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A Comparative Study on the Effects of Nonlinear Resistance Training With and Without Curcumin Supplementation on IL-6, TNF-α, Muscle Strength, and Perceived Pain in Male Bodybuilders from Isfahan

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Abstract

Background and Objectives: Some studies have highlighted the effects of resistance training on inflammatory factors. This study aimed to compare the effects of non-linear resistance training with and without curcumin supplementation on certain inflammatory markers, muscular strength, and perceived pain in male bodybuilders.

Methods: The study population included male bodybuilders aged 20–30 in Isfahan with at least one year of bodybuilding experience. Thirty participants were selected by convenience sampling and randomly assigned to two groups: non-linear resistance training with curcumin supplementation (n=15) and non-linear resistance training alone (n=15). Exercises were performed three non-consecutive days per week for 12 weeks. The curcumin group received one capsule daily. Blood samples (5 mL) were collected 24 hours before and after the intervention. Variables measured included IL-6, TNF-α, perceived pain, and muscle strength. Data were analyzed using analysis of covariance (ANCOVA) with significance set at $p<0.05$.

Results: There were no significant differences between the two groups in TNF-α (p=0.132) or IL-6 (p=0.421). Perceived pain differed significantly between groups (p=0.005), with greater improvement observed in the training plus curcumin group. No significant differences were found between groups in one-repetition maximum (1RM) for chest press (p=0.296) or leg press (p=0.188).

Conclusion: Non-linear resistance training combined with curcumin supplementation can reduce muscular pain, body weight, and fat percentage. However, further research is needed to clarify effects on inflammatory markers.

Keywords: Curcumin, non-linear resistance training, inflammatory markers, pain.

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Introduction

High-intensity exercise, such as resistance training, especially those that cause metabolic stress in the form of energy depletion and muscle damage (1), is characterized by the development of muscle soreness (2). The muscle soreness can limit performance (2). Several studies have reported that muscle soreness is caused by an increase in proinflammatory cytokines, such as tumor necrosis factor alpha (TNF-a) and interleukin 6 (IL-6), produced in the body in response to muscle injury (3). In most cases, inflammation peaks 1 to 2 days after an exercise session (4). Approximately 30 million people worldwide who experience pain are commonly treated with nonsteroidal anti-inflammatory drugs (NSAIDs) (5). One natural substance available for this purpose is curcumin. Curcumin is known for its anti-inflammatory properties. Curcumin blocks the signaling of proinflammatory cytokines by activating protein responses in the muscles, thereby accelerating the healing of muscle damage. In this regard, pro-inflammatory cytokines such as interleukin 10 (IL-10) play an important role in controlling the inflammatory response. Curcumin has been widely used to increase endurance and VO2Max (6). Curcumin has been widely used in medicine and healthcare for its role in accelerating wound healing. (7). It is well known that intensive exercises can cause muscle damage and inflammation, depending on the training kind, intensity, and duration (8). Exercise with eccentric movements produces the most muscle fiber damage, inflammation, delayed onset muscle soreness (DOMS), and various functional deficits. It is now thought that many of these muscle-damaging exercise responses may be mediated by large increases in inflammatory cytokines in active muscle, plasma, and perhaps even the brain (9). Exercise can increase inflammatory cytokines, such as IL-1, TNF-α, and IL-6, were originally thought to be expressed only in immune cells, but have now been identified to varying degrees in many other tissues. These cytokines are regulated by a variety of stimulators and suppressors in inflammatory pathways. The cytokine pathways mediated by NF-κB and the activator protein-1 (AP-1) and prostaglandin cyclooxygenase-2 (COX-2) cascade are the best studied (10). Muscle damage by free radical production in response to abnormal exercise can stimulate these pathways, leading to increased inflammatory cytokine production, pain, and muscle dysfunction (11). Recent evidence suggests that various plant extracts, including turmeric (Curcuma longa), have potent anti-inflammatory activity in a variety of inflammatory models (12).

Curcumin is a bioactive compound derived from the rhizome of Curcuma longa (turmeric) its importance is because of its potential health benefits. However, the use of it in clinical practice is limited due to its generally poor bioavailability. This issue can be overcome using novel delivery systems that enhance curcumin's solubility, extend its residence time in plasma, improve its pharmacokinetic profile, and increase its cellular uptake (13).

