

Review

Integrating Traditional Chinese Medicine Phytotherapy and Diet Therapy with Contemporary Endurance Nutrition: Mechanisms, Evidence, and Practical Applications.

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Abstract

Background: Traditional Chinese Medicine (TCM) is a holistic medical system emphasising energetic balance and personalised therapies, including diet therapy and phytotherapy. Its potential relevance in high-performance sport is increasingly recognised, as elite athletes face high physical and psychological demands, fatigue, injury risk, and metabolic or gastrointestinal disturbances. Contemporary endurance nutrition highlights carbohydrate periodisation, optimised protein intake, micronutrient adequacy, gut microbiota stability, and individualised dietary strategies to support performance and recovery.

Objective: To review evidence on the use of TCM diet therapy and phytotherapy in endurance sports, exploring physiological mechanisms, recovery effects, and the integration of TCM with modern nutritional strategies.

Methods: A narrative synthesis of experimental, clinical, and sports nutrition literature was conducted, including studies on macronutrient requirements, dietary periodisation, gut microbiota, and herbal interventions in athletes.

Results: Carbohydrates remain the key determinant of endurance performance, influencing time-to-exhaustion, metabolic efficiency, and gut microbial stability. Ketogenic or low-carbohydrate strategies often impair high-intensity performance. Many endurance athletes fail to meet energy and micronutrient needs, increasing the risk of deficiencies and Relative Energy Deficiency in Sport (RED-S).

TCM diet therapy focuses on strengthening Spleen Qi, nourishing Kidney Essence, and correcting imbalances, conceptually supporting metabolism, recovery, and gastrointestinal function. Constitution-based approaches (*ti zhi*) align with modern personalised nutrition. Experimental studies suggest that herbs such as ginseng and *Astragalus* may improve mitochondrial function, reduce oxidative stress, and enhance fatigue resistance, although human trials show limited and inconsistent performance effects. *Tribulus terrestris*, *Rhodiola*, and *Cordyceps* demonstrate minimal ergogenic benefits.

Conclusions: TCM diet therapy and phytotherapy may complement endurance nutrition through personalised, systemic, and recovery-focused strategies. Current evidence does not support most herbal supplements as primary ergogenic aids. Integration is most effective when TCM principles are applied alongside established nutritional practices, including adequate carbohydrate and protein intake, micronutrient sufficiency, and tailored fuelling. Further controlled human studies are required to determine efficacy and mechanisms.

Keywords: Traditional Chinese Medicine; Phytotherapy; Diet therapy; High-Performance Sport; Athletic Recovery; Herbal Medicine; Sports Nutrition.

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1. Introduction

TCM is an ancient holistic medical system deeply rooted in Chinese culture and history, with key foundational texts such as the *Huangdi Neijing* developed between 300-500 BCE¹⁻³. TCM views health as the harmonious balance of the body's energy systems (*Qi*), integrating diagnostics and treatment principles through modalities including acupuncture, herbal medicine (phytotherapy), and diet therapy⁴. In recent years, TCM modalities have gained interest as complementary approaches for managing the unique physiological and emotional demands faced by elite athletes in high-performance sports⁵⁻⁸.

Elite athletes are subject to extreme physiological and emotional demands due to high training loads, competitive pressure, and environmental variation, which can contribute to persistent fatigue, recurrent injuries, digestive disorders, and sleep disturbances beyond the reach of conventional biomedical approaches⁹⁻¹¹. In this context, TCM emerges as a complementary resource with high potential, offering both physical recovery and energetic/emotional regulation through strategies such as acupuncture, moxibustion, diet therapy, phytotherapy, and *Tuina* for injury prevention, enhanced muscular regeneration, and holistic resilience.

