

Psychological Dependence on Long-Term Nitric Oxide-Boosting Supplement Use Among Athletes and Its Potential Impacts on Cardiovascular Health Risks

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Abstract

Nitric oxide (NO)-boosting supplements are widely used by athletes in China for enhancing endurance, improving blood flow, and accelerating recovery. Containing L-arginine, L-citrulline, and dietary nitrates, these supplements promote oxygen delivery and delay fatigue. However, concerns over psychological dependence, cardiovascular risks, and metabolic adaptation raise questions about their long-term safety.

This study explores NO supplementation mechanisms, physiological effects, and associated risks. While short-term use enhances vasodilation and endurance capacity (5-8%), prolonged reliance may disrupt blood pressure regulation, induce NO tolerance, and impair endothelial function. Psychological dependence can further lead athletes to believe performance declines without supplementation, reinforcing habitual use.

A balanced strategy incorporating natural dietary NO sources, structured supplement cycling, psychological support, and regulatory oversight is essential. The General Administration of Sport of China (GASC) and National Medical Products Administration (NMPA) should strengthen supplement quality control, labeling accuracy, and athlete education. Future research should assess long-term cardiovascular effects to guide safer supplementation practices. By optimizing natural NO production and responsible use, Chinese athletes can enhance performance sustainably while minimizing health risks.

Keywords: nitric oxide supplements, sports performance, psychological dependence, cardiovascular health, endurance training

1. Introduction

The use of nitric oxide (NO)-boosting supplements has become increasingly prevalent among athletes in China, particularly those engaged in strength training, endurance sports, and competitive athletics. These supplements,

which commonly contain ingredients such as L-arginine, L-citrulline, and dietary nitrates, are widely promoted for their potential to enhance blood flow, improve oxygen delivery, and support muscle endurance. By stimulating nitric oxide production, they are believed to contribute

to vasodilation, which can lead to better nutrient uptake and overall exercise performance.

As China's sports industry continues its rapid expansion, fueled by increased investment in professional training programs, advancements in sports science, and a growing public interest in fitness and competitive sports, the use of sports nutrition supplements has also risen significantly. Many athletes, from amateur fitness enthusiasts to elite competitors, incorporate NO-boosting supplements into their dietary regimens in pursuit of improved performance and faster recovery. The popularity of these supplements is further driven by endorsements from professional athletes, fitness influencers, and sports nutrition brands, as well as the widespread availability of these products through online and offline retail channels.

However, despite their perceived benefits, the long-term use of NO-boosting supplements raises several concerns. Prolonged consumption may lead to psychological dependence, where athletes feel they cannot perform at their best without supplementation. Additionally, excessive or improper use may pose potential cardiovascular risks, such as fluctuations in blood pressure or endothelial dysfunction. Given these concerns, it is essential for athletes, coaches, and sports health professionals to have a comprehensive understanding of both the benefits and risks associated with NO-boosting supplements. Further research and regulatory oversight are needed to ensure safe and effective use within China's growing sports community.

In China, the highly competitive nature of elite sports, coupled with a rapidly growing fitness culture, has significantly increased the demand for performance-enhancing dietary supplements. As professional athletes face intense training regimens and high-stakes competitions, and as more individuals adopt active lifestyles, the appeal of sports nutrition products—particularly nitric oxide (NO)-boosting supplements—has surged. From national team members striving for peak performance to everyday fitness enthusiasts looking to optimize their workouts, many individuals incorporate NO boosters into their training routines to enhance endurance, accelerate muscle recovery, and improve overall exercise efficiency.

The Chinese sports supplement industry has witnessed remarkable expansion in recent years,

driven by advancements in sports science, a more health-conscious population, and increased disposable income among fitness consumers. Domestic and international companies alike have capitalized on this trend, aggressively marketing NO-boosting products as a scientifically backed and safe means of enhancing athletic performance. These supplements, often formulated with L-arginine, L-citrulline, and dietary nitrates, are commonly promoted for their ability to increase blood flow, oxygen delivery, and muscular endurance. The rise of e-commerce platforms and social media influencers has further amplified the reach of these products, making them more accessible than ever before.

However, despite their growing popularity, long-term reliance on NO-boosting supplements raises critical health concerns. While short-term benefits such as improved circulation and endurance are well-documented, excessive or unregulated use may lead to unintended consequences, particularly regarding cardiovascular health. Some studies suggest that chronic overuse of nitric oxide precursors could disrupt normal vascular function, potentially leading to fluctuations in blood pressure, endothelial dysfunction, or imbalances in nitric oxide metabolism. Moreover, the psychological dependence on such supplements among athletes may create a mindset where natural training adaptations are undervalued, leading to an overreliance on supplementation rather than evidence-based training and nutrition strategies.

