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Capsaicin-Related Compounds and Exercise Performance in Resistance and High-Intensity Exercise: A Narrative Review

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Abstract

Background: Capsaicin-related compounds, including capsaicin, capsinoids/capsiate, dihydrocapsiate and phenylcapsaicin, are investigated as potential TRPV1-related ergogenic aids, but human exercise evidence remains heterogeneous.

Objective: This structured narrative review summarizes human evidence on capsaicin-related compounds in resistance and high-intensity exercise, focusing on performance, rating of perceived exertion (RPE), fatigue, recovery, delayed-onset muscle soreness (DOMS), and selected physiological or neuromuscular outcomes.

Methods: A structured PubMed search was supplemented by targeted compound-specific queries. After deduplication and search refinement, 62 unique records were screened by title and abstract. Human studies of oral supplementation in resistance, high-intensity, sprint, intermittent, CrossFit-type and recovery-related exercise contexts were prioritized.

Findings: Current evidence suggests protocol-specific rather than universal ergogenic effects. Capsaicin showed selected benefits in small male crossover trials involving resistance exercise and high-intensity intermittent exercise, but not in repeated sprinting or continuous high-intensity running. Capsiate and dihydrocapsiate showed mixed findings, with no clear dose-response pattern. Phenylcapsaicin showed preliminary benefits for selected squat, jump, mechanical-performance and soreness-related outcomes, but not consistently for RPE, metabolic markers or whole-session CrossFit Workout-of-the-Day performance.

Conclusions: Capsaicin-related compounds may have compound- and protocol-specific ergogenic potential, particularly in selected resistance and intermittent high-intensity settings. However, current evidence is limited by small samples, heterogeneous protocols, inconsistent outcomes and limited independent replication. Larger, well-controlled trials are needed before firm practical recommendations can be made.

Keywords: capsaicin, phenylcapsaicin, TRPV1, ergogenic aids, perceived exertion, recovery

1. Introduction

Nutritional ergogenic aids are widely used in resistance, high-intensity and mixed-modality exercise, where small changes in fatigue tolerance, perceived exertion, mechanical output or recovery may influence training quality and competitive performance [1]. Capsaicin-related compounds have attracted interest through their interaction with transient receptor potential vanilloid 1 (TRPV1), a polymodal receptor involved in heat, nociception and discomfort perception, with potential relevance to sensory, cardiovascular, metabolic and fatigue-related responses during exercise [2-3]. However, biological plausibility alone does not establish an ergogenic effect in humans, and the exercise literature remains heterogeneous [4-6].

Several TRPV1-related pathways may connect these compounds with exercise outcomes, including discomfort-related sensory input [2,7], oral or taste-related ergogenic hypotheses [8], calcium handling and skeletal-muscle mechanisms [9-11], and preclinical exercise or fatigue models [12-13]. Capsaicin-related compounds have also been discussed in relation to thermogenesis and substrate metabolism [14-15], post-exercise metabolic recovery [16], autonomic responses [17], and broader vascular or metabolic hypotheses [18]. These

mechanisms justify investigation, but animal models, resting metabolic studies and mechanistic experiments should not be treated as direct evidence of improved performance in exercising humans [5].

Capsaicin, the pungent capsaicinoid found in chili peppers and the prototypical TRPV1 agonist [2], has been investigated in small human trials involving resistance exercise and high-intensity intermittent exercise [19-21], as well as repeated-sprint and continuous high-intensity running protocols [22-23]. Findings suggest benefits for selected outcomes, such as resistance-exercise volume or time to exhaustion during intermittent protocols [19-20], but not in repeated sprinting or continuous high-intensity running [22-23]. RPE and metabolic responses are also inconsistent across protocols [19-20,22].

Capsiate, dihydrocapsiate and related capsinoids are non-pungent or less-pungent analogs of capsaicin that retain TRPV1-related activity and may differ in tolerability [24]. Their human performance evidence is mixed: acute capsiate improved selected resistance or running outcomes in some protocols [25-26], but not all capsaicin-analog or capsinoid studies showed performance or metabolic benefits [27-29]. Chronic capsiate data are also difficult to interpret as acute ergogenic evidence [30].

Phenylcapsaicin has more recently emerged as a synthetic capsaicin analog with reported higher bioavailability, lower studied doses and novel-food safety assessment [31]. Early human studies suggest potential effects on selected squat, mechanical-performance, jump and DOMS outcomes [32-34], while additional work has examined aerobic capacity, ocular perfusion and physiological responses [35-36]. Nevertheless, effects do not consistently extend to RPE, metabolic markers or whole-session CrossFit® Workout-of-the-Day performance [32,34].

Given these mixed and compound-specific findings, a focused synthesis is needed to distinguish capsaicin, capsiate/capsinoids, dihydrocapsiate and phenylcapsaicin, and to evaluate whether effects differ by exercise modality and outcome domain. Previous reviews largely addressed capsaicinoids and capsinoids as a single class, primarily within endurance or broad ergogenic contexts [5,37], weight-management or thermogenesis contexts [14], and recent meta-analytic synthesis pooling compound classes [6]. None has explicitly separated compound-specific effects across these compounds in resistance and high-intensity exercise while distinguishing mechanistic plausibility from clinical evidence in humans [4-6]. This structured narrative review therefore summarizes current human evidence on capsaicin-related compounds as potential TRPV1-related ergogenic aids in resistance and high-intensity exercise, with attention to performance, RPE, fatigue, recovery, DOMS and selected physiological or neuromuscular outcomes.

2. Methods

A narrative review was conducted using PubMed, supplemented by targeted searches for capsaicin, capsinoids/capsiate, dihydrocapsiate and phenylcapsaicin. Search terms combined these compounds with resistance exercise, high-intensity exercise, sprint, intermittent exercise, CrossFit, exercise performance and recovery. After deduplication and search refinement, 62 unique records were screened.

Human studies of oral supplementation assessing exercise performance, perceived exertion, fatigue or recovery formed the main evidence base. Mechanistic, preclinical, metabolic, endurance-oriented and chronic-training studies were used only for relevant background context. Multi-ingredient studies were considered separately when the independent effect of a capsaicin-related compound could not be determined.

Findings were synthesized narratively by compound and outcome domain because of substantial differences in compounds, doses, populations, exercise protocols and outcomes. The literature selection process is summarized in Figure 1.