The primary energy source for muscle contraction is ATP, regenerated via carbohydrate, lipid, and to a lesser extent protein metabolism¹². The prevailing metabolic pathway shifted according to exercise intensity and duration, with carbohydrates dominating high-intensity efforts and lipids predominating in prolonged exercise. Energy systems include ATP-PCr for explosive activities, <10 seconds¹³, anaerobic glycolysis yielding lactate¹⁴, and aerobic metabolism using mitochondrial oxidation of glucose and fatty acids¹². Muscle and hepatic glycogen are the main carbohydrate reserves, while triglycerides store lipids¹⁵, with depletion associated with fatigue. Maximal effort relies on anaerobic pathways, while moderate/prolonged efforts depend on aerobic metabolism; the lactate threshold marks the point of significant lactate accumulation in blood¹⁶.

Skeletal muscle fibres are classified by metabolic and functional traits: Type I (slow oxidative) fibres are highly resistant to fatigue and suited for prolonged, low-intensity activities; Type IIa (fast oxidative) fibres combine aerobic and anaerobic capacities for moderate-strength and endurance; Type IIb (fast glycolytic) fibres specialise in explosive strength and speed, relying on anaerobic glycolysis and showing poor fatigue resistance¹⁷. Continuous training induces significant physiological adaptations such as increased mitochondrial density¹⁸, improved muscle capillarisation¹⁹, decreased post-exercise lactate¹⁴, and enhanced cardiovascular and neuromuscular efficiency¹². High-intensity training (>85% VO₂max) predominantly engages anaerobic pathways and accelerates lactate accumulation and muscle fatigue.

Endurance sports impose substantial physiological and metabolic demands, requiring finely tuned nutritional strategies to sustain performance, recovery, and adaptation²⁰. Diet therapy, defined as the application of individualised dietary interventions to optimise health and athletic performance, plays a central role in the management of endurance athletes²¹. Carbohydrates remain the cornerstone of endurance nutrition, as their availability directly influences time to exhaustion and work output²². Recent updates in carbohydrate research emphasise not only total daily intake but also the timing, form, and periodisation of carbohydrate availability around training sessions^{22,23}.

While some athletes adopt low-carbohydrate or ketogenic dietary approaches to enhance fat oxidation, evidence indicates that such strategies often compromise high-intensity performance and training quality^{23,24}. Periodised carbohydrate restriction, alternating between high- and low-carbohydrate availability, has been explored as a method to optimise metabolic flexibility; however, meta-analytical evidence suggests it does not consistently enhance endurance performance in trained athletes²⁵. Moreover, carbohydrate-rich diets have been shown to promote more stable gut microbiota profiles and better performance outcomes compared to high-protein or low-carbohydrate regimens²⁶.

Adequate protein intake is also essential for recovery, muscle repair, and adaptation to endurance training²⁷. Contemporary reviews emphasise the importance of protein distribution and timing across the day to maximise muscle protein synthesis and support training adaptation²⁷. Nevertheless, many endurance athletes fail to meet energy and micronutrient requirements, particularly for vitamins D, E, and folate, which may impair recovery and immune function²⁸. Additionally, inappropriate nutritional strategies can lead to adverse outcomes such as hyponatremia, dehydration, and gastrointestinal distress during competition²⁹.

Overall, diet therapy in endurance sports requires an integrative approach that considers macronutrient balance, energy availability, gastrointestinal tolerance, and individualised metabolic responses^{15,20,28}. Optimising these factors through evidence-based dietary planning may improve endurance capacity, enhance recovery, and reduce the risk of nutrition-related complications.

This review provides a bibliographic synthesis of TCM phytotherapy and diet therapy applications in sports medicine, focusing on physiological benefits, recovery, and performance optimisation.

2. Diet therapy in Endurance Sports

2.1. Carbohydrate Availability and Performance

Carbohydrates (CHO) remain the primary fuel substrate for endurance performance due to their high oxidative rate and role in maintaining muscle glycogen. Lima-Silva *et al.*³⁰ highlighted that inadequate carbohydrate availability leads to impaired time-to-exhaustion and reduced exercise economy. The recent paradigm of “fuel for the work required” proposes that carbohydrate intake should be periodised according to training load and session intensity³¹.