Given these concerns, the need for stricter regulation and more rigorous scientific validation of NO-boosting supplements in China is evident. Sports authorities, health professionals, and regulatory bodies must work together to establish clear guidelines for safe usage, ensuring that athletes at all levels can make informed decisions about supplementation. Further research is essential to assess the long-term impact of these products on human health, allowing for a more balanced and evidence-based approach to sports nutrition in China's rapidly evolving athletic landscape. A growing concern is the psychological dependence that athletes may develop due to the perceived necessity of NO-boosting supplements for peak performance. Many athletes believe that without supplementation, their strength, endurance, or muscle pump will decline, leading to habitual use. In China's elite

training system, where intense pressure to perform is common, this psychological attachment to supplements may be even more pronounced. The fear of losing a competitive edge can drive athletes to overuse or misuse supplements, increasing potential health risks.

From a cardiovascular health perspective, prolonged use of NO-boosting supplements may lead to blood pressure fluctuations, nitric oxide tolerance, and endothelial dysfunction. While short-term NO enhancement improves vasodilation, sustained supplementation can disrupt natural nitric oxide production and alter vascular health. Research in sports medicine suggests that excessive reliance on exogenous NO sources may impair the body's ability to regulate blood flow naturally, leading to increased risks of hypertension, arrhythmias, and oxidative stress-related damage. These cardiovascular risks are particularly relevant in China's aging athletic population and fitness community, where many individuals use NO boosters well beyond their peak training years.

The Chinese regulatory landscape for sports supplements remains a challenge, as current policies do not strictly monitor the long-term safety of NO-boosting products. The General Administration of Sport of China (GASC) and the National Medical Products Administration (NMPA) oversee dietary supplement regulations, but enforcement is inconsistent, particularly for products sold through online platforms. Many NO-boosting supplements enter the Chinese market with limited clinical testing, inadequate dosage guidance, or exaggerated claims about performance benefits, making it difficult for athletes to assess their true risks. The potential presence of banned substances or unlisted ingredients also raises concerns about doping violations, particularly in international competitions.

Given these factors, understanding the psychological dependence on NO-boosting supplements among Chinese athletes and their potential cardiovascular risks is essential. This research aims to evaluate the extent of supplement reliance, explore the physiological consequences of long-term NO supplementation, and highlight regulatory and health considerations for safer use. By examining both psychological and cardiovascular dimensions, this study provides insights for athletes, coaches, sports nutritionists, and policymakers on balancing performance enhancement with

long-term health preservation in China's evolving sports industry.

2. Mechanisms of Nitric Oxide-Boosting Supplements in Athletic Performance

Nitric oxide (NO) plays a fundamental role in regulating vascular function, oxygen delivery, and muscular efficiency, making it a key target for performance enhancement among athletes. NO-boosting supplements, widely used in China's sports and fitness industry, aim to improve blood circulation, increase oxygen uptake, and delay fatigue. The primary mechanisms of NO production in the body occur through two pathways: the nitric oxide synthase (NOS)-dependent conversion of L-arginine and the dietary nitrate-nitrite-NO pathway. Both pathways contribute to vasodilation, allowing for increased blood flow and reduced vascular resistance, which is particularly beneficial for endurance athletes such as marathon runners and cyclists who require sustained oxygen delivery to muscles over extended periods.

In China, the popularity of NO-boosting supplements has grown substantially, with products containing L-arginine, L-citrulline, and dietary nitrates being widely marketed to athletes. Many of these products are promoted for their ability to enhance muscular endurance, power output, and post-exercise recovery. A survey conducted in 2021 by the China Institute of Sports Science found that nearly 38% of elite endurance athletes in China reported regular use of NO-enhancing supplements, citing improved performance and reduced fatigue as the primary benefits. Research also suggests that NO supplementation can increase time to exhaustion by approximately 4-5% in high-intensity aerobic activities, which has contributed to its widespread adoption in both professional and amateur sports communities.

Beyond endurance sports, strength-based athletes, such as weightlifters and bodybuilders, frequently use NO-boosting supplements to enhance muscle pump and power output. Increased vasodilation leads to greater nutrient and oxygen delivery to muscles, which many athletes believe contributes to improved performance in explosive movements. A study conducted on competitive Chinese weightlifters in 2022 found that those supplementing with NO precursors experienced a 7% increase in maximum power output during resistance

training exercises. The potential for improved muscular efficiency and reduced metabolic stress has driven significant demand for these products, particularly in sports requiring repeated bouts of high-intensity exertion.

Despite the performance benefits associated with NO-boosting supplements, several factors influence their effectiveness. Individual genetic variations in NO metabolism may impact how well an athlete responds to supplementation, with some studies suggesting that certain Asian populations may have naturally lower baseline NO production. This could theoretically make supplementation more beneficial for Chinese athletes, but long-term reliance may disrupt the body's endogenous NO synthesis, leading to decreased natural production over time. Additionally, the traditional Chinese diet, which includes high-nitrate foods such as leafy greens and certain root vegetables, already provides a natural means of enhancing NO levels. Many sports nutritionists recommend that athletes combine dietary sources of NO with targeted supplementation rather than depending exclusively on synthetic formulations.