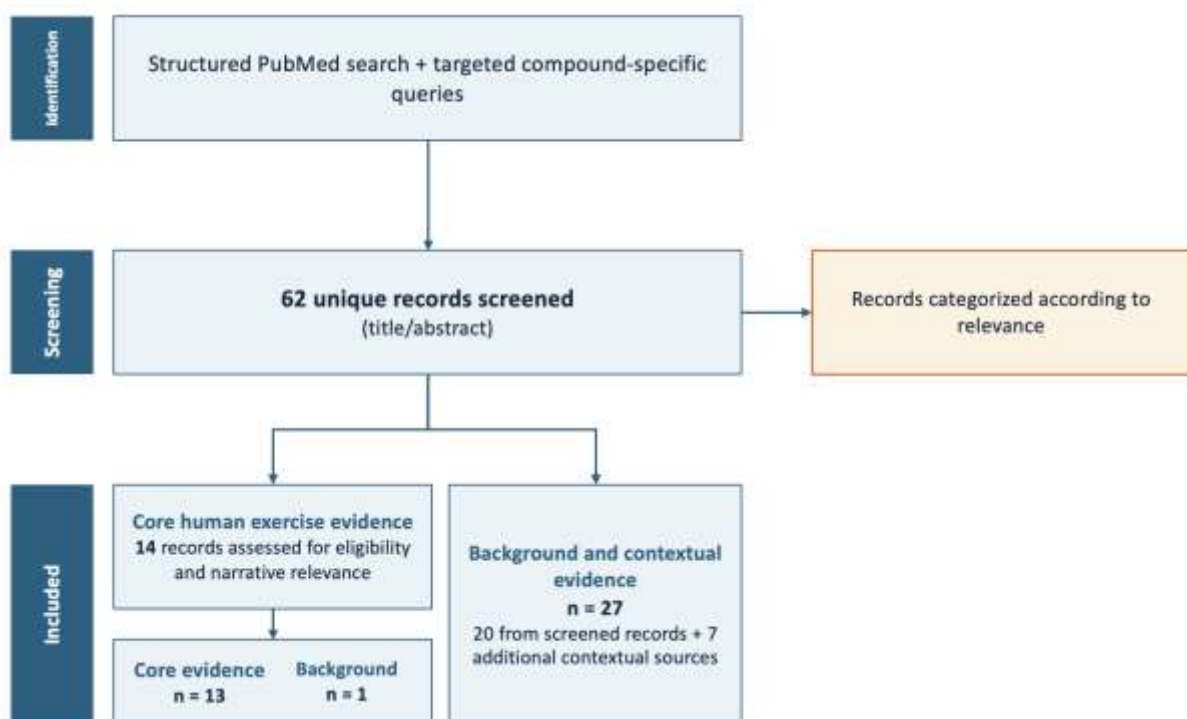


Figure 1. Literature and study selection flow diagram.

A total of 62 unique records were screened. Thirteen compound-specific human exercise or recovery studies formed the main evidence base, one multi-ingredient study was considered separately, and 27 additional records were used for mechanistic, physiological or broader contextual information.

3. Mechanistic rationale: TRPV1, perceived exertion and fatigue

Capsaicin-related compounds are commonly discussed in relation to TRPV1. TRPV1 was originally characterized as a capsaicin-sensitive, heat-activated ion channel involved in nociceptive signalling, providing a mechanistic basis for the burning sensation and discomfort associated with capsaicin exposure [38]. In exercise, this receptor system provides biological plausibility for effects on perceived discomfort, fatigue tolerance and selected performance outcomes. However, plausibility should not be interpreted as proof that TRPV1-mediated pathways explain ergogenic effects in humans.

One proposed pathway involves nociceptive and discomfort-related signalling. Intense resistance and high-intensity exercise can be limited partly by discomfort, pain perception and fatigue-related sensory feedback. TRPV1 modulation could therefore influence perceived exertion or tolerance of fatiguing work. This hypothesis is compatible with trials reporting lower RPE in selected resistance or concurrent-exercise protocols [19,21,32], but other studies reported unchanged RPE despite performance changes or no overall performance effect [20,23,34]. Current data therefore do not support a consistent RPE-mediated explanation across compounds and protocols.

A second pathway concerns group III and IV muscle afferent feedback. These afferents influence ventilatory and circulatory responses, neuromuscular fatigue and central motor output during exercise [39]. Because TRPV1 is relevant to nociceptive and sensory signalling, capsaicin-related compounds have been hypothesized to modify fatigue-related feedback. However, supplementation trials do not directly measure this pathway, so improvements in volume load, time to exhaustion or lifting velocity should not be interpreted as direct evidence that group III/IV afferent feedback was altered.

A third pathway relates to skeletal-muscle calcium handling and excitation-contraction coupling. Experimental work in mouse skeletal muscle reported functional TRPV1 channels in the sarcoplasmic reticulum and suggested interaction with calcium-release pathways [9]. This provides a preclinical rationale for possible effects on force production or fatigue resistance, but not clinical evidence of improved human performance. In phenylcapsaicin studies, selected mechanical-performance differences were observed, but one trial did not show clear condition-specific surface EMG changes [33]. Current human data therefore do not prove enhanced neuromuscular activation.

Finally, capsaicin and capsiate have been linked to thermogenesis, energy expenditure and substrate oxidation in human energy-balance research [14]. These pathways may be relevant to exercise, but exercise trials do not consistently show corresponding changes in lactate, heart

rate, oxygen-consumption-related variables or energy expenditure [20,26,34]. In several studies, performance-related effects occurred without parallel changes in common metabolic or physiological markers, leaving the relevant mechanisms uncertain.

Overall, TRPV1-related mechanisms provide a coherent framework for studying capsaicin, capsinoids and phenylcapsaicin as potential ergogenic aids. However, current human evidence supports only hypothesis-level mechanistic interpretation. Any ergogenic effects appear compound-, dose-, protocol- and population-specific rather than a uniform consequence of TRPV1 activation. Figure 2 summarizes the proposed TRPV1-related pathways and their relationship to the outcomes examined in this review.