Carbohydrate Periodisation

A systematic review and meta-analysis by Gejl *et al.*²⁵ assessed the effects of periodised carbohydrate restriction (i.e., “train-low, compete-high”) in trained endurance athletes. Across 11 controlled trials, they found no significant improvements in VO_2max , time-trial performance, or oxidative enzyme activity compared to traditional high-CHO diets. The authors concluded that metabolic adaptations induced by low glycogen availability do not necessarily translate into improved performance outcomes.

Furber *et al.*²⁶ investigated endurance athletes undergoing dietary periodisation and found that athletes maintaining higher carbohydrate intake exhibited greater gut microbial stability and superior performance outcomes; specifically, high-CHO diets improved time-trial performance by $\approx 6.5\%$, whereas a short-term high-protein, low-CHO regimen produced a $\approx 23.3\%$ decrement in performance, changes that were associated with shifts in bacterial and phage communities.

Carbohydrate Intake Recommendations

Authors³²⁻³⁴ recommend 8–12 g/kg/day of CHO for heavy training and 5–7 g/kg/day for moderate loads, emphasising multiple transportable carbohydrate sources (e.g., glucose–fructose blends) during prolonged events. Furthermore, pre-exercise CHO loading and intra-event fuelling at 60–90 g/h enhance glycogen availability and delay fatigue.

2.2. Ketogenic and Low-Carbohydrate Diets

The ketogenic diet (KD) has gained popularity as a potential strategy to increase fat oxidation and reduce dependence on glycogen. However, evidence consistently shows mixed or negative effects on performance in endurance athletes³⁵⁻³⁷. Shaw *et al.*³⁵ performed a randomised crossover study and found that while KD increases fat oxidation by 70–100%, it concurrently reduces exercise economy and high-intensity capacity. Similarly,

Burke³⁸ and Burke *et al.*³⁹ emphasised that the metabolic advantage of fat adaptation does not compensate for the reduced efficiency of ATP production from fatty acids.

Moreover, adaptation to KD often results in decreased glycogen availability, impairing performance in events involving surges or sprint finishes, common in competitive endurance sports³⁹. These findings collectively discourage the routine application of KD in endurance diet therapy.

2.3. Protein Nutrition in Endurance Athletes

Endurance athletes exhibit elevated protein requirements compared with sedentary individuals, reflecting increased amino-acid oxidation during prolonged exercise and the demands of muscle repair and mitochondrial biogenesis. Recent reviews²⁷ suggest a daily intake around ~1.8 g/kg/day is appropriate, with higher intakes (>2.0 g/kg/day) potentially warranted during periods of heavy training or carbohydrate restriction^{27,40}.

In line with recommendations from the International Society of Sports Nutrition, protein doses of ~0.25–0.3 g/kg per meal (or ~20–40 g), distributed every 3–4 h, including immediately before or within 0–2 h after exercise, may optimise muscle protein synthesis (MPS) and recovery^{41,42}.

Endurance exercise also increases oxidation of amino acids (including BCAAs) thereby increasing the need for sufficient protein to maintain nitrogen balance and support adaptation^{40,43}.

2.4. Micronutrient Adequacy and Energy Availability

The adequacy of energy and micronutrient intake in endurance athletes has been questioned. In a cross-sectional study of 95 endurance athletes, the majority (~77%) failed to meet estimated energy requirements; similarly, large percentages had intakes below recommendations for vitamins D (93.7 %), E (71.6 %), K (54.7 %), folate (54.7 %), dietary fibre (49.5 %), as well as other micronutrients⁴⁴.

As argued in a more general review on nutrition in athletes, chronic low energy availability (LEA) due to inadequate caloric intake may lead to micronutrient deficiencies, impair recovery, immune competence, and hormonal function, which are conditions associated with the clinical syndrome of Relative Energy Deficiency in Sport (RED-S)⁴⁵.

Female athletes may be particularly susceptible, because restrictive dietary practices associated with inadequate energy intake tend to be more common among women and the interplay between energy intake, micronutrient supply, and high training load may exacerbate nutritional deficits⁴⁴.

Given these findings, ensuring sufficient caloric intake, tailored to training load, is essential in nutritional planning for endurance sports ("periodised nutrition"), to avoid energy mismatch and prevent nutrient shortfalls²⁸.

