



Efficacy and safety of immediate release bio-enhanced curcuminoids (CurcIR)/ (ZING95) in muscle soreness: A prospective, open label, comparative case study

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Abstract

Background: Delayed onset muscle soreness (DOMS) is a common and transient musculoskeletal condition characterized by muscle pain, tenderness, stiffness, and reduced range of motion that typically develops 6 to 24 hours after unaccustomed or intensive physical activity, peaking between 24- and 72-hours post-exercise. DOMS is most frequently associated with eccentric muscle contractions, in which the muscle lengthens under tension, examples resistance training, or sudden increases in exercise intensity or volume.

Methodology: This prospective, open label, comparative case study evaluated and compared the efficacy of immediate release bio-enhanced curcuminoids (Zing 95) -200 mg of 95% Curcuminoid (T) with 500 mg of 95% standard Curcuminoid (C). 24 healthy human volunteer s aged between 21 and 35 years, who engaged in moderate physical activity and experienced muscle soreness following gym-based exercise were randomised into two groups and were followed for 7 days. All participants performed daily gym-based exercises for at least one hour throughout the study period, including treadmill exercise. Muscle pain, tenderness, fatigue, delayed onset muscle soreness, endurance, jump height performance, VO₂ max, and biochemical markers (CK, CRP, LDH) were assessed from baseline (Day 0) to Day 7 using validated scales and performance tests. Changes in muscle swelling, lean body mass, muscle mass, rescue medication use, tolerability, adverse events, and overall satisfaction (5-point Likert scale) were also evaluated to determine efficacy and safety of the intervention.

Results: Muscle pain, tenderness, and DOMS significantly reduced from Day 5 onwards in both the groups, with earlier and better improvements in the Test group, including a significant between-group difference for pain and DOMS by Day 7. Fatigue domains (tiredness, need for rest, energy, weakness, strength) showed earlier and consistent improvement in the Test group. Jump height and power improved significantly in the Test group. CRP, LDH, and CK decreased in the Test group, while showing delayed recovery in the Comparator group, though between-group differences were not significant. Blood parameters for safety assessments remained within normal limits before and after the study. Improvements in Vo₂ max and 6 min test were similar in both the groups.

Conclusion: The test product was safe well tolerated and demonstrated earlier and better improvement in muscle soreness, fatigue, functional performance, and recovery biomarkers compared to the reference product, over a 7-day study period.

Keywords: Delayed Onset Muscle Soreness (DOMS), Curcuminoids (Zing95 / CurcIR), Bio-enhanced immediate release, Muscle recovery biomarkers (CK, CRP, LDH), unctional performance improvement

Introduction

During strenuous exercise, myocytes undergo temporary structural alterations that can result in reduced muscle strength and power, delayed onset muscle soreness (DOMS), inflammation, restricted range of motion, and elevated extracellular (blood) levels of muscle-derived enzymes and proteins such as creatine kinase (CK) [1-3]. Delayed onset muscle soreness is a transient, exercise-induced condition that in 24 to 72 hours after unaccustomed or intensive physical activity and leads to muscles contract. causing trauma to muscle Fibers and leads to local inflammation and sensitization of nociceptors, which in turn results in pain, stiffness, diminished strength, and impaired functional performance [4, 5]. DOMS can adversely affect athletic performance, daily activities, and overall recovery capacity, warranting the importance of effective management strategies [6]. Consequently, various interventions, including topical formulations, nutritional supplements, physical therapy modalities, and rest, have been explored to alleviate muscle soreness, reduce inflammation, and improve functional recovery [7].

Curcumin, chemically known as 1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione or diferuloylmethane, is a natural polyphenolic compound isolated from the rhizome of *Curcuma longa* [8] and has been extensively studied over the past few decades for its potent antioxidant and anti-inflammatory properties in various chronic and malignant conditions, including metabolic syndrome [8]. Exercise-induced muscle damage (EIMD) is primarily mediated through inflammatory pathways such as NF-κB, cyclooxygenase-2 (COX-2), tumor necrosis factor-α (TNF-α), and interleukin-6 (IL-6) [9], all of which are known to be modulated by curcumin, the major bioactive curcuminoid. Supplementation with curcumin has been demonstrated to enhance functional recovery following eccentric or high-intensity exercise, reduce creatine kinase (CK) levels, and attenuate the severity of delayed onset muscle soreness (DOMS) [10].