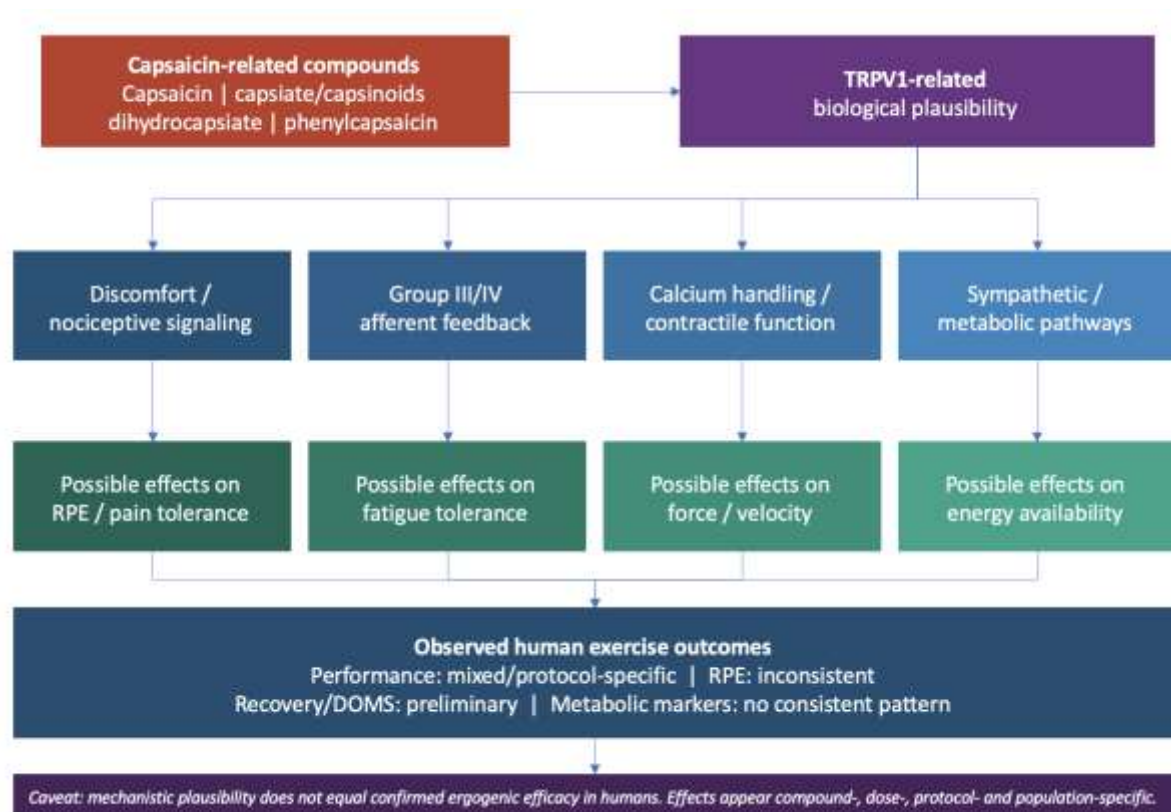


Figure 2. Proposed TRPV1-related mechanistic framework linking capsaicin-related compounds with exercise outcomes.

Capsaicin, capsinoids/capsate, dihydrocapsate and phenylcapsaicin may act partly through TRPV1-related pathways, including altered discomfort perception, fatigue-related sensory feedback, calcium handling, thermogenesis and substrate metabolism. These pathways provide biological plausibility for potential effects on performance, rating of perceived exertion and recovery. However, current human evidence remains heterogeneous, and mechanistic plausibility should not be interpreted as proof of a consistent ergogenic effect across compounds, doses, exercise modalities or populations [9,14,38-39].

4. Human evidence for capsaicin in resistance and high-intensity exercise

Human studies of isolated or cayenne-derived capsaicin in resistance and high-intensity exercise are limited and mostly based on small crossover trials in young, physically active or trained men. The observed effects appear protocol-specific rather than consistent across all forms of high-intensity exercise. [19-20,22]

In resistance exercise, de Freitas et al. reported that acute ingestion of 12 mg capsaicin 45 min before exercise increased total mass lifted during four sets of squat exercise performed to failure at 70% of one-repetition maximum in 10 resistance-trained young men. The same study reported lower post-exercise perceived exertion in the capsaicin condition, whereas blood lactate responses did not differ between conditions. These findings suggest a possible acute benefit for lower-body resistance-exercise volume in this specific protocol, but the very small male-only sample limits generalizability. [19]

In high-intensity intermittent exercise, de Freitas et al. found that 12 mg capsaicin ingested 45 min before exercise increased time to exhaustion during a 15 s:15 s running protocol performed at 120% of the speed associated with peak oxygen uptake in 13 physically active men. However, the performance effect was not accompanied by significant differences in rating of perceived exertion, lactate, oxygen-consumption-related variables, energy expenditure, or time spent above 90% of peak oxygen uptake. This suggests that, in this protocol, capsaicin may have increased exercise tolerance without clearly modifying the measured metabolic or perceptual responses. [20]

A related study in 11 resistance-trained men examined a concurrent exercise model consisting of high-intensity intermittent running followed by resistance exercise. In this study, capsaicin was administered as two 12 mg doses, one before the concurrent session and one immediately before the resistance component. Compared with placebo, capsaicin was associated with lower perceived exertion and lower mean heart rate during the intermittent running component, as well as greater total volume during subsequent half-squat exercise. Because the total dose and timing differed from most single-dose trials, these findings should be interpreted as specific to this split-dose concurrent-exercise protocol. [21]

Not all high-intensity protocols have shown benefit. In a placebo-controlled crossover study of 19 male experienced athletes, seven days of cayenne supplementation providing approximately 25.8 mg/day capsaicin did not improve fastest sprint time, mean sprint time, fatigue, interleukin-6 response, perceived exertion, or muscle soreness during a repeated-sprint protocol consisting of 15 × 30 m maximal sprints. Importantly, this study reported an

approximately 6.3-fold increase in gastrointestinal distress in the capsaicin condition, suggesting that formulation and tolerability may be relevant practical limitations. [22]

Similarly, in 15 recreationally trained runners, acute ingestion of 12 mg capsaicin did not improve time to exhaustion during continuous high-intensity running at 90% of the speed associated with peak oxygen uptake. No significant differences were observed for lactate, heart rate, rating of perceived exertion, time to reach peak oxygen uptake, or other physiological responses. This negative finding contrasts with the positive time-to-exhaustion result observed in the intermittent HIIE model and supports the interpretation that capsaicin effects may depend on exercise structure and protocol characteristics. [23]

Overall, capsaicin may benefit selected resistance and intermittent high-intensity protocols [19-20], but not repeated-sprint or continuous high-intensity running models [22-23]. Effects on perceived exertion and metabolic variables remain inconsistent, so current evidence supports preliminary, protocol-specific effects rather than a universal ergogenic effect.

5. Human evidence for capsiate and dihydrocapsiate

Capsiate and related capsinoids are non-pungent or less pungent analogs of capsaicin investigated as potential ergogenic aids because they may provide TRPV1-related plausibility with different tolerability. However, human exercise evidence remains limited and mixed, with positive and null findings varying by compound, dose, modality and study design [25-26]. Chronic training-adaptation and dihydrocapsiate findings further support cautious interpretation [29-30].