The anti-inflammatory properties of turmeric have been attributed to its active ingredient curcumin. Evidence suggests that curcumin, under some experimental conditions, can have anti-inflammatory activity similar to that of some common nonsteroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen, but without many of the side effects, such as gastrointestinal upset and cardiovascular complications (14, 15). The molecular basis of curcumin's anti-inflammatory properties is related to its effects on several targets, including transcription factors, growth regulators, and cell signaling molecules. Curcumin has been reported to directly affect the activity of various inflammatory regulators. It has been shown to reduce NF-κB activation, AP-1 binding to DNA, and also to reduce the production of the enzyme COX-2, all of which play a pivotal role in the inflammatory cascade (11, 16,). In addition, several studies have shown that curcumin can indirectly inhibit these inflammatory regulators through its ability to scavenge free radicals (17, 16). However, to date, there are no reports of curcumin's potential anti-inflammatory benefits and subsequent performance improvement following muscle damage induced by nonlinear resistance training. Curcumin has been reported to help prevent the decline in exercise performance following intense and strenuous exercise, mainly due to its membrane-protective properties, antioxidant activity, and anti-inflammatory effects (18). The anti-inflammatory properties attributed to curcumin are due to its ability to inhibit NF-kB, which may be a protective and regenerative factor in muscle and plays an important role in controlling the physiological mechanisms of inflammation and protein degradation (19). Curcumin can block TNF-α-dependent NF-kB activation and the ROS-induced activation pathway (20). Similarly, curcumin can have a down-regulating effect on COX-2 expression and inhibit the expression of a pro-inflammatory enzyme (lipoxygenase-5) in the leukotriene metabolic pathway (21) as well as intercellular adhesion. Curcumin induces negative regulation of proinflammatory interleukins (IL-1, IL-2, IL-6, IL-8, and IL-12), inflammatory cytokines, such as TNF-α. The protein (MCP-1), through the inhibition of the transcriptional signaling pathway (JAK/STAT), additionally protects cells from apoptosis by overexpressing Bcl-2 or Bcl-X L, which counteracts pro-apoptotic and pro-inflammatory attacks and restores the anti-inflammatory physiological phenotype (22). Curcumin attenuates the heat shock response to muscle injury (23) and regulates biomarkers of muscle injury, such as CK (11).

Several studies have investigated the effects of curcumin in various sports such as football and volleyball. However, considering the growing interest in resistance training and the common occurrence of muscle damage and pain following training sessions, an important question arises: Can curcumin supplementation, as a natural antioxidant and anti-inflammatory agent, reduce pain and inflammation after a period of resistance training?

Materials and methods

The research was a semi-experimental and an applied study that was conducted as a pre-test and post-test. Population and Sample The statistical population of the research included all male bodybuilders aged 20 to 30 years in Isfahan who had at least one year of bodybuilding experience. 30 of them were selected from 3 fitness gyms and were randomly divided into two groups: nonlinear resistance training (n=15) 3 sessions per week for 12 weeks, each session lasting 45 to 60 minutes and the nonlinear resistance training with curcumin supplementation (n=15) who eat Nano micelle curcumin capsule every day after breakfast in addition to resistance training(24). The independent variables in this study included nonlinear resistance training and curcumin supplementation. The dependent variables included IL-6, TNF-α, perceived pain, movement speed, agility, and muscular strength of male bodybuilders in Isfahan. The research assumptions included that participants were in good mental health, performed the exercises as instructed by the researchers, consistently consumed the curcumin capsules in the curcumin group throughout the entire study period, and did not change their diet compared to the pre-study period. 24 hours before and after the end of the trainings, blood samples were drawn between 7 and 9 am (5 ml from the antecubital vein) after a 12-hour fasting in the laboratory under the supervision of the researchers and a laboratory expert.

The code of research ethics was IR.IAU.KHUISF.REC.1403.235.

Nonlinear Resistance Training Program

Nonlinear resistance training of varying intensity levels was carried out according to Tables 1 and 2 (24).