When dietary intake remains inadequate (or in high-risk conditions, e.g. heavy training, restricted diet, limited sun exposure), supplementation (e.g. Vitamin D, Iron) might be considered after assessing status, particularly in athletes with documented deficiencies or physiological demands that exceed dietary supply⁴⁶.

3. Gut Microbiota and Diet therapy

Emerging evidence links gut microbial diversity and composition to endurance performance and metabolic efficiency in athletes. In a randomised dietary-periodisation trial in well-trained endurance runners, those whose gut microbial communities remained more stable during shifts between high-protein and high-carbohydrate diets exhibited better time-trial performance; by contrast, a short-term high-protein diet disrupted microbial stability, including reductions in gut phageome diversity, and was associated with a ~23.3% drop in performance, whereas a high-carbohydrate diet improved performance by ~6.5%²⁶.

Broader metagenomics also suggest that competitive athletes tend to harbour gut microbiota enriched in short-chain fatty-acid (SCFA) producing taxa (e.g., *Faecalibacterium*,

Eubacterium, *Ruminococcus*, *Blautia*) and metabolic pathways for SCFA and other beneficial microbial metabolites, features that may support metabolic efficiency, recovery and performance⁴⁷.

However, diet (especially high-protein, low-fibre intake) can perturb the microbial community, reduce SCFA-producing commensals, and alter microbial function⁴⁸⁻⁵⁰. This suggests that future nutritional interventions for endurance athletes might benefit from integrating prebiotic-rich foods or carefully selected probiotic strategies to support microbial homeostasis, gut barrier integrity, and recovery, provided that supplementation is evidence-based, strain-verified, and aligned with dietary fibre and carbohydrate intake^{47,51,52}.

Further research employing longitudinal, controlled trials and functional microbial/metabolomics readouts is warranted to elucidate the causal mechanisms linking diet-induced microbial modulation and endurance performance.

4. Nutrition-Related Adverse Outcomes

Martinez-Sanz *et al.*²⁹ reviewed nutrition-related adverse outcomes in endurance and ultra-endurance competitions and identified the most prevalent problems as exercise-associated hyponatremia (EAH), dehydration/heat illness, and gastrointestinal (GI) distress; they emphasised that misinformation about hydration and competition nutrition is a common contributor to these events²⁹.

Overhydrating with hypotonic fluids (drinking beyond thirst) is a principal cause of EAH, while excessive or poorly-tolerated carbohydrate intake during competition commonly precipitates GI symptoms such as nausea, cramping, bloating and diarrhoea^{53,54}. Implementing individualised, event-specific hydration and fuelling plans, practiced and refined under training conditions (i.e., “trial runs”), is recommended as the most effective strategy to prevent both EAH and exercise-induced GI complaints^{53,55}.

5. Principles of Chinese Diet therapy in Sports Context

Zhao *et al.*⁵⁶ defined Chinese diet therapy as the use of foods possessing specific energetic and organotrophic properties to prevent or correct imbalance. Applied to endurance training, diet therapy aims to strengthen *Spleen Qi* (associated with digestion and energy transformation), nourish *Kidney Essence* (vitality and recovery), and clear *Heat* or *Dampness* caused by prolonged physical exertion^{56,57}.

Su⁵⁸ expanded on this by developing individualised nutrition strategies grounded in TCM constitutions, such as *Qi-deficient*, *Yin-deficient*, or *Phlegm-Damp* types, suggesting that constitution-based dietary planning could improve adaptation to training load and metabolic efficiency in competitive athletes.

5.1. Experimental Evidence on Anti-Fatigue and Endurance Enhancement

Herbal Formulations

Zhao *et al.*⁵⁹ investigated the effects of a TCM dietary intervention on post-running energy metabolism. The TCM-based formula enhanced key metabolic indicators, such as aerobic enzyme activity and GLUT-4 expression, suggesting improved metabolic recovery following exercise. The authors attributed these effects to tonic components including *Astragalus membranaceus* (*Huang Qi*) and *Panax ginseng* (*Ren Shen*), which have been associated with supporting energy metabolism, mitochondrial function, and anti-fatigue activity.

