The use of creatine in adolescents

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Abstract

Creatine is a naturally occurring compound essential for cellular energy metabolism and is widely used as a dietary supplement to enhance high-intensity exercise performance. However, its use extends beyond structured athletic performance contexts. Due to broad availability in retail outlets and online platforms, creatine is increasingly used in recreational gym environments, school sports, and by adolescents seeking improvements in physique and muscle mass, often without professional guidance. While creatine supplementation is well established in adults, its use in adolescents remains controversial, largely attributable to ongoing safety concerns, persistent misconceptions, and the limited availability of robust long-term data. Beyond its ergogenic effects, emerging evidence suggests potential for creatine to influence cognitive performance. This review evaluates the prevalence of creatine use in adolescents, its mechanism of action, effects on athletic and cognitive performance, as well as safety profile, with emphasis on the pharmacist's role in counselling and monitoring. Current evidence suggests that creatine supplementation, when used appropriately, is generally well tolerated in adolescents, although long-term safety data remain limited. Pharmacists play a key role in promoting evidence-based use, mitigating risk, addressing misinformation, and supporting safe supplementation practices in adolescent populations.

Keywords: creatine, adolescents, dietary supplements, safety, pharmacist role

 https://doi.org/10.36303/SAPJ.4549

Introduction

Creatine is one of the most extensively researched ergogenic aids in sports nutrition and one of the most widely used dietary supplements worldwide. Synthesised endogenously from arginine, glycine and methionine, and obtained exogenously through dietary sources such as red meat and seafood, creatine plays a central role in cellular energy metabolism. In the skeletal muscles and brain cells, creatine contributes to the phosphocreatine system, which functions as a rapid buffer for adenosine triphosphate (ATP) regeneration during short-duration, high-intensity activity (muscles), and cognitive performance (brain).[1-4]

In adult populations, creatine supplementation has consistently demonstrated improvements in anaerobic performance, lean body mass, and training adaptations, with an established safety profile when used at recommended doses.[2,3] The increasing prevalence of creatine use among adolescent athletes, particularly in strength- and power-based sports, underscores the need for clear, evidence-based guidance.[5-7] Adolescents may initiate supplementation based on peer influence, social media exposure, or performance pressures, frequently without professional supervision. In this context, pharmacists are uniquely positioned to provide structured counselling, evaluate risk factors, and mitigate misinformation.

While the adolescent evidence base is smaller than that of adults, a growing body of controlled trials, observational studies, and clinical investigations has primarily examined performance outcomes, with safety parameters often reported as secondary outcomes in younger populations. These studies generally report modest ergogenic benefits and no consistent signal of clinically significant adverse effects when creatine is used responsibly. Nonetheless, long-term prospective data in healthy adolescent cohorts remain limited, warranting cautious interpretation.[1-3]

For the purposes of this article, adolescence is defined according to the World Health Organization (WHO) as individuals aged 10-19 years.[8] This review evaluates the current literature on creatine use in adolescents, synthesising evidence related to efficacy, safety, and common misconceptions. In addition, it provides practical, pharmacist-focused guidance for assessment, counselling, monitoring, and referral. By distinguishing between documented risks and persistent myths, this article aims to support evidence-informed decision-making in pharmacy settings.

Prevalence of creatine use in adolescents

Creatine supplementation is increasingly used by adolescents, particularly those engaged in competitive or recreational sports for performance enhancement.[9,10] Survey-based studies indicate that prevalence varies by sport type, competitive level, age, and sex.

