the placebo group (corn starch 100 mg/day) for a period of 14 days. On the experimental day, participants performed 100 countermovement jumps (CMJ). Blood samples were collected immediately after, 24 hours, and 48 hours post-exercise to measure IL-6 and CRP levels. Repeated Measures ANOVA with Bonferroni Post-hoc tests were used to analyze the data.

Results. The Kencur group showed a significant reduction in plasma IL-6 and CRP levels post-exercise at all time points ($p < 0.05$), while the placebo group exhibited no substantial changes ($p > 0.05$).

Conclusions. The findings indicate that Kencur supplementation significantly reduces the inflammatory response by lowering IL-6 and CRP levels following eccentric exercise.

Keywords: eccentric exercise, ROS, inflammation, immune response.

Introduction

Intense or unaccustomed exercise can result in muscle damage and tissue injury, often leading to a temporary loss of muscle function and the release of pro-inflammatory cytokines and free radicals (Aoi et al., 2004; Suzuki, 2018; Wilke & Behringer, 2021). Among various exercise modalities, eccentric exercise—where muscles lengthen

while contracting, such as during the lowering phase of a weightlifting movement—induces greater muscle cell damage and post-exercise discomfort compared to concentric exercise, which involves muscle shortening (Hotfiel et al., 2018; Lin et al., 2021). Eccentric exercise places significant mechanical strain on the muscle, particularly affecting the sarcolemma, the protective membrane surrounding muscle fibers (Bazzucchi et al., 2019; Peake, 2019). This strain can result in structural disruptions, such as Z-line streaming in the sarcomere, and leakage of intracellular proteins into the bloodstream, impairing muscle function and reducing force production capacity (Lee et al., 2021; Northeast & Clifford, 2021; Sonkodi, 2022).

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Following such muscle damage, individuals typically experience delayed-onset muscle soreness (DOMS), peaking between 24 to 72 hours post-exercise. DOMS is associated with localized inflammation and the mobilization of immune cells to the affected tissues (Farias-Junior et al., 2019; Sulistyarto et al., 2022). This process resembles the acute-phase response seen in trauma or infection, characterized by increased levels of oxidative stress and inflammatory markers (Stožer et al., 2020). Reactive oxygen species (ROS), generated during prolonged or intense exercise, contribute to cellular damage and amplify the inflammatory response, further promoting the release of pro-inflammatory cytokines such as Interleukin-1 β (IL-1 β), Interleukin-8 (IL-8), tumor necrosis factor-alpha (TNF- α) and interleukin-6 (IL-6) (Thirupathi et al., 2021; Tidball & Villalta, 2010).

Among these cytokines, IL-6 exhibits the most significant elevation following exercise, with circulating levels increasing up to 100-fold depending on exercise intensity and duration (Fleckenstein et al., 2021). IL-6 is released into the circulation by contracting muscles (i.e., muscle-derived IL-6) during intense exercise (Beba et al., 2022; Nieman et al., 2003). IL-6 reaches its peak immediately after completion of exercise, followed by a rapid decline to baseline levels (Hennigar et al., 2017; Waskiw-Ford et al., 2020). If tissue damage occurs during intense exercise (e.g., vigorous eccentric exercise), immune cells infiltrate the muscle and release IL-6 to signal the acute phase response and tissue repair (Batatinha et al., 2019; Brendler et al., 2021).

While IL-6 plays a critical role in initiating tissue repair and adaptation, excessive levels can have deleterious effects, such as muscle protein breakdown, impaired nutrient uptake, and disrupted recovery (Kistner et al., 2022). Similarly, CRP, an acute-phase protein synthesized in response to IL-6, serves as an indicator of systemic inflammation and muscle damage severity. Prolonged elevations of these markers are linked to suboptimal recovery and impaired training outcomes (Peake et al., 2017).