Table 1. Nonlinear Resistance Training Program

Exercises / Intensity	VL (Very Light)	L (Light)	M (Moderate)	H (Heavy)	VH (Very Heavy)
Leg Extension (Machine)	*1×20/40	2×15/60	3×10/75	3×4/90	4×2/95
Bench Press	1×20/40		3×10/75	3×4/90	4×2/95
Incline Bench Press		2×15/60			
Seated Row	1×20/40	2×15/60	3×10/75	3×4/90	4×2/95
Deadlift	1×20/40	2×15/60	3×10/75	3×4/90	4×2/95
Crunch (Knees Bent)	1×20	2×20	3×15	3×18	3×20
Lat Pulldown		2×15/60			
Calf Raise	1×20/40	2×15/60	2×10/75	2×4/90	
Leg Curl (Hamstring)	1×20/40	2×15/60	2×10/75	2×4/90	
Shoulder Press	1×20/40	2×15/60	2×10/75	2×4/90	
Barbell Row	1×20/40	2×15/60	2×10/75	2×4/90	
Biceps Curl	1×20/40	2×15/60	2×10/75	2×4/90	

*Represents 1 set at 40% intensity of one repetition maximum for 20 repetitions.

Table 2. Intensity of Nonlinear Resistance Training Across Training Sessions

Week	1	2	3	4	5	6	7	8	9	10	11	12
Session 1	L	L	M	VL	M	L	VL	H	L	M	L	VL
Session 2	M	VL	H	H	M	M	M	VL	L	M	M	H
Session 3	L	H	L	L	L	H	L	M	VH	VL	VL	L

The Magill Pain Questionnaire (25) was used to assess the subjects' perceived pain level. All participants recorded their perceived pain level on a five-point scale from mild to unbearable pain. Participants were then instructed not to perform any activity to relieve muscle pain after the 1RM test, but they were allowed to continue with their daily activities.

Fortunately, throughout the research, all participants followed the research protocol and no one was excluded from the study.

The health of the participants was maintained throughout the study. The training program and supplement intake were supervised by the researchers. All participant information remained confidential to the researchers.

Statistical analyses

To evaluate the effect of the pre-test, analysis of covariance (ANCOVA) was applied. The level of statistical significance was set at $p < 0.05$. Data were analyzed using SPSS software (version 27).

Results

Table 3. shows demographic characteristics of participants.

Table 3. Demographic characteristics of participants

variable	group	mean	sd
Age (year)	Nonlinear resistance training	25.13	2.90
	Nonlinear resistance training with curcumin	24.67	4.35
Height (cm)	Nonlinear resistance training	178.87	2.10
	Nonlinear resistance training with curcumin	180.00	2.93
Weight-pre (kg)	Nonlinear resistance training	84.15	2.43
	Nonlinear resistance training with curcumin	85.29	3.16
Weight-post (kg)	Nonlinear resistance training	82.20	2.40
	Nonlinear resistance training with curcumin	82.43	2.40
BMI-pre ($kg.m^{-2}$)	Nonlinear resistance training	26.33	0.73
	Nonlinear resistance training with curcumin	26.01	0.82
BMI-post ($kg.m^{-2}$)	Nonlinear resistance training	25.72	0.66
	Nonlinear resistance training with curcumin	25.48	0.91
% Body fat-pre	Nonlinear resistance training	13.75	1.01
	Nonlinear resistance training with curcumin	14.58	0.99
% Body fat-post	Nonlinear resistance training	12.65	0.96
	Nonlinear resistance training with curcumin	13.79	1.03

Figure.1 shows the mean TNF-α in the two groups.