Across middle- and high-school populations, approximately 5–20% of adolescents report prior or current creatine use.[10] Use is consistently higher among males than females and increases across advancing grade levels.[2,10] For example, Metzl et al.[11] reported use in 8.8% of males and 1.8% of females (Grades 6–12), with 44% of users in Grade 12. Similarly, Hoffman et al.[12] found higher prevalence among males, with rates increasing to 22% in Grade 12 males. Broader estimates suggest the general adolescent population use ranging from 0.6–22.2% in males and 0.6–3% in females.[13]

Among adolescent athletes, similar sex-related trends are observed and prevalence is generally higher, particularly in strength- and power-based sports. McGuine et al.[14] reported use in 16.7% of high school athletes, with the highest rates among football players (30.1%) and the lowest among female cross-country athletes (1.3%). Smith et al.[15] documented an overall prevalence of 8.2% among high school athletes, with rates increasing to 21% among football players. Reported motivations commonly include increasing lean body mass, strength, and anaerobic performance.[2,10] Even higher rates have been observed among adolescents engaging in muscle-building behaviours, particularly older boys and young men.[6]

Among elite adolescent athletes competing internationally, prevalence appears higher than in both school-based and general athletic cohorts. Petroczi et al.[16] reported use in 36.1% of elite adolescent athletes in the United Kingdom, with similar findings in subsequent cohorts (28%).[17] Jovanov et al.[18] reported use in 25.3% of internationally competing adolescent athletes across four countries, with higher use among males and older adolescents. Although earlier school-based studies suggested very low use among females, more recent elite cohorts demonstrate greater female representation among users.[18,19]

Despite these findings, creatine remains less frequently used than other dietary supplements such as protein powders and multivitamins which may reach prevalence rates of 60–80% in athletic populations.[2] Overall, evidence indicates higher use among males, older adolescents, and those participating in strength-oriented and elite sport, reflecting the growing normalisation of creatine supplementation in adolescent athletic contexts.

Mechanism of action of creatine

The mechanism of action of creatine is the same across age groups, with similar phosphocreatine-mediated ATP buffering system working in both adolescents and adults. Creatine exerts its primary physiological effect through augmentation of the intramuscular phosphocreatine system, a critical component of short-duration, high-intensity energy metabolism. Approximately 95% of total body creatine is stored in skeletal muscle, where it exists as free creatine and phosphocreatine.[2,20-22]

Creatine is derived from two principal sources (Figure 1). It is synthesised endogenously, from dietary sources such as red meat and fish, through a two-step process. Initially, arginine and glycine are converted to guanidinoacetate (GAA) in the kidneys via arginine:glycine amidinotransferase (AGAT). GAA is then methylated in the liver by S-adenosylmethionine (SAM), which serves as the methyl donor, to produce creatine; this reaction generates S-adenosylhomocysteines (SAH) as a by-product. Once transported to target tissues such as skeletal muscle, creatine is phosphorylated to phosphocreatine, which acts as a rapid energy buffer by donating inorganic phosphate (Pi) to adenosine diphosphate (ADP) to regenerate ATP (Figure A.1).[20-22]

Although the majority of creatine is endogenously synthesised in the kidneys and liver, a small amount is also synthesised in the brain. This occurs through enzymatic catalysation of arginine, glycine, and methionine to supply 20% of the body's energy expenditure.[4] This involves a two-step process. Firstly, AGAT synthesises GAA from arginine and glycine. Secondly GAMT (guanidinoacetate N-methyltransferase) methylates GAA to produce creatine, using S-adenosyl-L-methionine (SAMe). Creatine is then transported from the extracellular space into the cells through the sodium-chloride dependent transporter, Solute Carrier Family 6 Member 8 (SLC6A8), against a concentration gradient (Figure A.2).[23]

In addition to endogenous synthesis, creatine is obtained exogenously through creatine supplementation (Figure 1B).[20-22] Following absorption in the small intestine, supplemental creatine enters the systemic circulation and is transported into skeletal muscle through the sodium-dependent creatine transporter (CRT-1). Within the muscle cell, creatine is phosphorylated by creatine kinase (CK) using ATP generated through mitochondrial oxidative phosphorylation. During short-duration, high-intensity exercise, ATP is rapidly hydrolysed to adenosine ADP to supply energy for muscle contraction. This reversible reaction enables phosphocreatine to function as an immediate phosphate donor during periods of high ATP demand, thereby maintaining intracellular ATP concentrations and sustaining muscle contractile function.[1-3,20,22] The CK reaction, shown below (Equation 1), regenerates ATP from ADP:

$$\textit{Creatine} + \textit{ATP} \rightleftharpoons \textit{phosphocreatine} + \textit{ADP} \ldots \textit{(Equation 1)}$$