Given the physiological impact of eccentric exercise, nutritional interventions aimed at mitigating exercise-induced inflammation have gained traction in recent years. Common strategies include supplementation with antioxidants (e.g., vitamins C and E) (Torre et al., 2021), anti-inflammatory compounds (Kruk et al., 2021), and proteins or amino acids (Gao et al., 2022; Northeast & Clifford, 2021). However, reliance on pharmacological anti-inflammatory agents, such as Nonsteroidal Anti-inflammatory Drugs (NSAIDs) like ibuprofen, is commonly used to reduce inflammation but may have side effects. This is associated with risks such as gastrointestinal distress and impaired tissue healing (Pham & Spaniol, 2024). This has shifted focus toward natural alternatives, including herbal supplements, as safer and potentially effective options.

Kencur (*Kaempferia galanga* Linn), a traditional herb from the Zingiberaceae family, has shown promise due to its potent anti-inflammatory properties (Irawan et al., 2022; Yao et al., 2018). Kencur contains bioactive compounds such as flavonoids, polyphenols, and ethyl p-methoxycinnamate, which have been associated with reductions in inflammatory markers (Kiptiyah et al., 2021). Preliminary studies suggest that Kencur supplementation may attenuate IL-6 and CRP responses following intense exercise, providing a natural approach to modulating the inflammatory cascade (Zhang et

al., 2022). However, current research on Kencur in exercise recovery contexts remains limited, often involving small sample sizes and early-phase studies. Therefore, this study aims to evaluate the effects of Kencur supplementation on plasma IL-6 and CRP levels following eccentric exercise. By assessing these inflammatory markers, we seek to determine whether Kencur supplementation can modulate the post-exercise inflammatory response and support muscle recovery. This study addresses a critical gap in the literature and contributes to the growing exploration of traditional herbal remedies in modern sports science.

Materials and Methods

Study Participants

A total of 40 male recreational students from Universitas Negeri Surabaya were participated in this study. The participants were carefully selected according to specific criteria; all were healthy with a normal body mass index (BMI), excluding those who were already taking medications, using chemical substances, or consuming any supplements, and did not smoke and alcohol. Additionally, both groups were deemed to be at low risk of bias. Participants were then randomly divided into two groups: one group received kencur capsules (Kencur Group, $n = 20$) and the other group received a placebo capsules (Placebo Group, $n = 20$). The participants had the same body weight, and there were no significant differences in physical characteristics between the two groups. Prior to participating in the research, all individuals gave their explicit consent after being thoroughly briefed on the study's goals and methods.

Study Organization

Randomized controlled trial (RCT) with a double-blind, placebo-controlled design. This approach ensures robust comparisons and minimizes biases. The design was developed to investigate the effectiveness of 200 mg of Kencur capsule supplementation for 14 days (2 weeks) to modulates IL-6 and CRP as inflammation and muscle damage markers. The study was conducted over a period of one month, with an initial assessment on the first day to evaluate the participants' baseline condition. Participants were prohibited from engaging in vigorous physical activity, including exercise, for the 30 days of the study. The only exception was an experimental exercise protocol, which was specifically designed for this study.

Supplementation

Both the Kencur group and the Placebo group participants collected their initial data, which included body weight, height, body fat percentage, physical activity level, and VO_2 max measurements, to ensure that the groups were homogeneous at the outset of the study. The study involved two types of supplements: one containing 200mg of Kencur by Tazzaka™, a commercially available product, and another placebo consisting of a similar capsule with 100mg of corn starch. The Kencur supplement used in this study was manufactured by Tazzaka™ and is certified by the Indonesian Food and Drug Authority (Badan Pengawas Obat dan Makanan, BPOM). The subjects took either the Kencur supplement or the placebo capsule daily with breakfast for a