Similarly, Ding *et al.*⁶⁰ evaluated a compound extract composed of multiple TCM herbs (*Ginseng*, *Lycium barbarum* (Goji berry), *Polygonatum sibiricum*, and *Dendrobium officinale*) in an in vivo fatigue model. Supplementation increased time to exhaustion and reduced malondialdehyde (MDA) concentrations, indicating lower oxidative stress and en-

hanced resistance to exercise-induced fatigue. The authors reported improvements in energy metabolism pathways, which align with TCM concepts of replenishing *Qi* and nourishing *Yin* to counteract exercise-induced depletion.

Although human evidence remains limited, Liu *et al.*⁶¹ proposed the potential ergogenic effects of *Siraitia grosvenorii* based on experimental findings showing reductions in fatigue-related biomarkers (BUN and lactate) and improvements in metabolic function. Such mechanisms may have implications for athletic performance and recovery, consistent with TCM concepts of restoring *Qi* and maintaining metabolic balance.

Integrative and Mechanistic Perspectives:

Some experimental studies have shown that certain herbal extracts (e.g., red ginseng, ginger) can activate the AMPK–PGC-1 α pathway, promote mitochondrial biogenesis and increase mitochondrial function, which, in animal models, was associated with increased exercise endurance⁶²⁻⁶⁷. This suggests that, in principle, TCM-based diet therapy may improve endurance by optimising cellular energy production pathways. However, human data are still lacking.

5.2. Constitution-Based and Personalised Nutrition

Hsu *et al.*⁶⁸ and Zhao *et al.*⁶⁹ emphasise that effective application of dietotherapy should consider the individual constitution (*ti zhi*). Traditionally, *Qi*-deficient patients are recommended warming and supporting foods such as ginseng, yam, or jujube, whereas *Yin*-deficient individuals are advised cooling, hydrating foods such as pear or lotus root. This individualised approach parallels the principles of contemporary personalised nutrition, providing a culturally distinct yet complementary framework for tailoring endurance nutrition strategies.

6. Phytotherapy

Tribulus terrestris L. has been widely used in herbal medicine and promoted for purported ergogenic benefits, including claims of enhancing testosterone, physical recovery, and performance; however, scientific evidence regarding its efficacy remains controversial. In this context, Ardakani *et al.*⁷⁰ conducted a double-blind, randomised, placebo-controlled trial to investigate whether short-term *Tribulus terrestris* supplementation alters hormonal responses induced by a session of high-intensity resistance exercise, and found no significant differences between the supplementation and placebo groups.

The study by Antonio *et al.*⁷¹ aimed to investigate the effects of *Tribulus terrestris* supplementation on body composition and physical performance in trained male resistance athletes. Fifteen male volunteers with prior resistance training experience were randomly assigned to two groups: one group received *Tribulus terrestris* (3.21 mg/kg body weight per day) and the other received a placebo for eight weeks. Both groups followed the same training program. Results showed no statistically significant differences between groups in body composition (weight, body fat percentage, and total body water), maximal strength (1RM), or muscular endurance (maximum number of repetitions) after the supplementation period. Improvements in strength and endurance were attributed solely to the physical training performed and were similar between groups, except for bench press performance, which showed less progress in the *Tribulus*-supplemented group. Supplementation with *Tribulus terrestris* (3.21 mg/kg/day) did not promote any additional improvements in body composition, muscular strength, or muscular endurance in resistance-trained men over an 8-week period. The observed improvements were attributed to training effects regardless of supplementation intake. These results do not support the use of *Tribulus* as an ergogenic agent in trained athletes.