In upper-body resistance exercise, Moura et al. compared acute low-dose and high-dose capsiate supplementation in 20 resistance-trained men using a randomized, crossover, double-blind design. Participants ingested 6 mg capsiate, 12 mg capsiate, or placebo 45 min before performing four sets of bench press to failure at 70% of one-repetition maximum. The 6 mg dose increased total weight lifted compared with placebo and the 12 mg dose, whereas the 12 mg dose did not improve performance. No significant differences were observed for rating of perceived exertion or blood lactate. These findings suggest a possible dose-specific effect in this protocol, but they do not support a simple linear dose-response relationship. [25]

Capsiate has also been studied in running-based performance. Costa et al. examined acute supplementation with 12 mg of a capsaicin analog, described as capsiate, 45 min before 400 m and 3000 m running time trials in 12 physically active men. The study reported shorter completion times in both the 400 m and 3000 m trials compared with placebo, without significant differences in heart rate or rating of perceived exertion. Although these findings are

relevant to exercise performance, the running time-trial context is less central to the resistance and high-intensity strength-focused scope of this review and should be interpreted as background evidence. [26]

Chronic capsiate supplementation has been examined in combination with resistance training. In a randomized, placebo-controlled, double-blind parallel study, de Moura e Silva et al. investigated 12 mg/day capsiate during six weeks of resistance training in 20 young untrained men. The capsiate group showed greater change scores for fat-free mass and bench-press strength compared with placebo. However, the authors noted that most of the increase in fat-free mass was attributable to total body water, and no supplementation effect was observed for lower-body strength or cytokine responses to acute resistance exercise. Therefore, this study is best interpreted as background evidence on chronic capsiate plus training adaptation, rather than as evidence of an acute ergogenic effect. [30]

Evidence for dihydrocapsiate is currently less supportive. In a randomized, triple-blinded, placebo-controlled crossover trial, Osuna-Prieto et al. evaluated 12 mg dihydrocapsiate 30 min before testing in 25 resistance-trained young adults, including six women. According to the available data, dihydrocapsiate did not improve ballistic strength, maximal dynamic strength, or strength-endurance outcomes compared with placebo. [29]

Overall, evidence for capsiate and dihydrocapsiate is heterogeneous. Acute capsiate may improve selected outcomes, such as bench-press volume or running time trials [25-26], but effects are not consistent across doses or related compounds [25,29]. Current data do not support a generalizable ergogenic effect for capsinoids as a class, and dihydrocapsiate remains unsupported as an acute neuromuscular performance aid [29].

6. Human evidence for phenylcapsaicin

Phenylcapsaicin is the newest compound in this evidence base: a synthetic capsaicin analog studied at lower doses than traditional capsaicin protocols. Current human data are concentrated in resistance and mixed high-intensity exercise. Although studies report promising effects on selected outcomes, evidence remains preliminary, partly based on small samples, and requires independent replication. [32-34]

In a randomized, triple-blinded, placebo-controlled crossover trial, Jiménez-Martínez et al. evaluated two doses of phenylcapsaicin, 0.625 mg and 2.5 mg, in 25 resistance-trained men. Participants performed a full-squat protocol consisting of three sets of eight repetitions at 70% of one-repetition maximum. Outcomes included squat performance, active-muscle and overall-body ratings of perceived exertion, lactate, urea, aspartate aminotransferase, and 24-h recovery

measures. The higher 2.5 mg dose was associated with selected favorable effects on squat performance, active-muscle RPE, and AST compared with lower-dose or placebo conditions. However, not all measured outcomes differed significantly between conditions, and the study was limited to a small sample of young trained men. [32]

A related trial from the same research area examined phenylcapsaicin effects on mechanical performance and neuromuscular activity in 25 trained male subjects. The study used a randomized, triple-blinded, crossover, placebo-controlled design and compared 0.625 mg and 2.5 mg phenylcapsaicin with placebo. The protocol included squat exercise, countermovement jump, squat with 60% one-repetition maximum, isometric squat, and surface electromyography of the vastus lateralis and vastus medialis. Phenylcapsaicin was associated with selected differences in lifting velocity, velocity loss, dynamic squat performance, and countermovement jump responses. However, the study did not demonstrate clear condition-specific changes in surface EMG activity. Therefore, these findings may support a possible effect on selected mechanical performance outcomes, but they should not be interpreted as proof that phenylcapsaicin enhances neuromuscular activation. [33]

More recent evidence has examined phenylcapsaicin in a CrossFit® context. Triviño et al. conducted a randomized, triple-blind, placebo-controlled crossover trial in 50 CrossFit-trained adults, including equal numbers of women and men. Participants ingested 2.5 mg phenylcapsaicin or placebo 45 min before a standardized CrossFit session consisting of a warm-up, a weightlifting block, and a Workout of the Day. Phenylcapsaicin improved selected strength- and jump-related outcomes, including squat performance at 70% one-repetition maximum, attenuation of countermovement-jump decline, and maintenance of weightlifting performance over time. Delayed-onset muscle soreness was also lower at 24 and 48 h. However, no significant differences were observed for Workout-of-the-Day performance, rating of perceived exertion, perceived recovery status, lactate, or heart rate. Thus, the observed benefits were not global across the full CrossFit session. Sex-stratified analyses suggested differential effects: phenylcapsaicin reduced the post-session countermovement-jump decline in men ($p = 0.043$) and increased squat load in women ($p = 0.021$), indicating that some responses may not be uniform between sexes. Notably, 6 of 50 participants (12%) reported heartburn or acid reflux after phenylcapsaicin supplementation, with no adverse events reported after placebo; the authors identified this gastrointestinal discomfort as a potential limitation that may have influenced Workout-of-the-Day performance. [34]

Taken together, phenylcapsaicin appears relevant to selected resistance, jump and recovery-related outcomes. The strongest signal is not broad high-intensity performance enhancement,

but protocol-specific effects on mechanical performance and DOMS. RPE findings are inconsistent: active-muscle RPE was lower in one resistance-training protocol, whereas RPE did not differ in the CrossFit trial. Metabolic responses such as lactate and heart rate also do not show a consistent pattern. Phenylcapsaicin should therefore be described as a promising but preliminary TRPV1-related compound, with evidence limited by small samples, repeated research groups and the need for independent replication. [32-34]

7. Outcome-based synthesis: performance, perceived exertion and recovery

Exercise performance

Across the available human studies, the most consistent positive signals concern selected resistance-exercise or mixed high-intensity performance outcomes, although findings remain protocol-specific. In small crossover trials in trained men, acute capsaicin improved total mass lifted during squat exercise, and capsaicin administered in a split-dose protocol improved subsequent half-squat volume after high-intensity intermittent running. Similarly, low-dose capsaicin improved bench-press volume in resistance-trained men, whereas a higher 12 mg dose did not show the same effect. These findings suggest that any ergogenic effect may depend on compound, dose, exercise task, and fatigue context rather than reflecting a uniform class effect. [19,21,25]