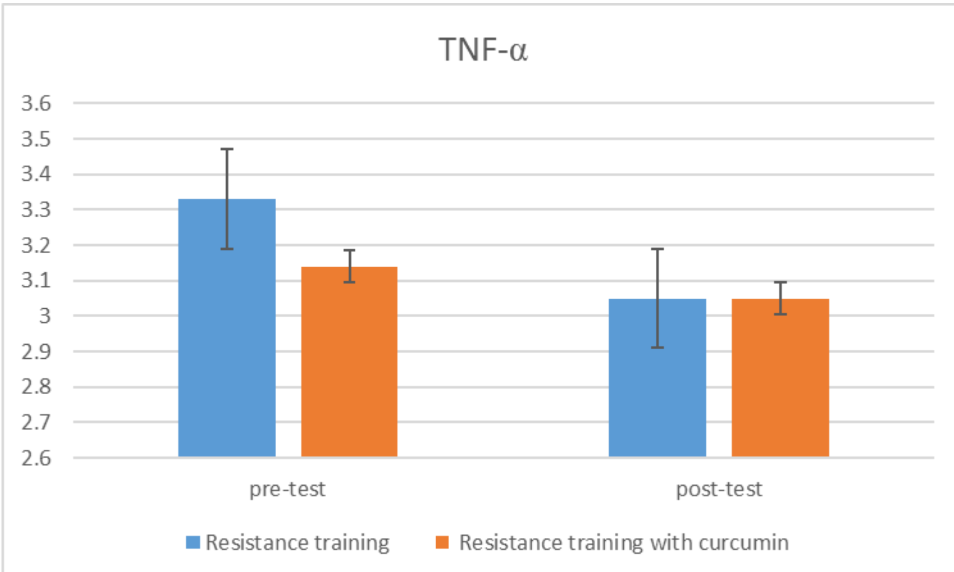

figure.1 the mean TNF-α in the two groups

Figure.2 shows the mean IL-6 in the two groups.

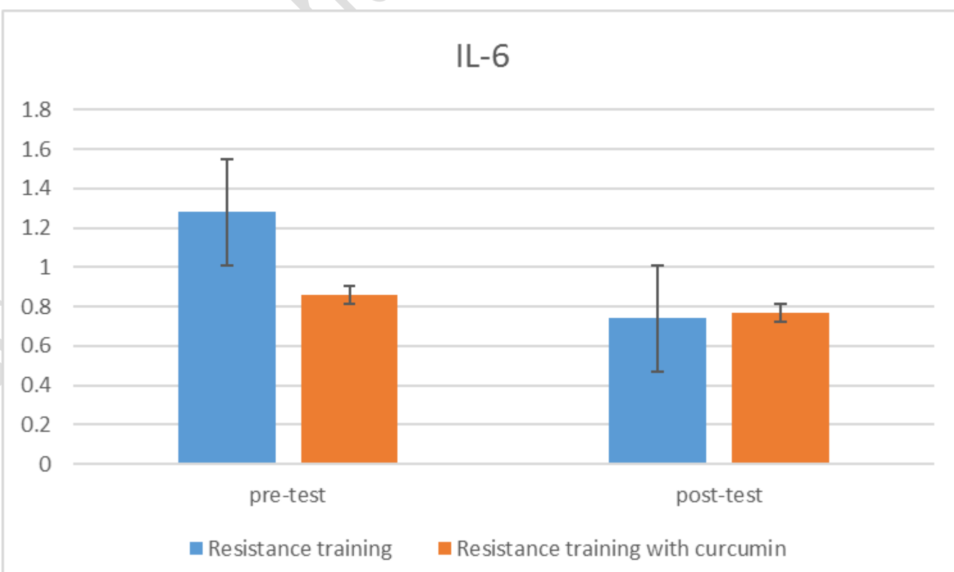

Figure.2 the mean IL-6 in the two groups

Figure.3 shows the mean perceived pain in the two groups.

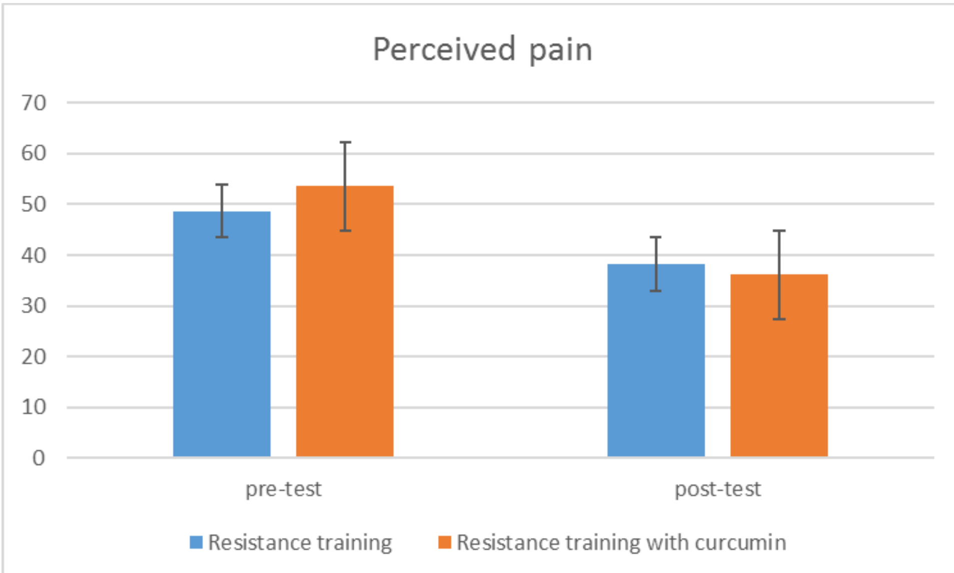

Figure.3 the mean Perceived pain in the two groups

Figure.4 shows the mean chest press in the two groups.