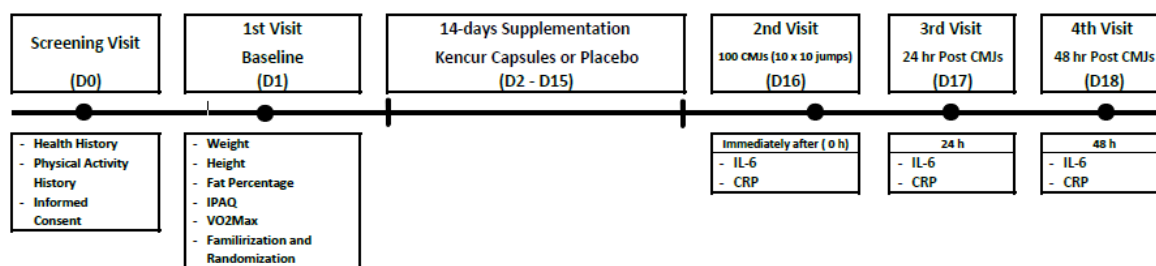


Fig. 1. Timeline of the study

period of 14 days. During this time, they were not allowed to engage in strenuous physical activity or participate in recovery programs such as massage or cryotherapy. Before starting any exercise, participants were required to be free from pain and injury, as confirmed by their completion of a physical activity readiness questionnaire.

Exercise Protocol

After 14 days of supplementation, on the 15th day, participants were asked to perform a specific exercise protocol designed to cause muscle damage. The protocol involved a series of countermovement jumps (CMJ) with proper technique and maximum effort encouraged. Participants performed a total of 100 countermovement jumps in 10 sets of 10 jumps every four seconds, with a 60-second rest between sets. The observer monitored the knee angle between jumps, ensuring it was maintained at 90°. This exercise has been proven to induce significant muscle damage in previous studies and was used to assess the effects of the supplements on muscle damage. A summary of the study design is presented in Figure 1.

Outcome Measures

The primary outcomes of the study were to measure IL-6 and CRP plasma concentration as an inflammatory marker due to eccentric exercise. The assessment of IL-6 and CRP plasma concentrations was performed at three specific time points: immediately after (0 h), 24 hours (24 h), and 48 hours (48 h) the countermovement jumps (CMJ) protocol was completed. The selection of specific time points (0 h, 24 h, and 48 h) is based on their established relevance in tracking post-exercise inflammatory responses, as demonstrated in previous studies (Kimble et al., 2023; Northeast & Clifford, 2021).

To assess IL-6 and CRP plasma concentration levels, blood samples were collected from the cubital vein, with up to 100 cc of blood taken and anticoagulated with EDTA, and placed into an SST (Serum Separator Tube). The tube with the frozen blood was then centrifuged at 3000 rpm for 15 minutes to separate the plasma from the blood. The plasma formed in the tube was transferred into several polypropylene tubes, sealed, and labeled with identity according to the research serial number. The tubes were then frozen at a temperature of ≤ -20 °C until analyzed.

Measurement of plasma IL-6 levels was performed using the Enzyme-Linked Immunosorbent Assay (ELISA) method, while the plasma concentration of CRP was measured using the DBC hs-CRP ELISA kit (Diagnostics Biochem Canada Inc., Canada). The analysis was conducted at the Sports Science

Laboratory of Universitas Negeri Surabaya and the Research Laboratory Installation of Airlangga University Hospital, which adhere to standard research protocols. Both laboratories are equipped for biochemical analysis, ensuring the reliability of the obtained IL-6 and CRP plasma concentration data.

Statistical Analysis

The data were processed both manually and digitally to convert it into usable information. Data are presented as mean \pm standard deviation. Prior to the analysis, normality was assessed for the data distribution in each group and time point using the Shapiro-Wilk test. To evaluate the effects of Kencur supplementation on the dependent variables, IL-6 and CRP levels were analyzed using Repeated Measures ANOVA with two factors: time (0 h, 24 h, and 48 h) as a within-subject factor and treatment group (kencur supplementation vs. placebo) as a between-subject factor. If the ANOVA results show significant differences, post-hoc testing using Tukey's HSD will be conducted to identify specific differences between time points (0 h, 24 h, and 48 h) within each treatment group. All analyses will be performed using SPSS 23 statistical software, with a significance level set at $p < 0.05$.