High-intensity running outcomes are more heterogeneous. Capsaicin increased time to exhaustion during a short-interval HIIE protocol in physically active men, but did not improve time to exhaustion during continuous high-intensity running in recreationally trained runners. Cayenne-derived capsaicin also failed to improve repeated-sprint performance in male experienced athletes. These divergent findings suggest that the structure of high-intensity exercise—intermittent, continuous, sprint-based, or combined with resistance exercise—may be an important determinant of whether capsaicin-related supplementation shows measurable benefit. [20,22-23]

For phenylcapsaicin, the current evidence points toward selected mechanical and strength-related outcomes rather than broad performance enhancement. In resistance-trained men, 2.5 mg phenylcapsaicin was associated with selected improvements in squat velocity or performance-related measures. In CrossFit-trained adults, phenylcapsaicin improved selected squat, countermovement-jump and weightlifting-block outcomes, but did not improve Workout-of-the-Day performance. Therefore, phenylcapsaicin should not currently be described as improving whole-session high-intensity mixed-modality performance, but rather as showing preliminary effects on specific strength- and jump-related components. [32-34]

Rating of perceived exertion and fatigue perception

Effects on RPE are inconsistent. Lower RPE was reported in some resistance or concurrent-exercise protocols [19,21,32]. By contrast, RPE did not differ in several capsaicin running protocols [20,22-23] or in selected capsiate and CrossFit protocols [25-26,34].

Thus, current evidence does not support a general conclusion that capsaicin-related compounds consistently reduce perceived exertion. RPE effects may occur in selected resistance or fatigue-accumulation protocols [19,21,32], but are not reproducible across all modalities or compounds [20,34].

Recovery, DOMS and muscle-damage-related outcomes

Recovery-related outcomes are promising but still preliminary. In male collegiate futsal players, acute capsaicin supplementation before an exercise-induced muscle damage protocol reduced subjective DOMS and improved selected recovery-related markers, including vertical jump height and pressure pain threshold, but did not significantly improve isokinetic or isometric strength. In CrossFit-trained adults, 2.5 mg phenylcapsaicin reduced DOMS at 24 and 48 h and attenuated countermovement-jump decline, but did not improve perceived recovery status. In the phenylcapsaicin resistance-training dose study, the 2.5 mg dose was associated with lower 24-h AST compared with placebo, although not all recovery or biochemical outcomes differed significantly. [32,34,40]

These findings suggest that recovery and soreness are relevant targets for future research, especially in high-intensity or eccentric-loading sports. However, evidence remains based on few studies, some with small and sex-specific samples, and should not yet be interpreted as definitive proof that capsaicin-related compounds enhance recovery. [32,34,40]

Metabolic and physiological responses

Despite mechanistic hypotheses involving sympathetic activation, thermogenesis, substrate metabolism and calcium handling, human exercise studies do not consistently show parallel changes in metabolic or physiological markers. For example, capsaicin improved time to exhaustion during HIIE without modifying measured metabolic responses, capsiate improved selected running time-trial outcomes without altering HR or RPE, and phenylcapsaicin improved selected CrossFit outcomes without corresponding lactate, RPE, perceived recovery or HR differences. [20,26,34]

Therefore, current human data do not show that performance effects are mediated by common physiological markers such as lactate, HR or oxygen-consumption-related variables.

Mechanistic explanations remain plausible but incompletely verified in exercise settings. [20,26,34]

8. Practical considerations: studied doses, timing and tolerability

Current evidence is insufficient to define routine use, optimal compound selection, dose, timing or target population. Capsaicin-related compounds remain experimental candidates for selected resistance, intermittent high-intensity and recovery-related contexts. This contrasts with ergogenic aids such as caffeine and beta-alanine, for which dosing ranges, timing and safety thresholds have been characterised across multiple populations [41-42]. Larger independent studies are needed before general pre-exercise recommendations can be made. [4,6,34]

Phenylcapsaicin also requires caution. Although evaluated at lower doses than traditional capsaicin protocols and discussed as a lower-pungency alternative, it is not free from gastrointestinal symptoms. In the CrossFit trial, 6 of 50 participants (12%) reported heartburn or acid reflux after phenylcapsaicin, with no adverse events after placebo; the authors noted that this discomfort may have influenced Workout-of-the-Day performance. [34]

Tolerability remains uncertain. Cayenne-derived capsaicin increased gastrointestinal distress in the repeated-sprint study, whereas several purified capsaicin or capsiate trials did not emphasize major adverse symptoms. However, available evidence does not directly compare formulations, supplement matrices, habitual spicy-food intake or individual gastrointestinal tolerance, and cannot establish which compound or formulation is safest or best tolerated. [19,22,25]

The doses and timing used in available studies are research protocols, not clinical or sports-nutrition recommendations. Most acute capsaicin studies used 12 mg approximately 45 min before exercise, whereas one concurrent-exercise protocol used two 12 mg doses across the session [19-21]. Capsiate studies used 6-12 mg acutely [25], and phenylcapsaicin studies most commonly evaluated 2.5 mg as the higher dose [32,34]. These protocols were tested in small, specific samples and cannot be generalized to all athletes or recreational exercisers.

9. Limitations of current evidence

This review has several limitations. The human evidence base remains small and heterogeneous, with most studies enrolling young, physically active or trained adults, often men [19,25,32]. Although one CrossFit trial included equal numbers of women and men, this does not resolve the broader lack of sex-specific evidence [34]. Compounds, formulations, doses, timing, exercise protocols and outcome measures varied substantially, limiting direct

comparison and generalizability. The available evidence therefore does not support a unified class-level conclusion for capsaicin-related compounds.

Findings were also inconsistent across modalities and outcomes. Positive effects were reported mainly in selected resistance, intermittent high-intensity, mechanical-performance and recovery-related outcomes, whereas null findings were observed in repeated sprinting, continuous high-intensity exercise, dihydrocapsiate neuromuscular performance and CrossFit® WOD performance [22-23,29,34]. Mechanistic interpretation remains limited because TRPV1-related plausibility has not been consistently linked to measured perceptual, metabolic or EMG changes in human trials [20,33-34].