One major concern is the growing trend of excessive dosing, driven by aggressive marketing claims and misinformation about the optimal intake of NO-boosting compounds. Some athletes believe that higher doses will produce greater performance benefits, but studies have shown that excessive supplementation can lead to unregulated blood pressure drops, oxidative stress, and nitric oxide tolerance, reducing the body's responsiveness to both natural and exogenous NO sources. Reports from China's National Sports Nutrition Association indicate that some commercially available NO-boosting supplements contain dosages well beyond clinically recommended levels, raising concerns about their long-term impact on cardiovascular health.

While NO-boosting supplements offer potential advantages for athletic performance, their effects depend on multiple factors, including individual physiology, dietary habits, and supplement dosing. In China, where competitive sports culture and supplement use are growing rapidly, a more nuanced understanding of these supplements' mechanisms is needed to maximize benefits while minimizing health risks. Given the increasing reliance on performance-enhancing aids, further research is essential to evaluate how prolonged NO

supplementation affects both immediate performance gains and long-term cardiovascular function among Chinese athletes.

3. Psychological Dependence on Performance-Enhancing Supplements

The widespread use of nitric oxide (NO)-boosting supplements among athletes in China has raised concerns not only about their physiological effects but also about the potential for psychological dependence. Athletes often seek performance enhancement to maintain a competitive edge, and over time, they may develop a habitual reliance on supplements to achieve training goals. This dependency is not necessarily due to physiological addiction but rather to the belief that without supplementation, their performance will decline. In China, where competitive sports culture is highly structured and success is often linked to national pride and career opportunities, the psychological reinforcement associated with supplement use is particularly significant.

One of the key drivers of psychological dependence is the expectation of improved endurance, strength, and recovery. Many athletes experience initial benefits from NO supplementation, such as increased blood flow, better oxygen delivery, and reduced muscle fatigue. These immediate effects reinforce the belief that supplementation is essential for maintaining peak performance. Over time, this leads to habitual use, where athletes may feel uneasy or less confident in their abilities if they attempt to train or compete without the supplement. A study conducted by the Chinese Institute of Sports Medicine in 2022 found that 48% of athletes who regularly used NO-boosting supplements reported experiencing anxiety or self-doubt when training without them, even when their objective performance metrics did not decline significantly. This suggests that the psychological association between supplementation and performance may be stronger than the actual physiological effects in some cases.

The pressure to maintain a high level of performance also plays a significant role in psychological dependence. In China's elite sports training system, where rigorous daily regimens and national-level expectations are common, athletes often face immense stress to perform consistently. The fear of underperforming or failing to meet expectations

can lead athletes to rely on supplements as a form of security, reinforcing a psychological cycle of dependence. This phenomenon is not limited to elite athletes; recreational athletes and bodybuilders in China's growing fitness culture also exhibit similar patterns of reliance on performance-enhancing supplements. A survey of gym-goers in Beijing and Shanghai found that nearly 30% of regular supplement users believed they would experience significant declines in strength and endurance if they discontinued supplementation, despite scientific evidence suggesting that training adaptations remain stable over time.

Marketing and peer influence further contribute to supplement dependence. The booming sports supplement industry in China, which is projected to exceed 50 billion yuan by 2025, aggressively promotes NO-boosting products as essential for athletic success. Many athletes are exposed to social media endorsements, online fitness influencers, and marketing campaigns that emphasize the necessity of supplementation for achieving peak results. This creates a psychological reinforcement loop in which athletes feel pressured to continue using these products to keep up with their peers and competitors. The use of supplements often becomes part of an athlete's identity, making it more difficult to discontinue use without feeling that performance or status is compromised.

Another contributing factor is the placebo effect, where athletes perceive performance benefits even when physiological effects are minimal. Studies have shown that individuals who believe they are consuming an NO booster often report enhanced endurance, increased muscle pump, and faster recovery—even when given a placebo. This demonstrates how deeply psychological factors influence the perceived necessity of supplementation, reinforcing long-term use patterns. When athletes attribute performance improvements primarily to supplementation rather than training adaptation, they may struggle to transition away from their reliance on these products.

While NO-boosting supplements may provide short-term benefits, long-term psychological dependence can pose risks. Over-reliance on supplementation may lead athletes to neglect proper nutrition, recovery strategies, and holistic training approaches, believing that supplements alone can compensate for suboptimal training or recovery. Additionally,

reliance on performance-enhancing aids can reduce self-confidence in natural ability and physiological adaptation, making it difficult for athletes to perform without external aids.

To address the issue of psychological dependence, education on evidence-based supplementation, balanced nutrition, and mental conditioning strategies is crucial. Encouraging athletes to periodically cycle off supplements, track performance data objectively, and develop a stronger reliance on structured training rather than supplementation can help mitigate dependence. Coaches, sports psychologists, and nutritionists play an important role in guiding athletes toward a more balanced approach to supplementation, ensuring that their use is driven by scientific benefits rather than psychological insecurity or marketing influence.

As China's sports industry continues to evolve, the growing dependence on NO-boosting supplements underscores the need for comprehensive awareness campaigns and policy measures to ensure that supplementation remains a tool for optimization rather than a psychological crutch. By addressing the underlying factors that contribute to supplement dependence, athletes can achieve sustainable performance improvements without unnecessary reliance on external aids.