Results

A total of 40 recreational male students from Universitas Negeri Surabaya participated in this study. They were randomly assigned to either the Kencur Group ($n = 20$) or the Placebo Group ($n = 20$). The average age of the Kencur Group was 18.70 years (± 0.47), while the average age of the PLA was 18.67 years (± 0.49).

The International Physical Activity Questionnaire (IPAQ) was used to assess participants' activity levels before the study commenced, categorizing them as low, moderate, or high activity based on metabolic equivalent task (MET) values. Body composition was measured using bioelectrical impedance analysis, while aerobic fitness was estimated via the VO_{2max} test using the Beep Test (Multistage Shuttle Run Test).

Additional characteristics from this study are presented in Table 1. (Data are presented as mean \pm standard deviation (SD), $n = 20$).

Kencur supplementation and changes on IL-6

IL-6 is a cytokine that serves as a marker of inflammation in response to the mechanical disruption of fibers. IL-6 plasma levels were measured at three different times: immediately after (0 h), 24 hours (24 h), and 48 hours (48 h) post-eccentric exercise. The plasma levels of IL-6 increased

Table 1. Respondent Characteristic

Indicators	Kencur Group	Placebo Group	Categories
Age (years)	19.65 (± 1.09)	19.70 (± 1.17)	
Height (cm)	166.30 (± 5.32)	167.75 (± 3.13)	
Weight (kg)	58.65 (± 4.83)	59.15 (± 3.53)	
BMI	21.19 (± 1.24)	22.50 (± .66)	Normal
Fat Percentage (%)	21.94 (± 2.20)	22.33 (± 2.11)	Average
IPAQ (MET)	1318.26 (± 252.48)	1266.63 (± 214.28)	Moderate
VO ₂ max (mL·kg ⁻¹ ·min ⁻¹)	34.84 (± 6.18)	36.89 (± 5.87)	Poor

in response to exercise in both groups. Peak IL-6 levels were observed immediately (0 h) post-exercise for both Kencur and placebo groups, followed by a decrease at 24 h and a subsequent increase at 48 h after eccentric exercise.

When compared to the placebo group, the Kencur group showed significantly lower IL-6 plasma values at all time points post eccentric exercise (Table 2). (Data are presented as mean ± standard deviation (SD), n = 20).

Table 2. Changes in IL-6 plasma were measured at three different times.

IL-6	0 h (pg/ml)	24 h (pg/ml)	48 h (pg/ml)	P
Kencur	45.65 ± 17.22	23.26 ± 18.23	29.28 ± 18.54	0.001
Placebo	75.26 ± 26.25	57.90 ± 22.21	65.66 ± 20.17	0.710

Repeated Measures ANOVA with two factors

Table 2 above shows the changes in IL-6 after a 2-week supplementation period for both the Kencur and Placebo groups. The p-value (time) indicates the significance of differences in IL-6 levels across the three time points (0 h, 24 h, and 48 h) within each group. In contrast, the Placebo group did not exhibit significant changes in IL-6 levels over time (p = 0.710), suggesting no measurable effect from the placebo intervention. This implies that Kencur supplementation resulted in reduced IL-6 plasma levels, while the placebo group did not see any reduction in IL-6 plasma levels.

Kencur supplementation and changes on inflammatory marker (CRP)

CRP is frequently used as an indicator of inflammation resulting from intense exercise. In a comparative study of plasma levels of inflammatory markers before and after kencur supplementation (after a 2-week period), we noted a significant change in CRP levels across the three time points (0 h, 24 h, and 48 h) within each group in the kencur group, while no such change was observed in the placebo group. The test results are shown in Table 3 below. (Data are presented as mean ± standard deviation (SD), n = 20).