Creatine supplementation increases total intramuscular creatine and phosphocreatine concentrations, thereby enhancing rapid ATP buffering capacity. Following optional loading protocols, a typical maintenance dose of 3–5 g/day is sufficient to sustain elevated intramuscular creatine stores in most individuals. Increased phosphocreatine availability support improvements in repeated sprint performance, peak power output, and resistance training adaptations in adolescent populations.[1-3]

In addition to its energetic role, intracellular creatine accumulation exerts osmotic effects, increasing intracellular osmolarity and promoting water influx into muscle cells (Figure 1). This cellular hydration may reduce protein breakdown, enhance anabolic signalling, and improve recovery following resistance training through the activation of the mTOR (mechanistic Target of Rapamycin)-related pathways.[1-3]

Effects on athletic performance in adolescents

The evidence evaluating the ergogenic effects of creatine supplementation in adolescent populations is evolving but remains less robust than that in adults. A 2023 systematic review of creatine use in paediatric and adolescent athletes identified 13 eligible studies involving participants aged approximately 11.5–18.2 years.[5] Although many of these studies were randomised controlled trials, the review concluded that the overall methodological quality was low and that findings regarding

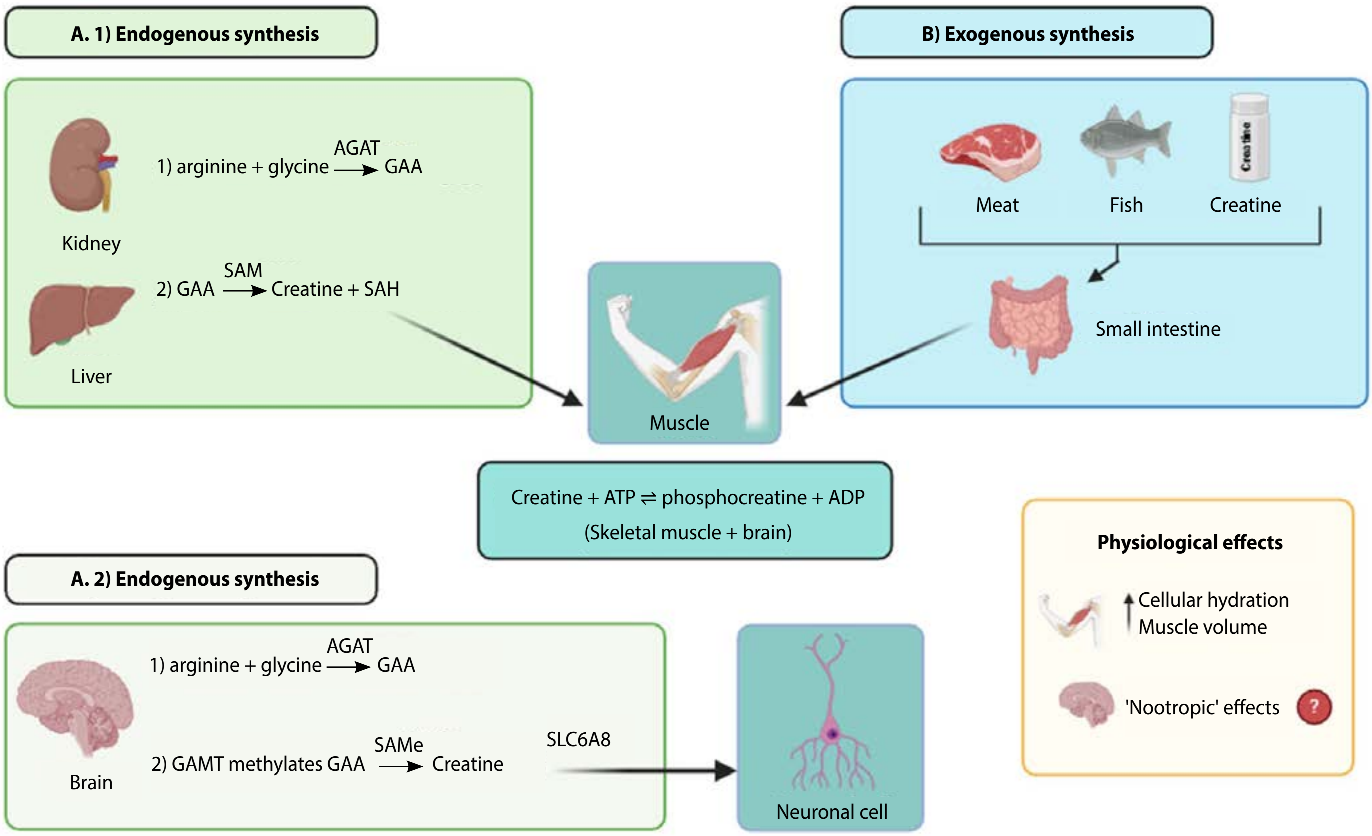

Figure 1: Synthesis and mechanism of action of creatine supplementation in skeletal muscle and the brain with associated physiological effects. Schematic illustration created by the authors based on published descriptions of creatine absorption, synthesis, transport, phosphocreatine buffering, CK shuttle activity, intracellular hydration effects, and anabolic signalling mechanisms.[1-3]

Abbreviations: ATP – adenosine triphosphate, ADP – adenosine diphosphate, GAA – guanidinoacetate, AGAT – arginine:glycine amidinotransferase, SAM – S-adenosylmethionine, SAMe – S-adenosyl-L-methionine, SAH – S-adenosylhomocysteines, Pi – inorganic phosphate, SLC6A8 – Solute Carrier Family 6 Member 8, CK – creatine kinase. Created with BioRender.com.

performance outcomes were inconsistent. Most studies focused on soccer and swimming cohorts, and heterogeneity in dosing protocols, supplementation duration, and outcome measures limited comparability. The authors concluded that, while some performance improvements were observed, definitive conclusions regarding efficacy in adolescents cannot yet be made due to study limitations.