10. Future directions

Future studies should prioritize adequately powered randomized trials with more diverse populations. Most available studies involved small samples, often young physically active or resistance-trained men. Future trials should include both women and men, report sex-specific analyses when appropriately powered, and examine whether training status, sport discipline, habitual spicy-food intake and baseline gastrointestinal tolerance modify responses. [19,25,34] Direct comparisons between compounds are also needed. Current evidence evaluates capsaicin, capsiate, dihydrocapsiate and phenylcapsaicin in separate protocols, making it difficult to determine whether differences reflect compound pharmacology, dose, formulation, timing, exercise model or population characteristics. Head-to-head trials using standardized protocols, together with dose-response and timing studies, would clarify whether newer analogs offer advantages over traditional capsaicin and whether higher doses are actually more effective. [19,25,32]

Future protocols should be selected according to clear mechanistic hypotheses and paired with comprehensive outcome batteries. Studies should distinguish resistance exercise to failure, repeated sprinting, continuous high-intensity exercise, high-intensity intermittent exercise, CrossFit®-type sessions and recovery models after eccentric or plyometric loading. Performance outcomes should be paired with RPE, pain or discomfort perception, DOMS, perceived recovery, muscle-damage markers, neuromuscular measures, heart rate, lactate, oxygen-consumption-related variables and adverse-event reporting, because current studies often report performance changes without parallel perceptual or metabolic changes. [20,34,40] Finally, future research should strengthen human mechanistic testing and improve transparency. Trials should assess whether changes in discomfort perception, afferent feedback, calcium handling, neuromuscular function, thermogenesis or substrate metabolism

mediate performance or recovery effects, rather than assuming mechanisms from TRPV1 plausibility. Pre-registration, transparent funding and conflict-of-interest reporting, detailed supplement composition, blinding procedures, diet/caffeine/spicy-food control, adverse-event reporting and independent replication are particularly important for phenylcapsaicin. [4,33-34]

11. Conclusions

Current human evidence supports a compound- and protocol-specific interpretation of capsaicin, capsinoids/capsiate, dihydrocapsiate and phenylcapsaicin rather than a universal ergogenic effect. Positive findings cluster around selected resistance and intermittent high-intensity outcomes [19-20], mechanical-performance outcomes [32,34], and preliminary recovery/DOMS signals [34,40]. Null findings were reported in repeated sprinting and continuous high-intensity exercise [22-23], dihydrocapsiate neuromuscular performance [29], and the CrossFit® WOD component [34].

Among the four compounds, phenylcapsaicin currently has the most recent evidence base, but this evidence is limited by small samples, related research groups and an absence of independent replication [32-34]. Capsiate and dihydrocapsiate show mixed results without a clear dose-response pattern [25,29], whereas capsaicin has the largest early literature but inconsistent effects across exercise modalities and tolerability concerns at higher cayenne-derived doses [19,22-23].

Overall, capsaicin, capsinoids/capsiate, dihydrocapsiate and phenylcapsaicin should be viewed as promising but not yet established TRPV1-related ergogenic aids [4,6]. Well-powered, independently replicated trials are required to determine whether these compounds have reliable effects in specific exercise contexts and whether improvements are mediated by perceptual, neuromuscular or metabolic responses [32,34].

Author Contributions

Conceptualization, J.G. and M.L.; methodology, M.L. and J.G.; literature screening and evidence mapping, M.P., J.W., B.B. and J.N.; writing - original draft preparation, M.P., J.G., J.J., J.N., and M.L.; writing - review and editing, M.P., J.G., J.J., J.N., and M.L.; visualization, M.P. and J.G.; All authors have read and agreed to the submitted version of the manuscript.

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Conflict of Interest Statement

The authors declare no conflict of interest.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

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References

1. Kerkick CM, Wilborn CD, Roberts MD, Smith-Ryan A, Kleiner SM, Jäger R, Collins R, Cooke M, Davis JN, Galvan E, Greenwood M, Lowery LM, Wildman R, Antonio J, Kreider RB. ISSN exercise & sports nutrition review update: research & recommendations. *J Int Soc Sports Nutr.* 2018;15(1):38. <https://doi.org/10.1186/s12970-018-0242-y>
2. Frias B, Merighi A. Capsaicin, nociception and pain. *Molecules.* 2016;21(6):797. <https://doi.org/10.3390/molecules21060797>
3. Giuriato G, Venturelli M, Matias A, Soares EMKVK, Gaetgens J, Frederick KA, Ives SJ. Capsaicin and its effect on exercise performance, fatigue and inflammation after exercise. *Nutrients.* 2022;14(2):232. <https://doi.org/10.3390/nu14020232>
4. Sukan-Karaçağıl B, Akbulut G, Açar Y, Demirkoparan M. A little pepper-upper? Systematic review of randomized controlled studies on capsaicinoids, capsinoids, and exercise performance. *Int J Sport Nutr Exerc Metab.* 2023;33(5):291-301. <https://doi.org/10.1123/ijsnem.2023-0016>

5. de Moura e Silva VEL, Cholewa JM, Billaut F, Jäger R, de Freitas MC, Lira FS, Rossi FE. Capsaicinoid and capsinoids as an ergogenic aid: a systematic review and the potential mechanisms involved. *Int J Sports Physiol Perform*. 2021;16(4):464-473. <https://doi.org/10.1123/ijsp.2020-0677>
6. Quizzini GH, Campos JMS, Nunes FAS, Rossi PAQ, Zawieja E, Zanchi NE, Neves LM, Rossi FE. Potential ergogenic aid of capsaicinoid or capsinoids in healthy adults: a systematic review with meta-analysis. *Nutr Res*. 2026;146:13-25. <https://doi.org/10.1016/j.nutres.2025.12.004>
7. Best R, McDonald K, Hurst P, Pickering C. Can taste be ergogenic? *Eur J Nutr*. 2021;60(1):45-54. <https://doi.org/10.1007/s00394-020-02274-5>
8. Gibson OR, Wrightson JG, Hayes M. Intermittent sprint performance in the heat is not altered by augmenting thermal perception via L-menthol or capsaicin mouth rinses. *Eur J Appl Physiol*. 2019;119(3):653-664. <https://doi.org/10.1007/s00421-018-4055-0>
9. Lotteau S, Ducreux S, Romestaing C, Legrand C, Van Coppenolle F. Characterization of functional TRPV1 channels in the sarcoplasmic reticulum of mouse skeletal muscle. *PLoS One*. 2013;8(3):e58673. <https://doi.org/10.1371/journal.pone.0058673>
10. Yashiro K, Tonson A, Pecchi E, Dalmaso C, Vilmen C, Le Fur Y, Bernard M, Bendahan D, Giannesini B. A single intake of capsiate improves mechanical performance and bioenergetics efficiency in contracting mouse skeletal muscle. *Am J Physiol Endocrinol Metab*. 2014;306(10):E1110-E1119. <https://doi.org/10.1152/ajpendo.00520.2013>
11. Yashiro K, Tonson A, Pecchi E, Vilmen C, Le Fur Y, Bernard M, Bendahan D, Giannesini B. Capsiate supplementation reduces oxidative cost of contraction in exercising mouse skeletal muscle in vivo. *PLoS One*. 2015;10(6):e0128016. <https://doi.org/10.1371/journal.pone.0128016>
12. Hsu YJ, Huang WC, Chiu CC, Liu YL, Chiu WC, Chiu CH, Chiu YS, Huang CC. Capsaicin supplementation reduces physical fatigue and improves exercise performance in mice. *Nutrients*. 2016;8(10):648. <https://doi.org/10.3390/nu8100648>
13. Haramizu S, Mizunoya W, Masuda Y, Ohnuki K, Watanabe T, Yazawa S, Fushiki T. Capsiate, a nonpungent capsaicin analog, increases endurance swimming capacity of mice by stimulation of vanilloid receptors. *Biosci Biotechnol Biochem*. 2006;70(4):774-781. <https://doi.org/10.1271/bbb.70.774>
14. Ludy MJ, Moore GE, Mattes RD. The effects of capsaicin and capsiate on energy balance: critical review and meta-analyses of studies in humans. *Chem Senses*. 2012;37(2):103-121. <https://doi.org/10.1093/chemse/bjr100>