Table 3. The changes in CRP plasma levels were measured at three different time points

hs-CRP	0 h (mg/l)	24 h (mg/l)	48 h (mg/l)	P
Kencur	2.42 ± 0.22	1.61 ± 0.16	1.74 ± 0.28	0.003
Placebo	2.65 ± 0.15	2.08 ± 0.17	2.36 ± 0.20	0.612

Repeated Measures ANOVA with two factors

Table 3 above shows the changes in plasma CRP after a 2-week supplementation period for both the Kencur and placebo groups. The results indicate a significant reduction in CRP levels over time (p < 0.001), suggesting a notable anti-inflammatory effect of Kencur supplementation. In contrast, CRP levels in the placebo group showed changes that were not statistically significant (p = 0.612), indicating no measurable effect from the placebo treatment. Therefore, it can be concluded that Kencur supplementation leads to a more pronounced decrease in CRP plasma levels compared to the placebo.

Discussion

This study investigated the effects of Kencur (*Kaempferia galanga* Linn) supplementation on plasma IL-6 and CRP concentrations following eccentric exercise, a well-established model for inducing muscle damage and inflammation. The aim was to explore its potential as an anti-inflammatory agent in eccentric exercise, enhancing recovery, and improving exercise performance by leveraging its anti-inflammatory pathway. This information can serve as a reference and consideration for athletes and active individuals regarding the risk of inflammatory response and muscle damage caused by eccentric exercise.

The primary finding of this study showed that taking kencur supplements for a 2-week period can attenuate the inflammatory response and prevent muscle damage, as indicated by significant changes in both IL-6 and CRP plasma levels, which are markers of inflammation and muscle damage due to eccentric exercise. The current findings support kencur supplementation to attenuate inflammation and muscle damage in the hours immediately following eccentric exercise. Thus, kencur supplementation may be an important consideration in developing and implementing strategies to aid in muscle recovery during the acute (0-48 h) time period following a bout of eccentric exercise-induced inflammation.

The benefits of taking kencur supplements before and after exercise-induced inflammation are uncertain due to variations in dosage, timing, and types of exercises studied. Inflammation and muscle damage levels also differed among the studies.

It has been shown in many studies that eccentric exercise, especially if done excessively, can result in inflammation and muscle damage (Bontemps et al., 2020). High intensity exercise can cause a temporary decrease in muscle strength, increased passive tension, increased pain and muscle inflammation, and elevated levels of intramuscular proteins in the bloodstream (Arazi et al., 2021). It is a common

symptom that occurs when engaging in high-intensity exercise. It is a temporary and natural part of the muscle's repair and adaptation process (Batatinha et al., 2019).

Eccentric exercise, characterized by muscle lengthening while contracting—such as during the lowering phase of a weightlifting movement—places unique and intense mechanical stress on muscle fibers. This type of exercise is not only more challenging than concentric exercise, where the muscle shortens, but it also elicits a distinct physiological response due to the higher strain it imposes on muscle structures (Heiss et al., 2019; Stožer et al., 2020). The sarcolemma, a critical membrane surrounding muscle fibers, is particularly vulnerable during eccentric contractions. Microscopic examination reveals structural disruptions, such as "Z-line streaming" within the sarcomere, the fundamental unit of muscle contraction (Uçar et al., 2024). These changes compromise the integrity of the muscle and can lead to the leakage of essential intracellular proteins, such as creatine kinase, into the bloodstream—a hallmark of muscle damage (Stožer et al., 2020).

The resulting impairment in muscle function significantly decreases the muscle's capacity to produce force, contributing to post-exercise soreness and a prolonged recovery period (Barker et al., 2023). Despite these challenges, eccentric exercise is highly valued for its ability to stimulate muscle remodeling and adaptation, making it a double-edged sword in physical training and rehabilitation. IL-6 is the most significantly elevated cytokine after intense exercise, often exceeding other cytokines by up to 100-fold (Nanavati et al., 2022). High levels of IL-6 can lead to muscle protein breakdown, hinder recovery, and disrupt training adaptations, impacting performance and long-term health.

