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Effects of Curcumin on Inflammatory Response During Exercise-Induced Muscle Damage (Literature Review)

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Abstract: This study aimed to evaluate the effect of curcumin on the inflammatory response during exercise-induced muscle damage (EIMD) is a literature review. The method applied to this article was a comprehensive strategy such as searching for articles in research journal databases. The databases were taken from Pubmed/MEDLINE, Scopus, Web of Science, and Embase. The keywords were curcumin, inflammation, Exercise-Induced Muscle Damage, Sport, Exercise, and Healthy Lifestyle. There were 30 articles obtained, and 10 articles were analyzed through the purpose, suitability of the topic, sample size, research protocol, and the results of each article. The results of this study explain that curcumin was able to provide anti-inflammatory effects by reducing pro-inflammatory cytokines such as IL-6, IL-8, TNF-α. Curcumin can also reduce muscle pain intensity, decrease CK activity, and increase ROM. The curcumin dose (>180 mg/day) showed to reduce various inflammatory responses due to EIMD. Therefore, it is recommended that curcumin be used in individuals who carry out physical activities, leading to muscle damage and inflammation.

Keywords: Curcumin; Exercise-Induced Muscle Damage; Sport; Exercise; Healthy Lifestyle.

1. Introduction

Resistance exercise is an essential component of a well-rounded fitness regimen for athletes and recreationally active people [1–3]. Although resistance exercise is an excellent long-term method of increasing lean muscle mass, the resulting exercise-induced muscle damage (EIMD) and discomfort might restrict performance following training sessions or competitive events [4–7].

In most cases, delayed onset muscle soreness (DOMS) and inflammation peak 1 to 2 days after a resistance training session [8–10]. The current phenomenon of about 30 million people worldwide who experience DOMS is usually treated with non-steroidal anti-inflammatory drugs (NSAID) [11,12]. While some inflammation reduction may be beneficial, the extreme blunting of inflammation produced by NSAID prevents or hampers the first stage of recovery [13–16]. Furthermore, despite the purported advantages of NSAIDs, clinical data show that NSAID treatment does not always help recovery after EIMD [17].

While many other compounds have been investigated as potential treatments for EIMD and DOMS, curcumin is of particular interest since it is thought to work similarly to NSAID, but with a less big decline in inflammation [18,19]. Curcumin's anti-inflammatory benefits have been well known [20–23]. Curcumin works by altering COX-2 pathway signaling, resulting in decreased pro-inflammatory cytokine and prostaglandin production [24–26]. This modulation might be noteworthy since prostaglandins contribute to the degree of pain after EIMD, and IL-1, IL-6, IL-8, IL-10, TNF- α, and CRP have emerged biomarkers of inflammation [27–30].

Even though curcumin has been studied extensively, there is no scientific consensus on its effects on physical activity. Consequently, we evaluated the available information from clinical studies on the effects of curcumin on EIMD

2. Materials and Methods

This study uses a literature review method using a comprehensive strategy such as searching for articles in research journal databases. The databases used are Pubmed/MEDLINE, Scopus, Web of Science, and Embase. The inclusion criteria in this study were journals that discussed curcumin, exercise, exercise, EIMD, DOMS, and inflammation. The exclusion criteria in this study were international journals published in the last five years in 2021.

3. Results and Discussion

The results of the research used in this literature review areas follows:

Table 1. Review of research results on the effects of curcumin on experimental animals.

Author	Sample Characteristics	Study Design	Intervention	Results
(Mohammadi *et al*., 2017) [31]	75 adult female Wistar rats weighing 170±20gr were divided into 3 groups, namely the dick group (n=12), the polycystic ovary syndrome group (n=12), the polycystic ovary syndrome group with curcumin administration (n=48). Polycystic ovary syndrome induced by injection of estradiol valerate.	Experimental	Injection of curcumin at a dose of 100, 200, 300, 400 mg/kgBW. The treatment was given for 14 consecutive days.	The curcumin intervention decreased inflammatory markers such as IL-6 and CRP significantly.
(Rosignoli Da Conceição *et al*., 2021) [32]	40 male rats aged 12 weeks were divided into 6 groups, namely the standard diet group, the standard diet group submitted after exercise, the whey protein+curcumin group, the whey protein+curcumin group after exercise, the	Experimental	Curcumin supplementation dose of 0.8 curcumin and 1 g of whey protein. Intervention gave after swimming training	Administration of whey protein+curcumin reduces blood glucose, oxidative damage, and inflammation caused by swimming exercise.

	curcumin group, and the curcumin group after exercise.			

Table 2. Review the results of research on the effects of curcumin on humans.