Moreover, the study by⁷² aimed to examine the effects of two weeks of *Tribulus terrestris* supplementation on inflammatory markers—interleukin-6 (IL-6) and high-sensitivity C-reactive protein (hs-CRP)—as well as muscle damage indicators, creatine phosphokinase (CPK) and lactate dehydrogenase (LDH), following a single session of high-intensity resistance exercise. Eighteen healthy, non-athlete males (age 22.44 ± 2.54 years; BMI

26.15 ± 1.62 kg/m²) were randomly assigned to either a *Tribulus terrestris* supplementation group or a placebo group, each comprising nine participants. Subjects consumed two 250-mg capsules per day of *Tribulus terrestris* or placebo (maltodextrin) for two weeks. After the supplementation period, participants completed six resistance exercises performed in three circuits at 80%, 85%, and 90% of 1RM. Blood samples were obtained at baseline (pre-supplementation), immediately before exercise, and immediately after exercise.

Both groups showed significant total increases in IL-6 ($p < 0.001$) and LDH ($p = 0.005$). Post hoc analysis demonstrated significant elevations in IL-6 and CPK after exercise compared with both pre-exercise and baseline values ($p < 0.001$) in the two groups. No significant within- or between-group differences were observed for hs-CRP ($p > 0.05$). Post-exercise IL-6 and CPK responses did not differ significantly between the *Tribulus terrestris* and placebo groups ($p > 0.05$). However, post-exercise LDH levels were significantly lower in the supplementation group compared with placebo ($p = 0.015$).

Overall, the findings indicate that short-term *Tribulus terrestris* supplementation does not influence IL-6 or hs-CRP responses to resistance exercise, but may contribute to reductions in certain muscle damage markers, specifically CPK and LDH, following high-intensity circuit training.

A literature review conducted by Sellami *et al.*⁷³ examined the potential benefits and risks associated with the use of herbal products by athletes, with a focus on traditional claims, available human data, and ergogenic relevance (Table 1).

Table 1. Herbal products and their evidence-based relevance according to Sellami *et al.*⁷³.

Herbal product	Relevance for athletes
Ginseng (<i>Panax</i>)	- Identified as one of the most extensively studied herbs in sports and exercise contexts. - Traditionally used for its putative anti-fatigue and vitality-enhancing effects. - Human studies show mixed results, with some reporting improvements in well-being, fatigue, and exercise tolerance, while others find no significant performance effects. - Variability in findings may be related to differences in training status, dosage, extract composition, and study design.
<i>Rhodiola rosea</i> and <i>Cordyceps sinensis</i>	- Both classified as adaptogenic herbs traditionally used to support physical and mental resilience. - Preliminary trials suggest possible benefits for fatigue and perceived exertion, but evidence for measurable improvements in endurance or aerobic performance remains inconsistent. - Findings across studies are heterogeneous, and neither herb has demonstrated consistent ergogenic effects in controlled human trials.
<i>Eurycoma longifolia</i> (Tongkat Ali) and <i>Tribulus terrestris</i>	- Commonly marketed for testosterone support, strength enhancement, or vitality. - Most controlled human studies do not show significant improvements in strength, muscle mass, power output, or anaerobic performance. - Evidence supporting performance enhancement is weak and inconsistent, and current data do not support their effectiveness as ergogenic aids.
Alkaloid-rich plants (<i>Guarana</i> , Green Tea, <i>Yerba Mate</i>)	- These plants contain bioactive compounds such as caffeine, catechins, and related alkaloids that may influence alertness, energy expenditure, and antioxidant activity. - Extracts from these plants have been associated with potential benefits on cognitive function, perceived energy, and metabolic parameters, though effects on athletic performance are variable. - Stimulant-containing products may enhance subjective alertness, but misuse or excessive intake increases the likelihood of adverse effects.

The review highlights antioxidant activity as one of the principal biological actions proposed for many herbal preparations. Although the broader scientific literature sug-

gests additional mechanisms, including modulation of stress-response systems and various metabolic pathways, Sellami *et al.*⁷³ emphasise that these hypotheses remain insufficiently substantiated in human athletic populations. Overall, the evidence supporting direct ergogenic mechanisms is limited, and many traditional claims regarding performance enhancement have not yet been validated in controlled studies.