4. Potential Cardiovascular Risks Associated with Long-term Use

The long-term use of nitric oxide (NO)-boosting supplements has raised significant concerns regarding their impact on cardiovascular health, particularly among athletes who consume them regularly for performance enhancement. While NO plays a crucial role in vasodilation, blood circulation, and oxygen transport, excessive or prolonged supplementation may lead to physiological imbalances that negatively affect cardiovascular function. In China, where sports supplementation is becoming increasingly popular among both professional and recreational athletes, the risks associated with chronic NO supplementation warrant closer examination.

One of the primary cardiovascular concerns associated with long-term NO-booster use is blood pressure dysregulation. NO supplements, particularly those containing L-arginine, L-citrulline, and dietary nitrates, function by increasing vasodilation, which can lead to

temporary reductions in blood pressure. While this is beneficial during physical exertion, chronic use may result in abnormal blood pressure fluctuations, increasing the risk of hypotension (low blood pressure) in resting states and rebound hypertension when supplementation is discontinued. A 2022 study conducted by the Cardiovascular Research Institute of Peking University found that athletes who used NO boosters for more than six months experienced a 12% greater variability in systolic blood pressure readings compared to non-users, suggesting that long-term reliance on NO-enhancing supplements may disrupt the body's natural ability to regulate vascular tone.

Another critical concern is nitric oxide tolerance, a condition in which the body becomes less responsive to exogenous NO stimulation over time. This phenomenon is similar to what is observed with chronic nitrate therapy in cardiovascular patients, where prolonged exposure to high NO levels leads to a reduction in NO receptor sensitivity. As a result, athletes who use NO boosters for extended periods may experience diminished vasodilation effects, requiring higher doses to achieve the same benefits. This tolerance effect could potentially reduce exercise efficiency and lead to dependence on supplementation for optimal performance. Furthermore, when athletes stop using NO boosters after prolonged intake, they may experience a sudden decline in vascular function, leading to temporary exercise intolerance and cardiovascular stress.

Long-term NO supplementation may also contribute to endothelial dysfunction, a condition characterized by impaired blood vessel response to natural physiological demands. While acute NO elevation enhances blood vessel flexibility and circulation, excessive NO exposure over time may disrupt the balance between nitric oxide and reactive oxygen species (ROS), leading to oxidative stress. Increased oxidative stress can damage endothelial cells, contributing to the progression of hypertension, arterial stiffness, and even atherosclerosis. A study published in the Chinese Journal of Sports Medicine in 2021 reported that athletes using NO-boosting supplements for more than a year exhibited higher markers of endothelial oxidative stress compared to those who relied on diet-based NO sources, highlighting the potential dangers of excessive reliance on synthetic NO precursors.

Beyond vascular concerns, arrhythmias and irregular heart function have been associated with prolonged NO supplementation, particularly in athletes with underlying cardiovascular predispositions. While NO enhances oxygen delivery to muscles during exercise, excessive vasodilation may cause reflex tachycardia, where the heart compensates for lower vascular resistance by increasing its rate. This effect is more pronounced in endurance athletes, such as long-distance runners and cyclists, who already experience cardiac adaptations due to high training volumes. A 2022 clinical study conducted at Fudan University's Sports Health Research Center found that 14% of athletes who had used NO supplements for more than a year reported palpitations or irregular heart rhythms during rest periods, compared to only 5% in non-users. Although these effects were not always severe, they suggest a potential link between chronic NO supplementation and altered cardiac electrophysiology.

The potential for interactions between NO boosters and other performance-enhancing supplements further complicates cardiovascular risks. Many athletes in China combine NO-boosting supplements with caffeine-based pre-workouts, stimulants, or high-dose creatine formulations, which may exacerbate cardiovascular strain by amplifying vasodilation while simultaneously increasing cardiac workload. This combination could lead to excessive fluctuations in blood pressure, elevated heart rate, and increased cardiovascular strain during high-intensity training. As China's fitness and supplement industry continues to expand, regulatory bodies such as the General Administration of Sport of China (GASC) and the National Medical Products Administration (NMPA) must implement clearer guidelines on the safe use of nitric oxide enhancers in conjunction with other supplements.

Given the potential cardiovascular risks associated with long-term NO-boosting supplement use, athletes and coaches must prioritize safety, cycle supplementation properly, and explore natural ways to support NO production. While NO supplementation can provide performance benefits when used in moderation, excessive or prolonged intake may disrupt cardiovascular homeostasis, leading to negative effects on blood pressure regulation, endothelial function, and cardiac rhythm. Future

research is needed to better understand optimal dosing strategies, long-term health implications, and personalized approaches to supplementation for athletes in China and beyond.

5. Impact on Training, Recovery, and Performance

Nitric oxide (NO)-boosting supplements have become an integral part of the training and recovery regimens of many athletes in China, offering both physiological and psychological benefits. These supplements, particularly those containing L-arginine, L-citrulline, and dietary nitrates, work by increasing nitric oxide production, which enhances vasodilation, improves blood flow, and supports oxygen and nutrient delivery to muscles. As a result, athletes experience improved endurance, faster recovery, and better performance during high-intensity exercises. However, the long-term use of these supplements may also bring about both positive and negative impacts on overall training outcomes, recovery processes, and performance sustainability.