Author	Sample Characteristics	Study Design	Intervention	Results
(Delecroix *et al*., 2017) [33]	The 16 rugby players have an average age of 20 years and an average height of 182 cm. Subjects were divided into 4 groups, namely 1) dominant foot and curcumin + piperine, 2) non-dominant foot and curcumin + piperine, 3) dominant foot and placebo, 4) non-dominant foot and placebo.	Cross over	Curcumin at a dose of 2 g and 20 mg piperine, 3 times a day starting 45 minutes before exercise, 45 after exercise, and 6 hours after the second administration. The exercise given is weight training.	The intervention of 6 g curcumin and 60 mg piperine daily between 48 hours before and 48 hours after EIMD had an effect on recovery 24 and 48 after exercise.
(Rodrigues *et al*., 2021) [34]	42 hemodialysis patients aged 20-75 years were randomly divided into 2 groups, namely the control group (n=21) and the curcumin group (n=21).	Experimental	Curcumin at a dose of 100 mg/day for 12 weeks	The effect of curcumin was significant on the antioxidant response, but it was not sufficient to reduce inflammation in hemodialysis patients.
(Tanabe, Chino, Ohnishi, *et al*., 2019) [35]	20 healthy men with an average age of 29 years were divided into 2 groups, namely the control group (n=10) and the curcumin supplementation group (n=10).	Cross over	Curcumin dose 180 mg/day, 7 days before exercise, and 7 days after exercise	The administration of curcumin increased ROM, decreased pain, decreased muscle damage, and there was no significant change in TNF-α levels.
(Basham *et al*., 2019) [36]	20 healthy men aged 18-39 years. All participants completed two trials separated by 25 days.	Randomized controlled trial double-blinded	Curcumin supplementation with a dose of 1.5g was given 2 times a day (breakfast and dinner). Blood was drawn before and 60 minutes, 24 hours, 48 after aerobic exercise	Curcumin supplementation significantly reduced muscle damage, muscle pain, and there was no significant change in TNF-α levels.
(Jäger, Purpura and Kerksick, 2019) [37]	32 women and 31 men aged 19-29 years were divided into 3 groups: placebo group, 50 mg curcumin group, and 200 mg curcumin group for eight weeks.	Randomized controlled, double-blind, parallel design	Curcumin supplementation with doses of 50 mg and 200 mg. At the end of the supplementation period, the subjects performed a downhill run to induce muscle breakdown.	Curcumin supplementation significantly attenuated the decline in performance, and there was no significant change in low-dose curcumin and placebo on performance decline after EIMD.
(Tanabe, Chino, Sagayama, *et al*., 2019) [38]	24 healthy men with an average age of 26 years, height 173 cm, and an average weight of 65 kg were divided into 2 groups: the curcumin group and the placebo group.	Randomized, single-blind, parallel design	Curcumin supplementation at a dose of 180 mg/day when 7 days before exercise and 4 days after exercise	Curcumin supplementation can reduce muscle soreness after eccentric exercise.
(McFarlin *et al*., 2016) [39]	28 men aged 19-20 years were divided into 2 groups: the curcumin group (n=16) and the placebo group (n=12).	Experimental	Curcumin supplementation at a dose of 400 mg/day When 2 days before to 4 days after EIMD	The administration of curcumin was able to significantly reduce levels of pro-inflammatory cytokines

Author	Sample Characteristics	Study Design	Intervention	Results
				such as IL-8 and TNF-α, as well as reduce markers of muscle damage, namely CK.
(Mallard *et al*., 2021) [40]	28 men aged 18-35 years were divided into 2 groups, namely the curcumin group and the placebo group	Randomized controlled, double-blind, parallel design	Curcumin supplementation dose of 450 mg before and after lower extremity resistance training	The administration of curcumin is able to accelerate recovery by modulating inflammatory pathways, reducing lactate accumulation and reducing post-exercise muscle pain.

The main aim of this literature review was to evaluate the effect of curcumin on the exercise-induced inflammatory response. Curcumin is well known for its anti-inflammatory properties [41–45]. Exercise performed at high intensity will cause EIMD [35,46,47]. EIMD will cause an inflammatory process associated with ROM and DOMS [48–50]. Inflammation is a protective response caused by injury or tissue damage caused by physical trauma, damaging chemical substances, or microbiological substances [27,51–53]. In response to tissue injury, the body initiates a chemical signaling cascade that stimulates a response to heal the injured tissue [54–60]. These signals activate the chemotaxis of leukocytes from the general circulation to the sites of damage [61–64]. These activated leukocytes produce cytokines that induce an inflammatory response [65–68].