Its positive benefits on pain reduction and attenuation of muscle injury biomarkers are further supported by systematic reviews and meta-analyses [11]. Despite these therapeutic benefits, traditional curcumin has poor oral bioavailability because of its low aqueous solubility, quick

metabolism, and restricted gastrointestinal absorption. As a result, greater doses typically more than 1500 to 2000 mg daily are required to achieve clinical efficacy^[12, 13]. Because of this difficulty, curcuminoid formulations that are bio enhanced and water-dispersible have been developed with the goal of enhancing solubility, absorption, and systemic exposure even at lower dosages. Studies on this enhanced-bioavailability formulations have demonstrated notable decreases in muscle pain and injury indicators^[14]. When compared to conventional curcumin powders, pharmacokinetic analyses also indicate significantly greater plasma concentrations for nanoparticle and other improved curcumin systems^[15].

Zing95 is a bio-enhanced, immediate-release curcuminoid formulation (T) also known as CurcIR standardized with 95% curcuminoids (C). The inclusion of natural bioenhancers is designed to boost systemic absorption and improve gastrointestinal dispersion. When compared to traditional Curcuminoid 95% formulations (500 mg), this improved profile is anticipated to have better therapeutic benefits at a lower dose (200 mg). Reductions in DOMS, muscular soreness, exhaustion and biochemical markers linked to muscle injury are expected to be further enhanced by improved bioavailability^[16]. Therefore, this study aimed to evaluate Efficacy and safety of (T) in conditions associated with muscle soreness in comparison to standard curcumin 95% (C).

Methodology

Study Design and Study Center

This prospective, open label, comparative case study was conducted in Oxymed Hospital Medical & Healthcare Center, Chennai, Tamilnadu.

Ethical Approval and Trial Registration

The study protocol was approved by the Institutional Ethics Committee, Oxymed Hospital (registration no: ECR/1861/Inst/TN/2023). The trial was registered prospectively in the Clinical Trials Registry of India (CTRI) on September 30, 2025 (registration no: CTRI/2025/09/095478).

This study was conducted in compliance with the International Council for Harmonization-Good Clinical Practice (ICH-GCP) guidelines E6 (R2), 2016; the Indian Council of Medical Research (ICMR) National Ethical Guidelines for Biomedical and Health Research Involving Human Participants, 2017; the Declaration of Helsinki, 2013; and all applicable local regulatory requirements and institutional policies. Written informed consent was obtained from each participant prior to study initiation.

Study Population

Men and women aged between 21 and 35 years who engaged in moderate physical activity and experienced muscle soreness in gym-based exercise were enrolled in the study. Participants were found eligible if they had not performed any structured exercise in the past two months; had no known musculoskeletal pathology; provided written informed consent to undergo all the study procedures.

Participants were excluded if they had used systemic corticosteroids within 2 months prior to screening; received

any investigational product within 1 month before randomization; had uncontrolled diabetes mellitus or hypertension; had a history of tuberculosis, HIV, ischemic heart disease, cancer, or renal failure; were pregnant or lactating; had clinically significant abnormal laboratory findings; or had known hypersensitivity to any ingredient of the test product.

Study Procedure and Treatment Randomization

After obtaining written informed consent, participants underwent a detailed screening procedure. Screening included participants demographic data (gender, height (cm), weight (kg), Body Mass Index (kg/m²) and age in years), personal history, medical history (allergy) and systemic examination of participants. Efficacy and safety assessments were conducted on Day 0, Day 1, Day 3, Day 5, and Day 7.