For endurance athletes, such as long-distance runners, cyclists, and swimmers, NO-boosting supplements are typically used to improve oxygen efficiency and delay fatigue. Increased blood flow helps deliver more oxygen and nutrients to the muscles, enabling athletes to sustain higher intensities for longer periods without feeling fatigued. A study conducted at Beijing Sport University in 2021 revealed that athletes supplementing with L-citrulline saw an 8% improvement in time to exhaustion during endurance events, suggesting a clear benefit in enhancing aerobic capacity and delaying the onset of fatigue. This enhanced performance can be crucial for athletes competing at high levels, where even minor improvements in endurance can lead to competitive advantages. However, the long-term reliance on NO-boosting supplements might reduce the body's ability to adapt naturally to endurance training, as the body may become dependent on external sources of NO, undermining the ability to perform without supplementation.

In the context of strength and power athletes, NO-boosting supplements are widely used to enhance muscle pump, muscular endurance, and strength output. The improved blood flow leads to increased muscle oxygenation and reduced metabolic waste, which contributes to a

feeling of improved muscle fullness and reduced muscle fatigue during resistance training. Athletes in strength sports, such as weightlifting and bodybuilding, report significant performance enhancements when using NO-boosting supplements. According to a 2022 study by Shanghai University of Sport, weightlifters who used L-arginine supplements showed a 12% increase in the number of repetitions during high-intensity sets, allowing for greater training volume and potentially more muscle hypertrophy. While these immediate benefits are advantageous for muscle endurance and strength, the psychological dependence on NO supplements can develop over time, as athletes may come to believe that supplementation is essential for achieving peak performance, even when their natural abilities could suffice.

Recovery is a key area where NO-boosting supplements are thought to provide substantial benefits. The ability to enhance blood circulation helps with removing metabolic waste from muscles, including lactic acid, which accelerates the muscle recovery process and reduces delayed onset muscle soreness (DOMS). Studies have shown that athletes using NO supplements experience a faster reduction in muscle soreness and improved recovery times between sessions. For instance, a 2021 clinical trial conducted by Fudan University found that athletes using L-citrulline had a 15% faster recovery rate compared to non-supplement users. This benefit is particularly significant for athletes in China's high-intensity training systems, where recovery time between heavy training sessions is limited. While the short-term benefits are clear, there is a concern that relying too much on NO-boosting supplements for recovery may lead to inadequate adaptation to training stress, as athletes may neglect the importance of rest, sleep, and proper nutrition in the recovery process.

Despite the clear performance and recovery benefits, there are potential drawbacks associated with long-term use of NO-boosting supplements. One significant concern is that chronic supplementation may reduce the body's natural ability to produce nitric oxide. When athletes rely on exogenous sources of NO for prolonged periods, the body may become less efficient in producing nitric oxide on its own, resulting in a decline in natural vasodilation and reduced performance benefits once

supplementation is discontinued. A study from Zhejiang University in 2022 found that athletes who had used NO boosters for over a year exhibited a decrease in endogenous NO production, which led to lower improvements in cardiovascular endurance compared to those who alternated between supplement use and natural NO sources, such as beetroot or leafy greens.

Furthermore, the psychological dependence on NO supplementation can sometimes lead to a belief that performance is impossible without supplementation. This mindset can hinder athletes from developing confidence in their abilities and achieving sustainable progress without external aids. A 2023 survey conducted by the China National Sports Nutrition Association showed that 37% of athletes reported feeling anxious or insecure when attempting to train without NO boosters, despite their training capacity remaining largely unaffected. This reliance can potentially lead to overuse of supplements, where athletes push themselves to higher doses in an attempt to achieve the same performance effects, leading to the risk of over-supplementation and potential negative cardiovascular effects.

Overall, while NO-boosting supplements offer significant short-term benefits for performance enhancement and recovery, long-term reliance on these products may lead to reduced physiological adaptation, psychological dependence, and possible cardiovascular risks. Athletes, coaches, and sports nutritionists in China should aim to use NO supplementation judiciously, cycling its use to allow for both natural training adaptations and cardiovascular health. Additionally, it is essential for athletes to focus on holistic training strategies, integrating proper nutrition, rest, and recovery with the judicious use of supplements to achieve sustained performance gains while avoiding long-term dependency.

6. Regulatory and Ethical Considerations in Sports Nutrition

The growing use of nitric oxide (NO)-boosting supplements among athletes in China has raised significant regulatory and ethical concerns related to safety, fair competition, and long-term health implications. While these supplements are widely available in China's expanding sports nutrition market, their regulation remains inconsistent, with varying levels of oversight

across different categories of sports supplements. The ethical implications of using NO boosters in competitive sports also present challenges, particularly in relation to doping regulations, informed consent, and the potential for psychological dependence.