Curcumin is well known for its anti-inflammatory properties [41–43]. The dose of curcumin given varies, research (Mohammadi *et al*., 2017) [31] conducted experiments on experimental animals, in their study reported that administration of curcumin for 14 consecutive days at a dose of 100, 200, 300, 400 mg/kgBW can reduce inflammatory markers such as CRP and IL-6, In this study, there was no decrease in inflammatory markers in the dick group. The study (Rosignoli Da Conceição *et al*., 2021) [32] also reported that the administration of curcumin (0.8g) + whey protein (100g) given to male rats that had been doing swimming exercises could reduce inflammation and blood glucose. In addition, a study conducted by (Rodrigues *et al*., 2021) [34] reported that curcumin at a dose of 1 gram/day given for 12 days a week to subjects who did an aerobic exercise program significantly reduced the intensity of muscle pain, muscle damage. Still, this study did not report a decrease in pro-inflammatory cytokines such as TNF-α. However, a study conducted by (Tanabe, Chino, Ohnishi, *et al*., 2019) [35] reported that administration of curcumin at a dose of 180 mg 7 days before and 7 days after EIMD experienced a significant reduction in pain intensity and pro-inflammatory cytokines such as TNF-α. Another study with a larger dose of 400 mg was also reported by (McFarlin *et al*., 2016) [39], in his study concluded that curcumin with a fixed-dose given 2 days before and 4 days after EIMD can reduce levels of TNF- α, IL-8, and CK. What distinguishes it from the previously described studies is the dosing. Research (Mallard *et al*., 2021) [40] also supports larger doses of 450 mg given before and after exercise to significantly accelerate recovery by modulating inflammatory pathways, reducing lactate accumulation, and reducing pain intensity. For more details, see the figure below:

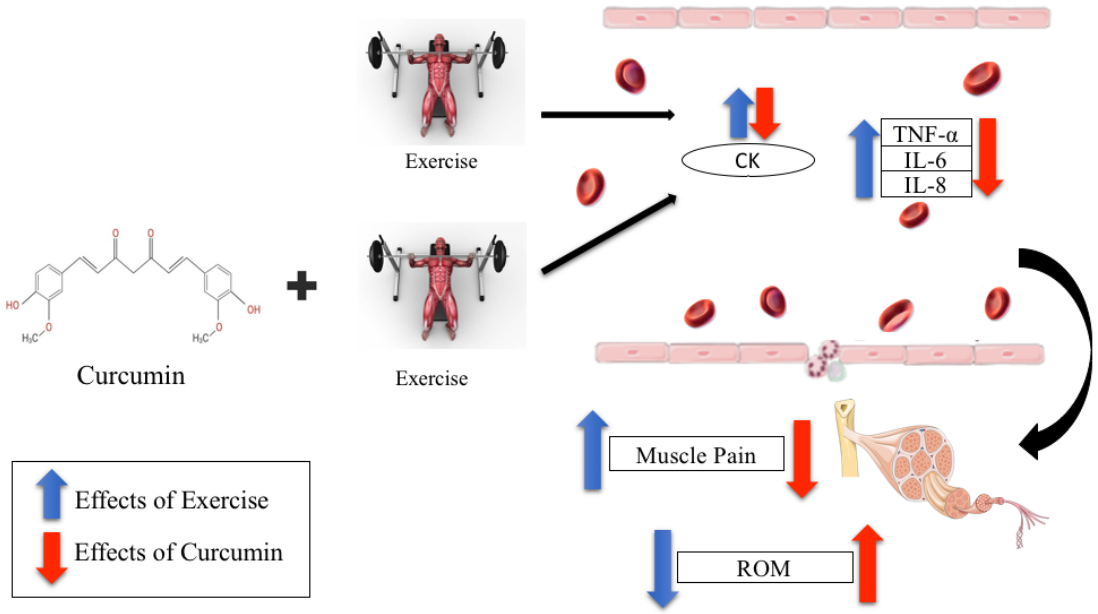

Figure 1. Effects of Curcumin on Inflammatory Response During Exercise-Induced Muscle Damage.

Thus, we report that curcumin is very rich in benefits, especially for recovery after EIMD; so far, we have not found reports that the use of curcumin has side effects post-exercise, which needs to be considered is the use of the right dose for maximum results.

4. Conclusions

Curcumin is able to provide anti-inflammatory effects by reducing pro-inflammatory cytokines such as IL-6, IL-8, TNF-a. Curcumin can also reduce muscle pain intensity, decrease CK activity, and increase ROM. The right dose used ranges from 180mg-450mg/day to get optimal results. We recommend that curcumin be used in individuals who engage in physical activity that results in muscle damage and inflammation.

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Conflicts of Interest

The authors declare no conflict of interest.

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