Eligible participants were equally randomized into two groups, using block randomization schedule,

T – Test (n=12): Immediate release bio-enhanced curcuminoids (Zing 95) (CurcIR) -200 mg of 95% Curcuminoid

C – Comparator (n=12): 500 mg of 95% standard Curcuminoid

Randomization was done using a computer-generated block randomization schedule prepared by a biostatistician

Study Endpoints

Study endpoints included changes in muscle pain and tenderness assessed by VAS, muscle swelling measured by standardized anthropometry, jump performance (vertical jump height and power using the Sayers equation), fatigue assessed by the Chalder Fatigue Scale, and delayed onset muscle soreness from baseline to Day 7. Secondary endpoints included changes in lean body mass, muscle mass, biochemical markers of muscle injury, inflammation (CK, CRP, LDH), VO₂ max, endurance assessed by the 6-minute walk test, and use of rescue medication. Overall condition, tolerability, and safety were evaluated using a 5-point Likert scale and adverse event monitoring throughout the study period.

Statistical Analysis

Demographic characteristics were analysed using Fisher's exact test. Non-parametric outcomes were analyzed using the Friedman test for within-group comparisons across time points, followed by Dunn's post-hoc test, and the Mann-Whitney U test for between-group comparisons. These outcomes included VAS scores for muscle pain, tenderness, and DOMS; Chalder Fatigue Scale scores; VO₂ max measured using the treadmill test; 6-minute walk test distance; and biochemical markers (LDH, CK, and CRP). Parametric outcomes were analyzed using one-way repeated-measures ANOVA for within-group comparisons and the unpaired *t*-test for between-group comparisons. These included changes in muscle swelling, jump performance and power output, lean body mass, and muscle mass. All statistical analyses were performed using GraphPad Prism version 10.6.1.

Results

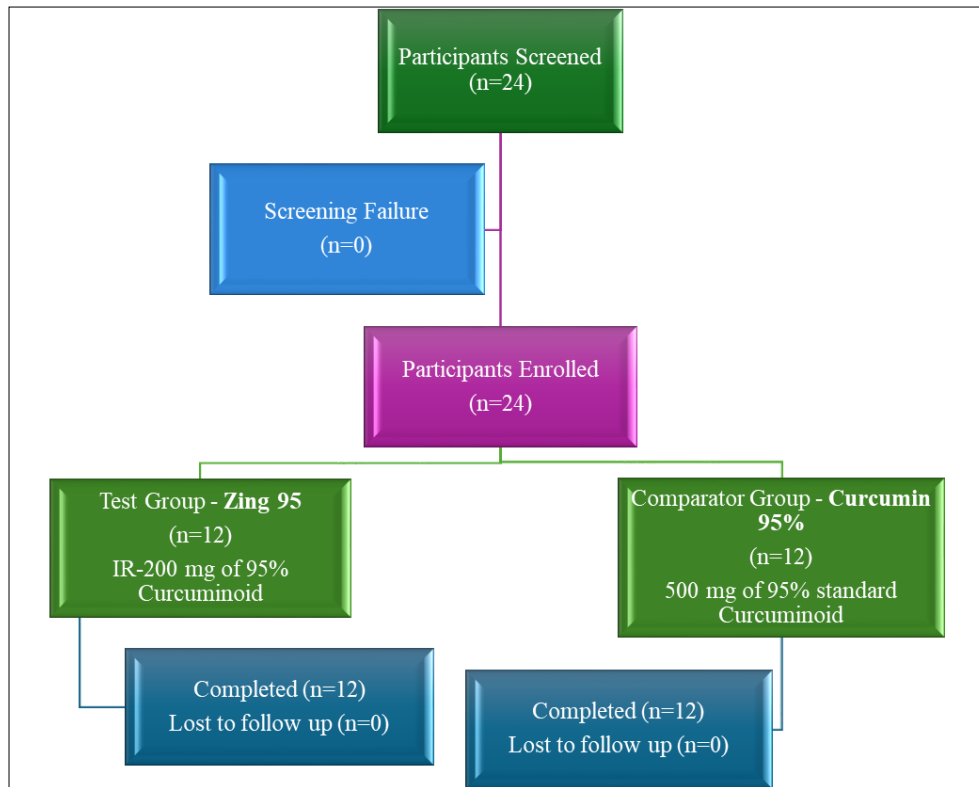


Fig 1: Participant Flowchart

1. Demographic Details

A total of 24 participants were screened and enrolled into the two study groups (Zing 95, Curcumin 95%), and All participants completed the study without any dropouts (Figure. 1). The gender distribution between groups showed a balanced representation of males and females, with no statistically significant differences ($p=0.37$). Age distribution was also comparable between groups, most of the participants age were within 21-30 years range with no significant differences between groups ($p =0.99$). Gender, age and BMI analyses confirmed that the study groups were demographically comparable at baseline.