15. Josse AR, Sherriffs SS, Holwerda AM, Andrews R, Staples AW, Phillips SM. Effects of capsinoid ingestion on energy expenditure and lipid oxidation at rest and during exercise. *Nutr Metab (Lond)*. 2010;7:65. <https://doi.org/10.1186/1743-7075-7-65>
16. Liao SF, Korivi M, Tsao JP, Huang CC, Chang CC, Cheng IS. Effect of capsinoids supplementation on fat oxidation and muscle glycogen restoration during post-exercise recovery in humans. *Curr Pharm Des*. 2021;27(7):981-988. <https://doi.org/10.2174/1381612826666200824104856>
17. Rossi PAQ, Lira FS, Bezerra VR, Clark NW, Fukuda DH, Panissa VLG. Acute response to capsiate supplementation at rest and during exercise on energy intake, appetite, metabolism, and autonomic function: a randomized trial. *J Am Nutr Assoc*. 2022;41(6):541-550. <https://doi.org/10.1080/07315724.2021.1938294>
18. McCarty MF, DiNicolantonio JJ, O'Keefe JH. Capsaicin may have important potential for promoting vascular and metabolic health. *Open Heart*. 2015;2(1):e000262. <https://doi.org/10.1136/openhrt-2015-000262>
19. de Freitas MC, Cholewa JM, Freire RV, Carmo BA, Bottan J, Bratfich M, Della Bandeira MP, Gonçalves DC, Caperuto EC, Lira FS, Rossi FE. Acute capsaicin supplementation improves resistance training performance in trained men. *J Strength Cond Res*. 2018;32(8):2227-2232. <https://doi.org/10.1519/JSC.0000000000002109>
20. de Freitas MC, Billaut F, Panissa VLG, Rossi FE, Figueiredo C, Caperuto EC, Lira FS. Capsaicin supplementation increases time to exhaustion in high-intensity intermittent exercise without modifying metabolic responses in physically active men. *Eur J Appl Physiol*. 2019;119(4):971-979. <https://doi.org/10.1007/s00421-019-04086-w>
21. de Freitas MC, Cholewa JM, Panissa VLG, Toloï GG, Netto HC, Zanini de Freitas C, Freire RV, Lira FS, Rossi FE. Acute capsaicin supplementation improved resistance exercise performance performed after a high-intensity intermittent running in resistance-trained men. *J Strength Cond Res*. 2022;36(1):130-134. <https://doi.org/10.1519/JSC.0000000000003431>
22. Opheim MN, Rankin JW. Effect of capsaicin supplementation on repeated sprinting performance. *J Strength Cond Res*. 2012;26(2):319-326. <https://doi.org/10.1519/JSC.0b013e3182429ae5>
23. Padilha CS, Billaut F, Figueiredo C, Panissa VLG, Rossi FE, Lira FS. Capsaicin supplementation during high-intensity continuous exercise: a double-blind study. *Int J Sports Med*. 2020;41(14):1061-1066. <https://doi.org/10.1055/a-1088-5388>

24. Sasahara I, Furuhashi Y, Iwasaki Y, Inoue N, Sato H, Watanabe T, Takahashi M. Assessment of the biological similarity of three capsaicin analogs (capsinoids) found in non-pungent chili pepper (CH-19 Sweet) fruits. *Biosci Biotechnol Biochem.* 2010;74(2):274-278. <https://doi.org/10.1271/bbb.90570>
25. de Moura HPDSN, Cholewa JM, Jäger R, Campos EZ, Rosa BV, Nunes FAS, Barros CAA, Rossi PAQ, Gerosa-Neto J, Zanchi NE, Rossi FE. Acute low-dose capsaicin supplementation improves upper body resistance exercise performance in trained men: a randomized, crossover and double-blind study. *Int J Exerc Sci.* 2022;15(2):1007-1018. <https://doi.org/10.70252/YNEM9216>
26. Costa LA, de Freitas MC, Cholewa JM, Nakamura FY, Panissa VLG, Silva VELM, Sá AMB, Queiroz PA, Galan SL, Santos MAP, Zanchi NE, Lira FS, Rossi FE. Acute capsaicin analog supplementation improves 400 m and 3000 m running time-trial performance. *Int J Exerc Sci.* 2020;13(2):755-765. <https://doi.org/10.70252/FQFA1206>
27. Osuna-Prieto FJ, Acosta FM, Perez de Arrilucea Le Floch UA, Riquelme-Gallego B, Merchan-Ramirez E, Xu H, De La Cruz-Márquez JC, Amaro-Gahete FJ, Llamas-Elvira JA, Triviño-Ibáñez EM, Segura-Carretero A, Ruiz JR. Dihydrocapsiate does not increase energy expenditure nor fat oxidation during aerobic exercise in men with overweight/obesity: a randomized, triple-blinded, placebo-controlled, crossover trial. *J Int Soc Sports Nutr.* 2022;19(1):417-436. <https://doi.org/10.1080/15502783.2022.2099757>
28. von Ah Morano AE, Padilha CS, Soares VAM, Andrade Machado F, Hofmann P, Rossi FE, Lira FS. Capsaicin analogue supplementation does not improve 10 km running time-trial performance in male amateur athletes: a randomized, crossover, double-blind and placebo-controlled study. *Nutrients.* 2020;13(1):34. <https://doi.org/10.3390/nu13010034>
29. Osuna-Prieto FJ, Milla-Martín D, Miras-Moreno S, Jurado-Fasoli L, Ramírez-Maldonado M, Soriano MA, García-Ramos A, Ruiz JR, Amaro-Gahete FJ. A single dose of dihydrocapsiate does not improve neuromuscular performance in resistance-trained young adults: a randomised, triple-blinded, placebo-controlled, crossover trial. *Eur J Sport Sci.* 2023;23(12):2299-2310. <https://doi.org/10.1080/17461391.2023.2229854>
30. de Moura e Silva VEL, Cholewa JM, Jäger R, Zanchi NE, de Freitas MC, de Moura RC, Barros EML, Antunes BM, Caperuto EC, Ribeiro SLG, Lira FS, Santos MAP, Rossi FE. Chronic capsaicin supplementation increases fat-free mass and upper body strength but not the inflammatory response to resistance exercise in young untrained men: a