Similarly, Jagim et al.[2] reviewed creatine supplementation in children and adolescents and reported that several studies demonstrate improvements in strength, sprint performance, and high-intensity exercise capacity. Importantly, this review noted limited evidence of ergolytic effects and suggested that creatine's physiological rationale in adolescents is comparable to that observed in adults, given its role in phosphocreatine resynthesis and rapid ATP regeneration. However, the authors also emphasised that the volume of high-quality paediatric and adolescent data remains small relative to adult literature.

More recent literature suggests that performance benefits may be more context specific. A 2024 review by Ortiz-Barroso et al.[24] reported positive effects on muscular function and physical performance in adolescent athletes but highlighted substantial variability in dosing regimens and study design. This heterogeneity complicates the ability to establish standardised recommendations, particularly in younger populations where maturation status may influence responsiveness.

Notably, newer controlled trials provide stronger sport-specific evidence. In a 2024 double-blind, placebo-controlled study in adolescent soccer players (~17 years), Huerta Ojeda et al.[25] demonstrated that low-dose creatine supplementation (0.3 g/kg/day for 14 days) improved muscle power output following acute fatigue compared to placebo. This finding is clinically meaningful, as fatigue resistance and recovery capacity are highly relevant to competitive match conditions.

Extending beyond pure strength outcomes, a 2025 randomised crossover trial in adolescent basketball players (13–14 years) found that acute creatine supplementation enhanced technical performance during cognitively demanding dual-task conditions and reduced internal load.[26] These findings suggest that creatine may influence not only muscular power but also performance during complex motor-cognitive integration tasks, which are central to many team sports.

Collectively, current evidence indicates that creatine supplementation may improve muscular power, repeated sprint ability, fatigue resistance, and potentially sport-specific technical performance in adolescents. However, the literature remains characterised by small sample sizes, protocol heterogeneity, and limited long-term follow-up. While emerging data are promising, adequately powered studies are required before definitive performance claims can be established for adolescent populations.