Body temperature, pulse rate and blood pressure assessments showed that values were within the normal physiological range in both groups throughout the study. No significant differences were observed between the Test and Comparator groups until study completion.

Muscle pain (VAS) scores showed significant reduction from Day 5 onward in both groups, Test ($p = 0.003$) and Comparator ($p = 0.001$) groups, it sustained throughout the study period. Between-groups analysis demonstrated a statistically significant reduction in the Test group compared to the Comparator group on Day 7 (Table 1). Similarly, tenderness VAS scores on palpation showed a significant reduction in tenderness from day 5 onwards in both Test ($p = 0.0004$) and Comparator ($p = 0.004$) groups, it sustained throughout the study period. No significant differences were observed in the between group analysis at any timepoint, indicating comparable efficacy throughout the study period (Table 2). No swelling was observed, for any of the participants throughout the study period. Muscle development showed no significant differences between groups across most anatomical sites; however, significant improvements were observed in left relaxed biceps (Test Vs

Comparator on Day 7), left forearm compared within groups from baseline, and right thigh (Test Vs baseline).

Jump height and power assessments showed statistically significant improvements on day 7 of Test group compared to baseline, however it was not observed in the comparator group. Between group comparison did not show any statistically significant throughout the study period (Table 3).

Fatigue outcomes improved earlier and more consistently in the Test group, with significant reductions in tiredness, need for rest, improved energy and improved strength from Day 5 onward, whereas improvements in the Comparator group were observed only on Day 7. Cognitive fatigue domains showed no significant changes.

The Test group demonstrated an earlier and better decline in DOMS, with lower mean scores from Day 3 onward compared to the Comparator group, indicating faster recovery from muscle soreness in the Test group over the study period (Figure 2). Lean body mass and muscle mass assessments showed no statistically significant changes within and between groups

Biochemical markers (CRP, LDH, and CK) showed consistent reductions from baseline to day 7 in the Test group, while the Comparator group demonstrated transient increases with minimal recovery by Day 7. The finding show that there were no statistically significant differences, in biomarker level between-group (Table 4). VO_2 max assessment showed a statistically significant difference on Day 7 compared with baseline in both test and comparator groups. However, no significant differences were observed between the groups (Table 5).

The 6-minute walk test demonstrated a statistically significant improvement on Day 7 in both groups compared with baseline in both Test and Comparator groups.

However, the between-group comparison showed no significant difference (Table 6). None of the participants required rescue medications during the study period.

Considering the overall Changes in participants Condition, Investigators reported the feedback that 100% of participants in both groups as satisfied, and participants feedback reported as 41.7% of the participants in test group were satisfied with the effect of the test product, while 50% participants in the Comparator group were satisfied. No dissatisfaction was reported in either group. According to the investigator 91.7% of participants the Test group were satisfied with the tolerability of the Test product and 50% participants in the comparator group were satisfied with the products tolerability. Blood investigations, including Complete Blood Count and Random Blood Sugar, were performed for safety monitoring. Although minor variations in certain parameters were observed post-study, all values remained within the normal reference ranges.

Discussion

This prospective, open-label comparative case study evaluated the effectiveness and safety of an immediate-release bio-enhanced curcuminoid formulation (Zing 95; 200 mg providing 95% curcuminoids) against a higher-dose conventional Curcumin 95% formulation (500 mg) in healthy individuals experiencing exercise-induced muscular pain. The study design enabled assessment of whether the lower-dose, bio-enhanced formulation could achieve comparable or superior therapeutic benefits in comparison to a standard higher-dose curcumin preparation.

The demographic characteristics, including age, BMI, and gender distribution, demonstrated confirming the groups were comparable at the baseline.

Muscle Soreness

Muscle pain and tenderness, assessed using the VAS, demonstrated statistically significant reductions from Day 5 onwards compared to baseline values in both groups. The Test group showed a significant improvement by Day 7 compared with the Comparator. Several studies have demonstrated that curcumin supplementation significantly reduces exercise-induced muscle soreness measured by VAS (e.g., dampening pain at 24–48 h) [17, 18].