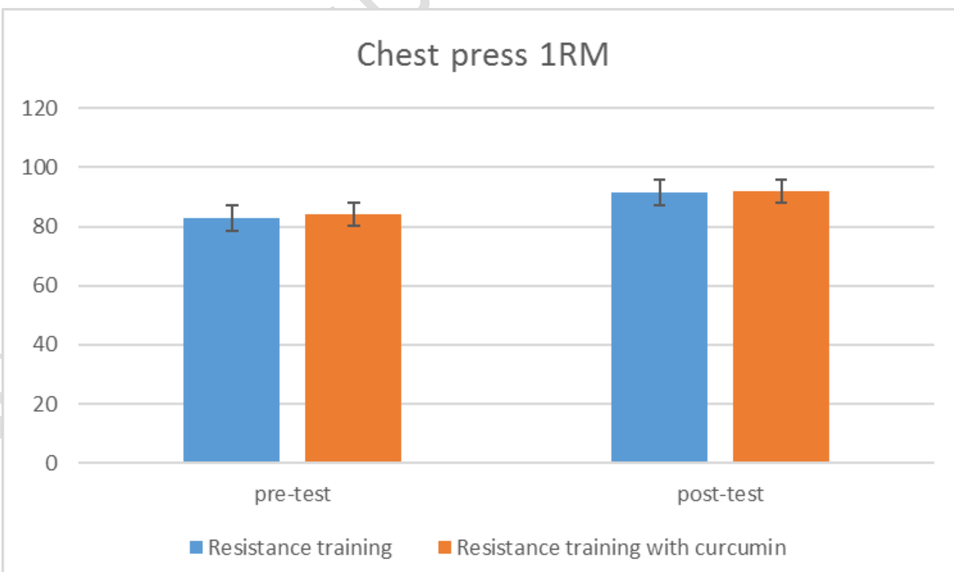

Figure.4 the mean chest press in the two groups

Figure.5 shows the mean leg press in the two groups.

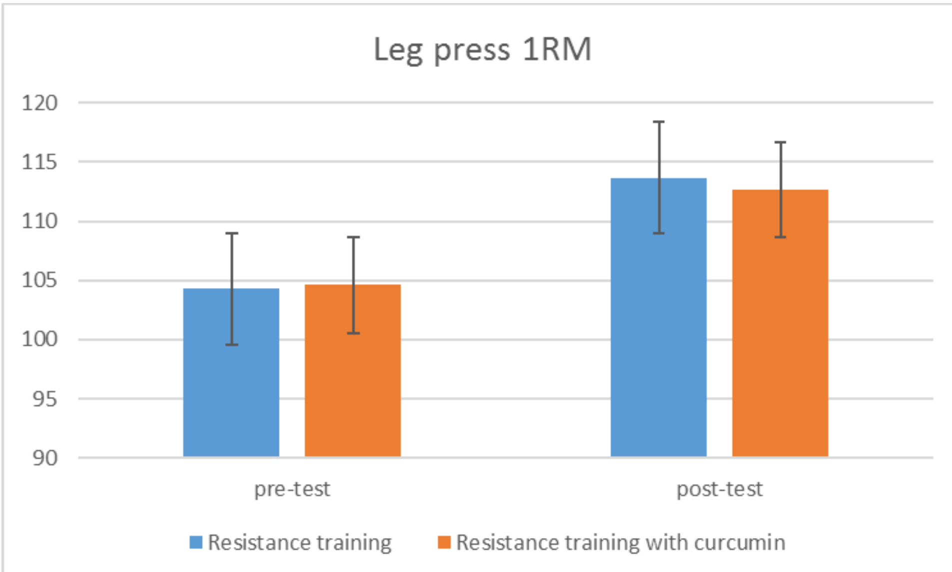

Figure.5 the mean leg press in the two groups

Table.4 shows analysis of Covariance Test.

Table.4 analysis of covariance test result.