- randomized, placebo-controlled and double-blind study. *J Int Soc Sports Nutr.* 2021;18(1):50. <https://doi.org/10.1186/s12970-021-00446-0>
31. EFSA Panel on Nutrition, Novel Foods and Food Allergens (EFSA NDA Panel), Turck D, Castenmiller J, De Henauw S, Hirsch-Ernst KI, Kearney J, Maciuk A, Mangelsdorf I, McArdle HJ, Naska A, Pelaez C, Pentieva K, Siani A, Thies F, Tsabouri S, Vinceti M, Cubadda F, Engel KH, Frenzel T, Heinonen M, Marchelli R, Neuhäuser-Berthold M, Pöting A, Poulsen M, Sanz Y, Schlatter JR, van Loveren H, Amundsen M, Knutsen HK. Safety of phenylcapsaicin as a novel food pursuant to Regulation (EU) 2015/2283. *EFSA J.* 2019;17(6):e05718. <https://doi.org/10.2903/j.efsa.2019.5718>
 32. Jiménez-Martínez P, Cornejo-Daza PJ, Sánchez-Valdepeñas J, Asín-Izquierdo I, Cano-Castillo C, Alix-Fages C, Pareja-Blanco F, Colado JC. Effects of different phenylcapsaicin doses on resistance training performance, muscle damage, protein breakdown, metabolic response, ratings of perceived exertion, and recovery: a randomized, triple-blinded, placebo-controlled, crossover trial. *J Int Soc Sports Nutr.* 2023;20(1):2204083. <https://doi.org/10.1080/15502783.2023.2204083>
 33. Jiménez-Martínez P, Sánchez-Valdepeñas J, Cornejo-Daza PJ, Cano-Castillo C, Asín-Izquierdo I, Alix-Fages C, Pareja-Blanco F, Colado JC. Effects of different phenylcapsaicin doses on neuromuscular activity and mechanical performance in trained male subjects: a randomized, triple-blinded, crossover, placebo-controlled trial. *Front Physiol.* 2023;14:1215644. <https://doi.org/10.3389/fphys.2023.1215644>
 34. Triviño AR, Díaz-Romero C, Martín-Olmedo JJ, Jimenez-Martinez P, Alix-Fages C, Cwiklinska M, Pérez D, Funes Pol D, Jurado-Fasoli L. Acute phenylcapsaicin supplementation improves CrossFit performance: a randomized, triple-blind, placebo-controlled crossover trial. *J Int Soc Sports Nutr.* 2026;23(1):2615274. <https://doi.org/10.1080/15502783.2026.2615274>
 35. Jiménez-Martínez P, Alix-Fages C, Janicijevic D, Miras-Moreno S, Chacón-Ventura S, Martín-Olmedo JJ, De La Cruz-Márquez JC, Osuna-Prieto FJ, Jurado-Fasoli L, Amaro-Gahete FJ, García-Ramos A, Colado JC. Effects of phenylcapsaicin on aerobic capacity and physiological parameters in active young males: a randomized, triple-blinded, placebo-controlled, crossover trial. *Front Physiol.* 2023;14:1190345. <https://doi.org/10.3389/fphys.2023.1190345>
 36. Lara Vázquez PM, Morenas-Aguilar MD, Chacón Ventura S, Jiménez-Martínez P, Alix-Fages C, García-Ramos A, Vera J, Redondo B. Effects of phenylcapsaicin on intraocular and ocular perfusion pressure during a 30-min cycling task: a placebo-controlled, triple-

- blind, balanced crossover study. *Int J Sport Nutr Exerc Metab.* 2024;34(5):298-306. <https://doi.org/10.1123/ijsnem.2024-0051>
37. Grgic J, Memon AR, Chen S, Ramirez-Campillo R, Barreto G, Haugen ME, Schoenfeld BJ. Effects of capsaicin and capsiate on endurance performance: a meta-analysis. *Nutrients.* 2022;14(21):4531. <https://doi.org/10.3390/nu14214531>
 38. Caterina MJ, Schumacher MA, Tominaga M, Rosen TA, Levine JD, Julius D. The capsaicin receptor: a heat-activated ion channel in the pain pathway. *Nature.* 1997;389(6653):816-824. <https://doi.org/10.1038/39807>
 39. Amann M, Wan HY, Thurston TS, Georgescu VP, Weavil JC. On the influence of group III/IV muscle afferent feedback on endurance exercise performance. *Exerc Sport Sci Rev.* 2020;48(4):209-216. <https://doi.org/10.1249/JES.0000000000000233>
 40. Rashki M, Hemmatinafar M, Safari K, Imanian B, Rezaei R, Koushkie Jahromi M, Suzuki K. Capsaicin's role in mitigating muscle soreness and enhancing futsal players' recovery after exercise-induced muscle damage. *Nutrients.* 2025;17(5):813. <https://doi.org/10.3390/nu17050813>
 41. Wojciechowska UJ, Rafałowicz A, Zajkowska I. Caffeine as an ergogenic aid: a literature review of mechanisms of action, performance effects and safety thresholds. *Quality in Sport.* 2025;43:61460. <https://doi.org/10.12775/QS.2025.43.61460>
 42. Stanibuła D, Redner A, Rybowski J, Popiel M, Smala K, Dziekoński K, Zwierzchlewska P, Głowacz J, Kulig K, Wiśniowski M. Beta-alanine: a comprehensive review of athletic and systemic benefits. *Quality in Sport.* 2025;40:59882. <https://doi.org/10.12775/QS.2025.40.59882>