Delayed-onset muscle soreness (DOMS), evaluated through a combined assessment of VAS pain and fatigue scores, showed a significant reduction from Day 3 onwards, which was sustained throughout the study period. When compared with the standard Curcumin 95% formulation, the Immediate and controlled-release bio-enhanced curcuminoid formulation (Test) showed significant reduction in DOMS from Day 3 through Day 7. This outcome was consistent with prior evidence demonstrating that curcumin supplementation attenuates exercise-induced muscle soreness within 24–72 hours [19–22]. Reduction in VAS score to the extent of 53% from baseline with just 190mg/day curcuminoid dosing observed here with moderate exercise is quite significant when compared to 59% reduction in VAS with a large dose(500mg/day), that too with eccentric continuous exercise [38].

Fatigue

Chalder Fatigue Scale assessment revealed that Curcumin Immediate and controlled Release produced has significant reduction in fatigue within 7 days. Similar benefits were

reported by previous studies where curcumin supplementation significantly reduced fatigue severity [23]. Evidence from other studies also support curcumin's anti-inflammatory and antioxidant actions that help alleviate fatigue [24, 25]. The findings of this study reinforce that fast-acting curcumin formulations can meaningfully reduce fatigue over short durations.

Physical Endurance

In addition to reducing DOMS, curcumin supplementation improved jump height on day 7, indicating better short-term muscle function and neuromuscular performance, likely due to its anti-inflammatory and muscle-protective effects. A previous ten-day study of curcumin supplementation demonstrated the maintenance of vertical jump performance following plyometric exercise, supporting the rapid improvements in jump performance and power [26–29].

VO₂ max and 6-minute walk test assessments revealed improved oxygen and walking capacity on day 7. The observed reductions in muscle pain, muscle soreness, and delayed-onset muscle soreness (DOMS) may be attributed to these enhancements in aerobic efficiency and functional capacity. A randomized, double-blind, placebo-controlled trial in moderately active participants reported that curcumin for eight weeks significantly improved VO₂-max while also reducing inflammatory and muscle damage markers [29].

Another controlled trial in sedentary older adults undergoing elastic-band resistance training demonstrated that curcumin supplementation enhanced improvements in 6-Minute Walk Test (6MWT) compared with training alone [30]. In another randomized double blind study reported an increase in VO₂ max to the extent of 2.39% after eccentric continuous exercise (downhill running) [38]. In comparison, much higher increase of (10.44%) in VO₂ max increase is observed in this study demonstrates superior endurance provided by Zing95.

Overall, consistent Curcumin intake may support both muscular power, aerobic performance and improved exercise outcomes within 7 days

Inflammation and Biomarkers

Analysis of biochemical markers revealed that the Test group showed consistent reductions from day 3 onwards compared to Baseline values in CRP, LDH, and CK, indicating immediate reduction in inflammation, muscle stress and damage. CRP levels decreased by 30.05% in the Test group over the 7-day period, which is unprecedented considering a smaller dose of 200mg/day. When compared to their baseline values LDH and CK levels in the Test group decreased by 17.8% and 12.54%, respectively, similarly reduced the muscle stress and damage by Day 7, when compared to their baseline values.

Recent meta-analysis evidence indicates that curcumin supplementation significantly reduces serum creatine kinase (CK) levels and decreases muscle soreness scores following exercise-induced muscle damage, highlighting its effectiveness in mitigating muscle damage and pain [31]. In controlled trials, optimized curcumin formulations have demonstrated attenuated increases in CK and inflammatory cytokines such as TNF- α and IL-8 post-exercise, suggesting an anti-inflammatory and muscle-protective effect [32]. In addition, studies in healthy adults have reported significant reductions in CRP (30.05%) and LDH after prolonged curcumin supplementation, further supporting its role in

reducing systemic inflammation and muscle stress [33]. Also in a double blind placebo controlled study, where a reduction of 15.54% in CK has been reported with curcumin dose of 500mg/day. In comparison, the reduction of 12.54% in CK may appear smaller, but it is quite significant considering smaller dose of 200mg/day of Zing95 [38]. These findings corroborate our study observations of reductions in CRP, LDH, and CK in the Test group over 7 days, thereby reinforcing the possibility of the bio-enhanced curcuminoid formulations efficiency in faster recovery and reduced muscle damage, compared with the standard formulation of curcumin.