Variables		Sum of squares	Freedom degree	F	p
TNF-α	Pre-test	6.999	1	78.223	0.000
	groups	0.215	1	2.408	0.132
	error	2.416	27		
	total	288.063	30		
IL-6	Pre-test	0.099	1	3.08	0.091
	groups	0.021	1	0.668	0.421
	error	0.864	27		
	total	18.072	30		
Perceived pain	Pre-test	868.53	1	34.304	0.000
	groups	238.307	1	9.412	0.005
	error	683.603	27		
	total	43025	30		
Chest press	Pre-test	371.243	1	49.797	0.000
	groups	8.475	1	1.137	0.296
	error	201.29	27		
	total	253207	30		
Leg press	Pre-test	918.244	1	126.221	0.000
	groups	13.249	1	1.821	0.188
	error	196.422	27		

total	385323	30

As Table 4 shows, there was no significant difference in TNF-α between the two groups of nonlinear resistance training with curcumin consumption and the nonlinear resistance training group (p=0.132). There was no significant difference in IL-6 between the two groups (p=0.421). There was a significant difference in perceived pain between the two groups (p=0.005), so that the training and curcumin supplement group showed greater improvement in the pain variable than the training group per se. There was no significant difference in the variables of one repetition maximum of the chest press (p=0.296) and one repetition maximum of the leg press (p=0.188) between the two groups.

Discussion

In the present study, there was no significant difference in TNF-α levels between the nonlinear resistance training groups with curcumin consumption and the nonlinear resistance training group per se (p=0.132). This finding was consistent with the research of Liu et al (2024), Calle and Fernandez (2010), and Akbar Pour (2013) (26-28) and inconsistent with the research of Moradi Kelardeh et al (2020), shargh et al (2025), Matin Homaei et al (2017) and Hong et al (2025) (29,30). In the present study, there was no significant difference in IL-6 levels between the nonlinear resistance training group with curcumin consumption and the nonlinear resistance training group (p=0.421). This finding was consistent with the research of Cheng and Yang (2024), Johnson et al. (2022), Calle and Fernandez (2010), and inconsistent with the research of Kader et al. (2018), Matin Homaei et al. (2017), Cao et al (2025) (31) and Akbar Pour (2013).

Based on current evidence, resistance training has uncertain effects on cytokines. A review of the literature suggests that inflammatory cytokines response to training can vary. Inflammatory cytokines are secreted by a variety of cells, including neutrophils, activated macrophages, and muscle cells (17). The multifold increase in IL-6 secretion from skeletal muscle following exercise may be a hormonal signaling of blood glucose utilization and glycogen depletion, and there is a positive correlation between plasma IL-6 levels and exercise intensity, muscle glucose uptake, and plasma adrenaline (17).

Cao et al (2025) corroborates that resistance training promoted macrophage polarization to the M2 phenotype, decreased the mRNA levels of TNF-a, NF-kB, and IL-1b, and elevated the mRNA levels of IL-6 and IL-10 in aged muscle (31). previous researches demonstrated that IL-6 had both pro-inflammatory and anti-inflammatory properties. Conventional perspectives have predominantly characterized interleukin-6 as a pro-inflammatory cytokine in skeletal muscle On the contrary, during muscle contraction, IL-6 is produced and released into circulation by muscle tissue, suggesting that resistance training may increase skeletal muscle IL-6 secretion to enhance its anti-inflammatory effects (32). These findings indicated that resistance training may help mitigate inflammation in aging skeletal muscle. Shargh et al bring attention to the role of miR-21 and miR-146a in oxidative stress-induced inflammation and their modulation by curcumin and exercise therapy. Their findings suggest that these interventions may serve as promising strategies for reducing inflammation and mitigating age-related diseases (29).

The conflicting results reported in different studies could be due to differences in training protocols, subject types, and changes in body composition. The response of inflammatory markers depends on age, fitness level and pathological conditions such as obesity and diabetes. Also the basal levels of inflammatory factors play an important role in the response to training, such that lower basal levels lead to no changes following exercise (22). Therefore, it seems that resistance training improves the inflammatory status caused by aging and type 2 diabetes, and one of the main reasons for the different responses of the two inflammatory markers IL-6 and TNF-α after resistance training is probably due to their different basal levels in subjects. Studies have reported that changes in inflammatory cytokines in response to lifestyle interventions are mainly dependent on changes in body weight. Both IL-6 and TNF-α are also secreted as adipokines from adipose tissue, and an increase in fat mass is associated with an increase in circulating levels of these adipokines (22,23). Previous studies have shown that a reduction of at least 10% of body weight is required to significant changes in inflammatory markers (27). Some other studies have also shown that a 5% reduction in weight can lead to improvements in the inflammatory profile following training (28).