7. Integration of Phytotherapy, Diet Therapy, and Modern Endurance Nutrition

The intersection of TCM phytotherapy, classical diet therapy principles, and contemporary endurance nutrition offers a promising yet complex framework for supporting athletic performance and recovery. Modern sports nutrition has become increasingly nuanced, emphasising periodised carbohydrate intake, optimised protein distribution, micronutrient adequacy, gut microbiota stability, and individualised fuelling strategies tailored to training load. Within this evolving landscape, TCM-based dietary and herbal strategies introduce complementary perspectives that focus on systemic balance, energetic restoration, and individualised constitution types (*ti zhi*). However, the integration of these paradigms requires careful critical appraisal.

From a modern physiological standpoint, endurance performance hinges on the capacity to sustain energy production, manage metabolic stress, control inflammation, and maintain adequate recovery. Evidence shows that macronutrient periodisation, carbohydrate availability, and protein timing significantly influence these processes. TCM diet therapy parallels this logic through its emphasis on strengthening Spleen *Qi* for metabolic transformation, nourishing Kidney Essence to support recovery and resilience, and modulating Heat, Dampness, or other imbalances that may emerge from heavy training loads. Although conceptually distinct, these frameworks converge in their shared aim of optimising metabolic efficiency, recovery quality, and adaptive capacity.

Similarly, phytotherapy offers theoretical mechanisms that could complement established nutritional strategies. Experimental studies indicate that certain herbal extracts, such as ginseng, *Astragalus membranaceus*, or polyherbal formulations, may influence mitochondrial function, reduce oxidative stress, and improve fatigue-related biomarkers. *Tribulus terrestris*, despite its popularisation in the sports domain, exemplifies the discrepancies between traditional claims and empirical evidence: controlled trials consistently show minimal effects on hormonal, performance, or inflammatory outcomes, with only modest and context-specific effects on muscle damage markers. The broader review by Sellami *et al.*⁷³ reinforces this cautious interpretation, highlighting that most phytotherapeutic agents lack consistent, reproducible ergogenic effects in well-controlled human trials.

A reflexive integration therefore requires acknowledging both the theoretical potential and the empirical limitations of phytotherapy. While many herbal preparations possess bioactive compounds capable of modulating antioxidant pathways, stress responses, or metabolic processes, current evidence remains insufficient to position them as primary ergogenic tools. Instead, their value may lie in adjunctive roles (supporting general vitality, modulating subjective fatigue, or contributing to long-term metabolic balance) particularly when used within a diet therapy framework aligned with personalised constitution-based recommendations.

The most compelling area of convergence between TCM and modern nutrition may be in the domain of individualised dietary planning. Endurance athletes exhibit considerable inter-individual differences in gastrointestinal tolerance, substrate utilisation, recovery kinetics, and gut microbiota composition. TCM's constitution-based approach offers a culturally distinct yet conceptually compatible model of personalisation. For example, *Qi*-deficient athletes may benefit from energetically warming, easily digestible foods that parallel modern guidance for optimising glycogen replenishment and digestive comfort, whereas *Yin*-deficient individuals may require hydration-supporting foods and cooling

properties that incidentally align with strategies for recovery and inflammation management. This alignment suggests that constitution-based diet therapy can serve as a complementary lens for tailoring nutrition without contradicting evidence-based principles.

Nevertheless, integration must remain grounded in methodological rigor. Herbal preparations vary widely in composition, standardisation, and bioavailability, and many claims remain untested in athletic populations. Similarly, the application of TCM principles should not replace established strategies such as carbohydrate periodisation, adequate protein intake, or evidence-supported micronutrient supplementation where appropriate. Instead, integration works best when TCM diet therapy and phytotherapy are positioned as supportive adjuncts within a broader, scientifically validated nutritional framework.

8. Conclusion

The integration of phytotherapy and TCM diet therapy with contemporary endurance nutrition presents a multidimensional approach that may enhance athlete health, recovery, and long-term resilience. While current evidence does not support the widespread use of many herbal agents as direct ergogenic aids, both TCM modalities contribute valuable paradigms of personalisation, systemic balance, and holistic recovery. Future research integrating biochemical, microbial, and performance outcomes will be essential to fully elucidate the mechanisms, applications, and limits of these complementary strategies in high-performance sport.

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