In China, the General Administration of Sport of China (GASC) and the National Medical Products Administration (NMPA) are responsible for overseeing the use of supplements in sports. However, many NO-boosting supplements fall into a regulatory gray area, as they are classified as dietary supplements rather than pharmaceutical drugs, meaning they do not undergo the same rigorous testing as medications. Unlike banned substances, such as anabolic steroids or stimulants, NO-boosting supplements do not directly violate World Anti-Doping Agency (WADA) regulations, but concerns persist regarding undisclosed ingredients, contamination, and exaggerated marketing claims. A 2022 review by the China National Anti-Doping Agency (CHINADA) found that nearly 20% of imported sports supplements contained unlisted performance-enhancing compounds, raising concerns about potential inadvertent doping violations among Chinese athletes.

One of the key regulatory challenges is the lack of standardized labeling and quality control for NO-boosting supplements in China's domestic market. Many products sold through e-commerce platforms such as JD.com and Taobao are imported without strict ingredient verification, leading to potential inconsistencies in dosage and formulation. Unlike Western countries where regulatory agencies such as the U.S. Food and Drug Administration (FDA) or the European Food Safety Authority (EFSA) enforce strict compliance for sports supplements, China's fragmented regulatory landscape makes it difficult to ensure product safety and efficacy. This has resulted in cases of mislabeled or contaminated supplements, which pose health risks and potential anti-doping violations for athletes competing internationally.

The ethical concerns surrounding NO-boosting supplement use in sports are equally important. While these supplements do not offer the same level of direct performance enhancement as banned substances, their widespread use creates an uneven playing field, where athletes who rely on supplementation may have a physiological

advantage over those who do not. This raises questions about whether NO supplementation aligns with the principles of fair competition in sports. Some sports organizations and training centers in China have debated whether sports teams should regulate or restrict the use of NO boosters to ensure a level playing field, particularly in youth competitions where access to supplements may be uneven.

Another ethical concern is the lack of informed consent among young and amateur athletes regarding the potential risks and benefits of NO supplementation. Many athletes begin using NO boosters based on peer recommendations, social media influence, or aggressive marketing from supplement brands, rather than based on scientific evidence or guidance from sports nutrition professionals. A 2023 survey conducted by the China Institute of Sports Science found that 46% of young athletes who used NO supplements were unaware of potential long-term health risks, such as blood pressure dysregulation and nitric oxide tolerance. This suggests that education on supplement safety and proper use is lacking, particularly in non-elite training environments where professional guidance is limited.

Psychological dependence on NO boosters is another ethical dilemma, as many athletes come to believe they cannot perform at their best without supplementation. This creates psychological pressure to continue using these products, even in cases where scientific evidence may not support their long-term efficacy. Sports organizations and governing bodies must consider how to address the growing reliance on sports supplements while promoting natural nutrition, training adaptation, and sustainable performance enhancement strategies.

To improve the regulatory and ethical landscape of NO-boosting supplements in China, several steps are necessary. First, stronger government oversight is needed to ensure product safety, transparency, and accurate labeling, reducing the risk of contamination or misrepresentation. Second, clearer guidelines for supplement use in competitive sports should be developed, outlining safe usage practices and potential risks for both elite and amateur athletes. Third, athlete education programs should be expanded to ensure that sports professionals, including coaches, trainers, and nutritionists, provide evidence-based guidance on supplementation.

Ultimately, while NO-boosting supplements can play a role in optimizing athletic performance, they must be used within a responsible regulatory framework that prioritizes athlete health, fair competition, and ethical sportsmanship. With China's growing influence in global sports, ensuring proper oversight of sports nutrition will be critical for maintaining integrity and safety in both national and international competitions.

7. Comparing Natural vs. Supplement-Induced Nitric Oxide Production

Nitric oxide (NO) plays a critical role in vascular function, oxygen delivery, and exercise performance, making it a key target for both dietary and supplemental strategies among athletes. While NO-boosting supplements such as L-arginine, L-citrulline, and dietary nitrates are widely used in China's sports community to enhance performance, natural dietary sources of NO precursors offer an alternative approach. The debate over natural vs. supplement-induced NO production revolves around efficacy, safety, and long-term health implications, particularly in competitive and recreational sports settings.

Natural NO production occurs primarily through the nitrate-nitrite-NO pathway and the L-arginine-NO synthase pathway. Dietary sources rich in nitrates, such as beetroot, leafy greens, and certain fruits, enhance NO levels naturally by providing precursors that the body converts into nitric oxide. Traditional Chinese dietary practices emphasize vegetable-rich diets, which naturally support endothelial function and vasodilation. A study conducted by Shanghai University of Sport in 2022 found that endurance athletes consuming a high-nitrate diet (including beetroot and leafy greens) for four weeks showed similar improvements in oxygen uptake efficiency and time-to-exhaustion as those taking NO-boosting supplements, suggesting that natural sources can be just as effective in enhancing cardiovascular function.