Several studies have suggested a strong link between inflammation and muscle recovery. Inflammatory responses, particularly through IL-6 and CRP pathways, play a crucial role in post-exercise adaptation and tissue repair (Irawan et al., 2022; Jakubczyk et al., 2020). This response involves the release of pro-inflammatory cytokines such as tumor necrosis factor- α (TNF- α), interleukin-1 beta (IL-1 β), and interleukin-6 (IL-6), as well as other inflammatory mediators like prostaglandins and leukotrienes (Lin et al., 2021). These cytokines not only amplify the inflammatory process but also contribute to the recruitment and activation of immune cells, perpetuating a cycle of oxidative damage and inflammation (Suzuki, 2018; Tanabe et al., 2021).

Studies have demonstrated that muscle damage is frequently associated with oxidative stress (OS), which is marked by an increase in reactive oxygen species (ROS). The level of the biomarker produced is dependent on the extent of muscle damage or fatigue. One study observed that cytokines response and muscle damage during eccentric exercise have been linked to a shift toward greater glycolytic energy production. As a result, inflammatory processes are consistently connected with OS, and both are directly involved in muscle damage, meaning they should be examined and managed together (Amalraj et al., 2020).

Preventing excessive increases in IL-6 following eccentric exercise is important because sustained high levels of IL-6 are associated with detrimental effects such as muscle protein breakdown, prolonged inflammation, and impaired recovery (Jomova et al., 2023; Waskiw-Ford et al., 2020). IL-6 is a pleiotropic cytokine that plays a dual role: while it acts as

a myokine facilitating glucose uptake and tissue repair during moderate elevation, excessive levels can shift toward pro-inflammatory actions, promoting catabolic effects (Fuller et al., 2020; Kistner et al., 2022). Elevated IL-6 also stimulates the production of acute-phase proteins like CRP, exacerbating systemic inflammation and contributing to oxidative stress, which can delay muscle regeneration and adaptation (Boukhris et al., 2020; Del Giudice & Gangestad, 2018).

Studies have shown that unchecked inflammation marked by elevated IL-6 levels can impair mitochondrial function, amplify muscle soreness, and reduce force production, potentially leading to overtraining syndrome or compromised athletic performance (Fischer et al., 2004). Therefore, nutritional or therapeutic strategies targeting IL-6 modulation, such as antioxidant or anti-inflammatory supplementation, can help maintain an optimal inflammatory balance post-exercise, supporting recovery and training benefits (Nara & Watanabe, 2021).

In this study, IL-6 and CRP plasma concentrations in blood were measured as an inflammatory marker. As shown in the results above, there is changes in both IL-6 and CRP plasma levels 0 hours, 24 hours and 48 hours post single bout eccentric exercise. The results of statistical analysis showed that there is a difference in IL-6 and CRP plasma levels after 14 days of Kencur supplementation. Recent studies have also shown a slight increase in IL-6 and CRP levels as an inflammatory marker after CMJs as an EIMD (Cerqueira et al., 2020; Costello et al., 2018; Kawamura & Muraoka, 2018). The presence of this inflammatory marker (IL-6 and CRP) is suggested to be the result of muscle cell damage as a consequence of intense eccentric exercise (Boukhris et al., 2020; Mal'tseva et al., 2022). The present study showed that daily Kencur capsules intake demonstrated to be efficient in attenuating IL-6 and CRP plasma levels as a consequence of intense eccentric exercise.

The excessive inflammatory response that follows can ultimately lead to additional tissue damage (Taherkhani et al., 2020). Previous evidence has suggested that an acute bout of exercise increases NF- κ B activity. NF- κ B is a critical regulator of various physiological and pathological processes, including inflammation and oxidative stress (Suzuki et al., 2020).