Studies have confirmed that adipose tissue is the main cause of low-grade inflammation and reducing fat mass is a key factor in the anti-inflammatory effect of resistance training (33,34). A study by Tomeleri reported that adipose tissue may influence the production of pro-inflammatory cytokines. The results also confirmed a positive correlation between changes in fat mass and reductions in inflammatory markers, which was more pronounced in trunk fat (35).

However, Nicholas et al. observed that regular physical activity reduced the concentration of systemic inflammatory markers even in the absence of weight loss (36). Three possible mechanisms for the anti-inflammatory effects of exercise include a reduction in visceral fat mass, a reduction in the number of pro-inflammatory monocytes in the circulation, and an increase in number of regulatory T cells in the circulation. Furthermore, Hong and colleagues showed that cardiorespiratory fitness was associated with low-grade inflammation, which may be due in part to an increased ability of immune cells to suppress inflammatory responses via adrenergic receptors (38).

Resistance training improves insulin resistance by reducing chronic inflammation, as a reduction in the levels of some inflammatory cytokines such as IL-6 and TNF-α improves insulin sensitivity by activating different steps of the insulin signaling pathway (39). However, the level of insulin resistance was not examined in the present study.

Resistance training with its direct effect on adipose tissue and increased lipolysis (by increasing hormone-sensitive lipase activity), can reduce the production of pro-inflammatory mediators from adipose tissue and increase the production of anti-inflammatory mediators from adipose tissue (4). Therefore, this kind of training can reduce circulating inflammatory markers by lowering sources of inflammation. On the other hand, adipose tissue is also considered as an endocrine organ due to the secretion of substances such as TNF-α, IL-6, leptin, and adiponectin (1). TNF-α is an important mediator of inflammatory processes and is expressed in large quantities in adipose tissue (especially abdominal fat), and its presence in the circulatory system may indicate the production of this factor in adipose tissue (13). Regarding the effect of exercise on TNF-α levels, researchers have reported inconsistent findings, with some studies indicating a decrease (4), while others reporting no change (37) in response to exercise.

In the present study, a significant difference was observed in the perceived pain levels between the nonlinear resistance training with curcumin supplementation group and the nonlinear resistance training group per se ($p = 0.005$). Specifically, the resistance training plus curcumin group showed greater improvement in pain compared to the training-only group. This finding is consistent with the results reported by Mansouri et al. (2016) and inconsistent with Cheng and Yang (2024) and Clarkson et al (2006). In the current research, the combined effect of supplementation and training enhanced the efficiency and performance of the muscular system and increased the pain perception threshold of the participants.

In previous studies investigating the effects of resistance training on perceived pain, muscle soreness has generally been reported to increase following resistance exercise (26, 41). However, in the present study, a reduction in perceived pain was observed compared to the pre-test values, particularly in the curcumin supplementation group. This outcome may be attributed to the interactive effect of nonlinear resistance training, characterized by muscle endurance benefits, in combination with curcumin intake. The sinusoidal variation in training intensity inherent in nonlinear resistance programs likely prevents excessive muscle damage and delays the onset of muscle soreness, which is consistent with the findings of the present study regarding muscle pain. Furthermore, nonlinear resistance training is typically performed with higher repetitions, which can enhance muscular performance and improve body composition. This is supported by the measured outcomes in the current research, including improvements in muscular performance indices (increased 1RM in bench press and leg press) and favorable changes in body composition (decreased body fat percentage and BMI).

Several mechanisms have been proposed to explain the onset of exercise-induced muscle damage, functional impairment, and soreness. Classical theories such as lactic acid accumulation, muscle spasm, connective tissue disruption, inflammation, and edema formation have been frequently cited (41-44). However, current evidence suggests that eccentric muscle contractions play a central role in the development of delayed-onset muscle soreness (DOMS), irrespective of sex, age, or baseline fitness level, although the symptoms are more pronounced in untrained individuals. Following unaccustomed eccentric exercise, structural disruptions at the muscle–tendon junction initiate a cascade of pathophysiological events, including calcium overload, mitochondrial dysfunction, and impaired ATP synthesis. The subsequent inflammatory response is characterized by an acute neutrophil infiltration within the first 6–12 hours' post-exercise, followed by macrophage accumulation and histamine release, which peak around 48 hours after injury. These immune responses stimulate the production of prostaglandins, thereby sensitizing type III and IV afferent nerve endings to mechanical, thermal, and chemical stimuli (41), In parallel, the accumulation of histamine, potassium, and kinins resulting from cellular necrosis, combined with phagocytic activity, localized edema, and elevated muscle temperature, further contributes to the activation of nociceptors within the muscle and musculotendinous junction. These processes, together with the leakage of muscle-specific enzymes such as creatine kinase, aspartate aminotransferase, and lactate dehydrogenase, provide biochemical markers that accompany the subjective sensation of soreness (44).