Lean body mass and muscle mass

Lean body mass and muscle mass showed no significant changes during the 7-day Curcumin Immediate Release (IR) intervention, which is expected since curcumin primarily supports anti-inflammatory and recovery pathways rather than rapid anabolic adaptations. Previous short-duration curcumin studies similarly reported improvements in soreness and biochemical recovery without measurable effects on body composition [34-37]. Muscle circumference increased by a maximum of 1%, which is attributed to the transient post-exercise muscle pump rather than true hypertrophic change.

Conclusion

This prospective, open-label comparative study demonstrated that a lower-dose, immediate-release bio-enhanced curcuminoid formulation (CurcIR) (Zing 95; 200

mg of 95% curcuminoids) showed therapeutic benefits that were comparable to, and in several domains superior to, a higher-dose conventional Curcumin 95% formulation (500 mg) over a 7 day of study period in healthy individuals with exercise-induced muscular pain. The Test formulation consistently improved muscle soreness, tenderness, and DOMS from as early as day 3, with significantly greater reductions than the Comparator by Day 7. Fatigue scores also declined in the Test group. Measures of physical endurance, including jump height, power, VO₂-max, and 6-minute walk distance, improved by Day 7, suggesting enhanced cardiovascular efficiency and functional capacity that likely supported faster muscular recovery. These functional gains were accompanied by decreases in CRP, LDH, and CK, indicating reduced systemic inflammation and muscle stress. Although no significant differences in lean mass were observed over the short duration, overall tolerability was high in both groups, with no adverse events reported. Collectively, the findings of this study indicate that supplementation with a bio-enhanced curcuminoid formulation may deliver rapid improvements in recovery, performance, and inflammatory biomarkers at a lower dose than conventional curcumin.

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Conflicts of Interest: None

Table 1: Change in Muscle Pain on VAS Scale

Study Visits	Test		Comparator		p value (Between Groups Comparison)
	Mean ± SD	Median (min-max)	Mean ± SD	Median (min-max)	
Baseline	7.42±0.9	8(5-8)	7.25±0.62	7(6-8)	0.37
Day 1	6.83±0.94	7(5-8)	6.83±0.83	7(5-8)	0.98
Day 3	5.75±1.14	6(4-7)	5.83±0.72	6(5-7)	0.96
Day 5	5±0.43	5(4-6)	5.17±0.72	5(4-6)	0.39
Day 7	3.5±0.67	3(3-5)	4.58±0.51	5(4-5)	0.001
P Value (Compared to Baseline)	<0.0001		<0.0001		

Table 2: Change in Muscle Tenderness by VAS on Palpation

Study Visits	Test		Comparator		p value (Comparison Between Groups)
	Mean ± SD	Median (min-max)	Mean ± SD	Median (min-max)	
Baseline	5.92 ± 1.93	6.5(1-8)	5.75 ± 1.55	5.5(3-8)	0.64
Day 1	5.17 ± 1.99	5(1-8)	5.17 ± 1.12	5(3-7)	0.91
Day 3	4.17 ± 1.34	4.5(1-6)	4.17 ± 1.4	4(2-7)	0.72
Day 5	3.5 ± 1.31	4(1-5)	3.25 ± 0.97	3(2-5)	0.49
Day 7	2.92 ± 1.17	3(1-5)	2.92 ± 1.17	2.5(2-5)	0.72
P Value (Compared to Baseline)	<0.0001		<0.0001		-

Table 3: Jump Performance and Power

Parameters	Study Visits	Mean ± SD		p value (Between group Comparison)
		Test	Comparator	
Jump Height (cm)	Day 0	25.37 ±2.89	23.16 ±6.51	0.29
	Day 1	25.63 ±3.09	23.93 ±6.11	0.4
	Day 3	25.68 ±2.95	24.11 ±5.9	0.26
	Day 7	26.62 ±3.45	24.21 ±6.32	0.42
P value (Compared to Baseline)		<0.0001	0.31	-
Power (W)	Day 0	2650 ±843.9	2670 ±612.9	0.95
	Day 1	2689 ±834.9	2716 ±562.8	0.95
	Day 3	2705 ±846.3	2719 ±539.4	0.96
	Day 7	2784 ±851.9	2753 ±584.7	0.92
P value (Compared to Baseline)		<0.0001	0.19	-