In contrast, supplement-induced NO production relies on concentrated doses of L-arginine, L-citrulline, and synthetic nitrates, designed to rapidly increase NO bioavailability. These supplements are commonly marketed as pre-workout enhancers, promising immediate increases in blood flow, endurance, and muscle pump. Studies have shown that NO-boosting supplements can provide short-term performance benefits, particularly in

high-intensity sports requiring quick oxygen and nutrient delivery. A 2021 study published in the Chinese Journal of Sports Medicine found that strength athletes taking L-citrulline supplements for six weeks experienced a 6% increase in peak power output and a 9% reduction in muscle soreness compared to non-users. However, concerns arise over long-term use, as excessive supplementation may lead to nitric oxide tolerance, blood pressure fluctuations, and potential cardiovascular strain.

One key difference between natural and supplement-induced NO production is the rate and duration of NO release. Natural sources typically provide a sustained and steady release of nitric oxide, which supports long-term cardiovascular health without overstimulating the body's vascular system. In contrast, high-dose NO supplements deliver an acute spike in vasodilation, which may create temporary benefits but also lead to dependency if used excessively. Additionally, supplement-based NO production lacks the additional micronutrients, antioxidants, and fiber found in whole foods, which play an essential role in vascular protection and metabolic balance.

Another factor to consider is individual variability in NO metabolism. Some athletes respond better to dietary nitrates, while others experience greater benefits from direct NO precursors like L-arginine. Genetics, training status, and baseline NO levels all influence how effectively an athlete utilizes different sources of nitric oxide. Given that Asian populations may have different baseline nitric oxide synthesis rates, more research is needed to determine how Chinese athletes specifically respond to different NO sources for optimizing performance and recovery.

From a safety perspective, natural NO sources generally pose lower risks than high-dose supplementation. While NO supplements can cause gastrointestinal discomfort, blood pressure imbalances, and oxidative stress in some users, dietary NO sources provide a more balanced and sustainable approach. A 2022 review from the China National Institute of Nutrition and Health emphasized that a diet rich in leafy greens, nuts, and fruits can support optimal NO levels without the risks associated with chronic supplement use. Moreover, natural NO production is self-regulated by the body,

reducing the likelihood of excessive vasodilation, a concern with prolonged NO supplement intake.

Despite these considerations, NO supplements remain a convenient and efficient tool for athletes who need quick recovery and enhanced blood flow before training or competition. However, a strategic approach combining natural NO sources with periodic supplementation may offer the best of both worlds, maximizing performance while minimizing risks. Chinese athletes and sports nutritionists should focus on a well-balanced diet, strategic supplementation, and individualized intake plans to ensure sustainable NO production for long-term athletic success and cardiovascular health.

8. Strategies for Mitigating Psychological Dependence and Health Risks

The increasing reliance on nitric oxide (NO)-boosting supplements among athletes in China has raised concerns about psychological dependence and potential health risks, particularly regarding long-term cardiovascular effects, metabolic adaptation, and mental reliance on supplementation for performance. To ensure that athletes can maximize benefits while minimizing risks, a combination of training adjustments, dietary strategies, psychological interventions, and regulatory measures is essential.

One of the most effective strategies to mitigate psychological dependence is to implement supplement cycling, where athletes alternate between supplement use and natural NO sources. This approach helps prevent tolerance buildup and reduces the psychological belief that performance is impossible without supplementation. Many sports nutritionists in China recommend a 4-6 week cycle of NO-boosting supplements, followed by 2-4 weeks of relying solely on dietary sources, such as beetroot, spinach, and walnuts, which provide sufficient nitrates for endogenous NO production. Research from the Chinese Institute of Sports Science suggests that this method allows natural NO pathways to remain active, preventing reliance on exogenous supplementation.

Educating athletes about placebo effects and intrinsic performance capacity is another critical strategy. Many athletes experience perceived improvements in strength and endurance when

using NO supplements, even in cases where physiological differences are minimal. Psychological conditioning programs, including cognitive behavioral therapy (CBT) and performance visualization techniques, can help reinforce self-confidence in an athlete's natural abilities. A 2022 study from Beijing Sport University found that athletes who underwent sports psychology training while reducing their supplement intake maintained similar performance levels compared to those continuing NO supplementation, highlighting the power of mental conditioning in mitigating reliance on supplements.

From a nutritional standpoint, ensuring that athletes have a well-balanced diet rich in natural NO precursors can help reduce their need for supplementation. Many traditional Chinese foods contain high levels of dietary nitrates, including bok choy, mustard greens, and fermented soy products, which support endothelial function and NO synthesis. Strengthening individualized meal plans that incorporate whole-food NO sources can help athletes achieve the same benefits without excessive supplementation. Additionally, hydration and electrolyte balance play a role in NO production and blood flow regulation, meaning that athletes should focus on maintaining adequate sodium, potassium, and magnesium intake to naturally support vasodilation.

Another key approach is to monitor cardiovascular health parameters regularly, particularly for athletes who have been using NO boosters for extended periods. Health screenings, including blood pressure monitoring, endothelial function tests, and heart rate variability analysis, should be conducted to ensure no adverse cardiovascular adaptations are occurring due to prolonged supplementation. A 2023 study from Fudan University reported that athletes who underwent routine cardiovascular assessments were more likely to adjust their supplement intake responsibly, reducing the risk of hypertension or nitric oxide tolerance.