On the other hand, resistance training itself has been shown to exert protective and adaptive effects on muscle tissue. The reduction in perceived soreness and improvement in functional capacity observed after training interventions may be explained by enhanced central nervous system activation, inhibition of phosphodiesterase activity, blockade of adenosine receptors, attenuation of fatigue perception, increased Na^+/K^+-ATPase activity, improved calcium handling within muscle fibers, and reduced potassium efflux during repeated contractions (40-44). Taken together, these findings suggest that while eccentric contractions serve as the primary driver of muscle soreness and damage, resistance training can induce physiological adaptations that mitigate these negative outcomes and promote recovery.

Helder et al (2025) revealed curcumin may act through multiple biochemical pathways than just suppression of the COX-2 pathway and also may be more enzyme/tissue specific (42).

Curcumin is recognized for mitigating inflammation by suppressing the prominent COX-2 pathway, resulting in a reduction of inflammatory markers like TNF-α and IL-4 (43).

A study has shown that while inflammation biomarkers tend to be reduced post-exercise with curcumin, significant reductions are lacking in the literature comparing low and high doses. Therefore, the reductions in muscle soreness observed may be attributed to mechanisms beyond the COX-2 pathway, such as the NF-kB pathway, which has been associated with pain modulation (44).

In the present study, there was no significant difference in the maximum repetition of the chest press ($p=0.296$) and the maximum repetition of the leg press ($p=0.188$) between the two nonlinear resistance training groups with curcumin consumption and the nonlinear resistance training group. This finding was consistent with the research of Gavanda et al (2025), Moradi Kelardeh et al. (2020), Betz et al. (2025), and Betz et al. (2024).

The improved performance of participants in the one-repetition maximum test may be due to neuromuscular adaptations such as accelerated transmission of nerve signals, increased use of larger motor units, improved muscle metabolism, and increased motor unit recruitment (22). On the other hand, the excitability and sensitivity of motor units are higher in trained athletes, and training can also increase motor nerve excitability and the frequency of motor nerve discharges increases with training, which may be a possible factor in the increase in dynamic strength resulting from resistance training (22).

Also muscle microvascular volume at 10 min after end of training, elevated up to 40 min after exercise (47).

A study has shown low type II muscle fiber capillarization is associated with lower muscle microvascular blood volume (48). The long term elevation of post-exercise muscle perfusion is so important to ensure removal of waste products accumulated and allow sufficient delivery of nutrients and growth factors to provide muscle tissue recovery and reconditioning (49, 50, 51).

Totally as a natural compound with clear immunopharmacological effects, curcumin has garnered significant research attention over the past 20 years. Bibliometric analysis of literature from 2004 to 2024 not only reveals the diverse effects of curcumin in immune modulation but also emphasizes its crucial roles in cancer, inflammation, and infectious disease treatments (52) so it seems the survey of curcumin to decrease the inflammation follow training may be useful for athlete.

The limitations of the study included the following:

- Since the reduction in the levels of some inflammatory cytokines such as IL-6 and a-TNF improves insulin sensitivity by activating different steps of the insulin signaling pathway, it would have been better to examine insulin sensitivity in this study.
- Lack of control over the psychological conditions of the participants.
- Lack of control over the participants' nutrition.
- Lack of control over other inflammatory markers.
- Lack of follow-up examination of the status of the variables.

After conducting a 12-week study, researchers suggest that:

- Since nonlinear resistance training plus curcumin reduced pain perception in participants, bodybuilders and trainers are advised to include this type of resistance training program and herbal supplement in their training process.
- Since a small (non-significant) decrease in the inflammatory factors IL-6 and TNF-α was observed in the nonlinear resistance training program along with the use of curcumin supplement, it is recommended that different doses of this supplement be investigated in future research.

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