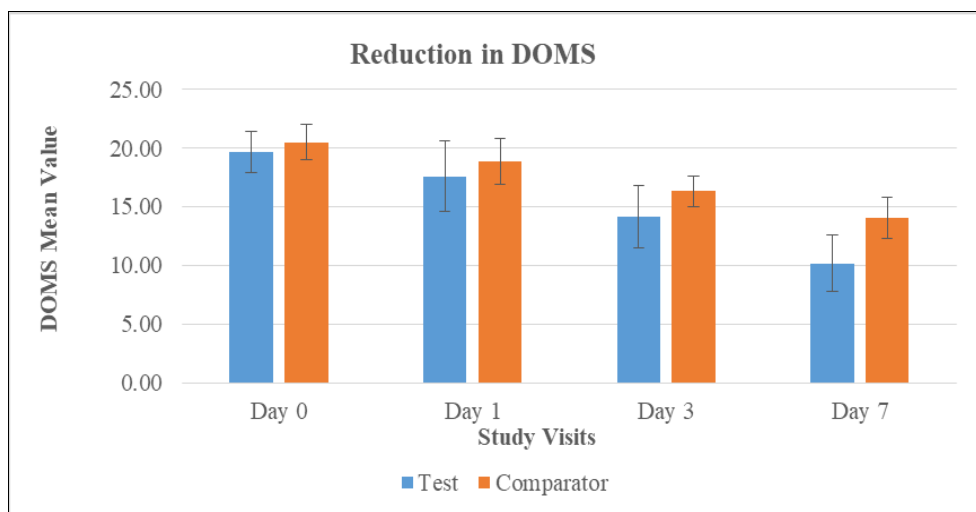


Fig 2: Delayed Onset Muscle Soreness:

Table 4: CRP, LDH and CK

Parameter	Study Visit	Test	Comparator	p value (Between Groups Comparison)
		Mean ± SD		
CRP (mg/L)	Baseline	3.66±3.68	2.09±1.87	0.10
	Day-3	3.33±2.85	2.73±2.74	0.35
	Day 7	2.56±1.85	3.23±3.78	0.8
P Value (Compared to baseline)		0.40	0.47	-
% Change from Baseline		-30.05	54.54	-
LDH (U/L)	Baseline	303.3±109.4	238.3±59.47	0.11
	Day-3	267.3±82.39	255.8±52.5	0.7
	Day 7	249.3±48.11	234.5±36.18	0.5
P Value (Compared to baseline)		0.47	0.17	-
% Change from Baseline		-17.8	-1.59	-
CK (U/L)	Baseline	161±55.15	160.8±90.47	0.84
	Day-3	153.6±68.61	166±99.52	0.8
	Day 7	140.8±48.56	157.1±63.1	0.43
P Value (Compared to baseline)		0.56	0.37	-
% Change from Baseline		-12.54	-2.3	-

Table 5: VO2 Max (mL/kg/min) through Treadmill Test

Study visits	Test	Comparator	p value (Between Groups Comparison)
	Mean ± SD		
Baseline	32 ±2.73	32.36 ±2.68	0.47
Day 1	32.69 ±2.63	32.91 ±2.74	0.60
Day 3	33.88 ±2.48	33.61 ±2.96	0.94
Day 7	35.73 ±3.08	35.03 ±3.32	0.68
P Value (Compared to baseline)	<0.0001	<0.0001	-

Table 6: 6 Minute Walk Test (m)

Study visits	Test	Comparator	p value (Between Groups Comparison)
	Mean ± SD		
Baseline	575.4 ±49.79	610.4 ±47.5	0.12
Day 1	585.8 ±48.98	635 ±57.45	0.1
Day 3	589.2 ±51.78	638.3 ±64.96	0.1
Day 7	600.7 ±64.88	645 ±59.35	0.25
P Value (Compared to Baseline)	0.01	0.0007	-

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