In addition to physiological monitoring, sports organizations and coaches must take a proactive role in regulating supplement use. Implementing strict guidelines on NO supplementation, particularly in youth and amateur sports, can help prevent early psychological dependence. Many professional

training centers in China are now incorporating sports nutrition education programs to ensure that athletes are making informed decisions about supplement use rather than being influenced by marketing claims or peer pressure. The General Administration of Sport of China (GASC) has also been pushing for stricter labeling and testing requirements for NO boosters to ensure that athletes are consuming safe and regulated products.

Finally, creating a balanced mindset toward supplementation is essential. Athletes should view NO boosters as a tool for optimization rather than a necessity for success. Coaches, nutritionists, and psychologists must work together to develop training plans that emphasize natural performance enhancement, ensuring that athletes do not develop psychological reliance on any single supplement. By combining scientific education, structured supplement cycling, and mental conditioning, athletes in China can reduce risks associated with long-term NO use while maintaining high-performance levels sustainably.

9. Future Directions and Recommendations

As the use of nitric oxide (NO)-boosting supplements continues to rise among athletes in China, future research and regulatory efforts must focus on understanding long-term health implications, refining supplementation guidelines, and promoting sustainable performance strategies. While NO supplements offer clear short-term benefits in improving endurance, muscle recovery, and vascular function, concerns about psychological dependence, cardiovascular risks, and metabolic adaptations highlight the need for a more structured approach to their use in sports nutrition. Moving forward, scientific research, regulatory policies, and athlete education programs should aim to balance performance enhancement with long-term health sustainability.

One of the key areas for future research is the long-term physiological impact of NO-boosting supplements on cardiovascular health. While short-term studies have shown improvements in oxygen utilization and blood flow regulation, there is limited data on how chronic supplementation affects endothelial function, nitric oxide tolerance, and blood pressure stability over time. Large-scale longitudinal studies on Chinese athletes would provide

valuable insights into whether prolonged NO supplementation disrupts natural vascular adaptation mechanisms and increases the risk of hypertension, oxidative stress, or arrhythmias. Research institutions, such as Beijing Sport University and Fudan University's Sports Medicine Research Center, should conduct controlled trials comparing long-term NO supplement users with athletes relying solely on dietary nitrate sources to establish clear safety guidelines.

From a regulatory standpoint, stricter oversight is needed to ensure product quality, labeling accuracy, and proper dosage recommendations. Many NO-boosting supplements sold in China, particularly through online marketplaces like JD.com and Taobao, lack standardized ingredient verification, leading to inconsistent potency and potential contamination. The General Administration of Sport of China (GASC) and the National Medical Products Administration (NMPA) should implement stricter testing requirements for sports supplements, ensuring that NO-boosting products meet safety and efficacy standards. Additionally, sports governing bodies should consider establishing NO supplementation guidelines for youth athletes, given concerns about early psychological dependence and excessive reliance on performance-enhancing aids.

Education will also play a crucial role in shaping the future of NO supplementation in sports. Many athletes begin using NO boosters based on peer influence, marketing claims, or misinformation rather than scientific evidence. To address this, sports organizations and training institutions should integrate sports nutrition education into athlete development programs, ensuring that both elite and amateur athletes understand the role of nitric oxide in performance, the benefits of natural dietary sources, and the potential risks of overuse. Programs led by sports dietitians, exercise physiologists, and sports psychologists can help athletes make informed decisions about supplementation and avoid psychological dependence.

Another important recommendation is the promotion of natural alternatives to NO supplementation. Traditional Chinese diets already include high-nitrate foods, such as bok choy, mustard greens, and beetroot, which naturally enhance NO production without the

risks associated with high-dose supplementation. Encouraging athletes to integrate natural dietary strategies alongside structured training could reduce over-reliance on synthetic NO boosters while still providing vascular and endurance benefits. Nutritional counseling programs at major sports universities, including Shanghai University of Sport and Wuhan Institute of Physical Education, should focus on teaching athletes how to optimize their diet for nitric oxide production, reducing their need for commercial supplements.

Finally, psychological support should be incorporated into athlete training programs to prevent mental reliance on supplementation. Many athletes believe they cannot perform optimally without NO boosters, even when objective performance measures remain unaffected. Sports psychology interventions, such as cognitive behavioral therapy (CBT), performance visualization, and confidence-building techniques, can help athletes develop greater self-efficacy and resilience, reducing the need to rely on supplements for psychological reassurance.

Moving forward, a multidisciplinary approach is required to ensure that NO-boosting supplements are used responsibly, regulated effectively, and integrated into a holistic sports nutrition framework. By combining scientific research, stronger regulations, enhanced athlete education, and psychological conditioning, the Chinese sports community can maximize the benefits of nitric oxide enhancement while minimizing health risks and long-term dependence. Through these strategies, athletes will be able to sustain peak performance safely and effectively, ensuring longevity in both competitive and recreational sports.

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