In conclusion, this study provides evidence supporting the potential of kencur supplementation to modulate exercise-induced inflammation, as indicated by its effects on plasma IL-6 and CRP levels following eccentric exercise. The anti-inflammatory pathway of kencur, attributed to its bioactive compounds such as ethyl p-methoxycinnamate and flavonoids, appear to play a crucial role in attenuating the acute inflammatory response associated with muscle damage. These findings suggest that kencur may serve as a natural and effective alternative for managing post-exercise inflammation, promoting recovery, and maintaining training adaptations. However, further research involving larger sample sizes, diverse populations, and varying exercise protocols is necessary to confirm these effects and explore the broader applications of kencur in sports and clinical settings.

Conclusions

This study demonstrates the potential of kencur supplementation to modulate inflammatory responses following eccentric exercise. Specifically, kencur

supplementation was associated with reductions in plasma IL-6 and CRP concentrations following eccentric exercise, suggesting a potential role in modulating the inflammatory response. These findings suggest that kencur, with its anti-inflammatory properties, may serve as a natural and effective strategy to mitigate exercise-induced muscle damage (EIMD).

Future research should explore the dose-response relationship and long-term effects of kencur supplementation across diverse populations and exercise modalities. Additionally, comparative studies with other anti-inflammatory interventions could further establish kencur's role as a viable alternative in sports nutrition and recovery.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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Приймання добавок із вмістом кенкура модулює показники інтерлейкіну-6 (IL-6) та С-реактивного білка (CRP) як реакція на пошкодження м'язів після виконання ексцентричних вправ

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 9 с., 3 табл., 1 рис., 55 джерел.

Історія питання. Інтенсивні або некастомізовані фізичні вправи можуть спричинити пошкодження м'язів і травмування тканин, що призводить до тимчасової м'язової дисфункції і вивільнення прозапальних цитокінів та вільних радикалів. Вказані фактори можуть викликати розпад м'язових білків, порушення засвоєння поживних речовин та уповільнення процесу відновлення.

Мета дослідження. Метою цього дослідження було оцінити вплив приймання добавок із вмістом кенкура на рівні ІЛ-6 та С-реактивного білка в плазмі крові після виконання ексцентричних вправ.

Матеріали та методи. Проведено рандомізоване контрольоване дослідження (РКД) із застосуванням подвійного сліпого, плацебо-контрольованого дизайну за участю 40 студентів чоловічої статі, які навчалися на факультеті рекреації Державного університету Сурабаї — Universitas Negeri Surabaya (вік: 19,65 ± 1,09 років, ІМТ: 21,10 ± 1,16 кг, відсотковий вміст жиру в організмі: 22,14% ± 2,14%). Учасників було рандомізовано до групи, яка приймала добавки із вмістом кен-

кура (200 мг/добу), або до групи плацебо (кукурудзяний крохмаль 100 мг/добу) на період спостереження 14 днів. У день проведення експерименту учасники виконали 100 вертикальних стрибків із контррухом (КРС). Забір зразків крові проводився одразу після тренування, через 24 години та 48 годин після завершення вправ з метою визначення рівнів ІЛ-6 та С-реактивного білка. Для аналізу даних було застосовано метод дисперсійного аналізу повторних вимірювань (ANOVA) із використанням post-hoc-тестів Бонферроні.

Результати. У групі, яка приймала добавки із вмістом кенкура, спостерігалось достовірне зниження рівнів ІЛ-6 та СРБ у плазмі крові після тренування в усіх часових проміжках ($p < 0,05$), тоді як у групі плацебо суттєвих змін не встановлено ($p > 0,05$).

Висновки. Отримані дані свідчать про те, що вживання добавок із вмістом кенкура сприяє значному зменшенню запальної реакції за рахунок зниження рівнів ІЛ-6 та СРБ після виконання ексцентричних вправ.

Ключові слова: ексцентричні вправи, АФК, запалення, імунна відповідь.

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