Effects on cognitive function in adolescents

The term 'nootropics' is commonly used to describe compounds proposed to enhance cognitive function.[27] Creatine has been investigated for its potential 'nootropic' effects, with some studies reporting improvements in specific cognitive domains, including attention, memory, and executive function, whereas others have failed to demonstrate significant cognitive benefit.[27-29] Notably, most of this research has been conducted in the adult population, with comparatively limited data specifically evaluating adolescents.[28,29]

Findings from early controlled trials are conflicting. Some investigations report improvements in tasks involving short-term memory, reasoning, or rapid information processing, while others demonstrate no measurable benefit.[29] Differences in dietary intake may further influence response, particularly among individuals with lower baseline creatine stores, such as vegetarians. For example, Benton et al.[30] observed improvements in short-term memory among vegetarians but not meat-eaters. In contrast, Sandkühler et al.[31] reported only modest effects, with no additional cognitive benefit observed in vegetarians compared with omnivores.

Some evidence suggests that cognitive effects may be more apparent under conditions of physiological stress, such as sleep deprivation or mental fatigue. Gordji-Nejad et al.[32] reported improved cognitive performance following a single high dose of creatine in sleep-deprived individuals, and sleep-deprived rugby players demonstrated improved throwing accuracy after supplementation.[33] However, these findings are not consistently supported, and some reviews conclude that overall evidence for cognitive benefit remains inconclusive.[28]

Evidence specific to adolescents remain limited. In a study examining both brain creatine concentrations and cognitive performance in adolescents, no significant changes were observed in either outcome following supplementation.[34] These findings highlight the difficulty of extrapolating adult data to younger populations.

Overall, the current literature on cognitive effects is derived largely from adult studies and is limited by small sample sizes, short supplementation durations, variable dosing protocols, and heterogeneous cognitive outcome measures. Differences in baseline dietary creatine intake, age ranges, and methodological design further complicate interpretation. Given the paucity of adolescent-specific data and the inconsistency of adult findings, well-designed, adequately powered trials in adolescents are required before definitive conclusions can be drawn. Nonetheless, this remains an emerging and evolving area of research.

Safety considerations

With the increasing use of creatine among adolescents, its safety in this population warrants consideration. Although creatine is well-established as safe and well tolerated in adults across short- and long-term studies,[1,35,36] comparatively limited research has evaluated its safety in adolescents.

A review by Jagim et al.[2] reported no evidence of adverse effects in adolescent athletic populations. However, the included studies were generally small, short in duration, and primarily assessed performance rather than comprehensive clinical safety markers. While short-term use appeared well tolerated, long-term clinical safety remains insufficiently characterised.

Renal safety

Renal safety remains one of the most frequently discussed concerns.[3,5] However, current evidence does not support an association between creatine supplementation and kidney injury in healthy individuals, including adolescents and young adults.[37] Although modest increases in serum creatinine may occur, these do not reflect renal dysfunction.[37,38]

Growth and musculoskeletal development

Concerns have also been raised regarding supplementation during periods of rapid growth and musculoskeletal development.[5,39] As an osmotically active compound, creatine increases intramuscular water content and total body mass, contributing to gains in lean mass and strength.[5] However, the long-term implications during pubertal development and potential effects on musculoskeletal maturation remain insufficiently studied.[40,41]

Hydration and thermoregulation

Related concerns include dehydration and muscle cramping, as creatine's effects on intracellular water distribution have been speculated to impair thermoregulation during intense exercise, extreme heat, or fluid loss.[3] However, adult data do not demonstrate an increased risk of dehydration or heat-related illness at recommended dosages,[42] and similar findings have been reported in adolescent football players.[43] Some evidence further suggests that creatine's osmotic effects may attenuate exercise-induced increases in core body temperature and heart rate, potentially mitigating heat-related risk.[3,42]

Clinical, regulatory and additional health-related concerns

Evidence from younger populations further supports the tolerability of creatine supplementation. In children, creatine has been associated with clinical and functional improvements in conditions including systemic lupus erythematosus and neuromuscular conditions, without adverse effects on laboratory markers such as renal function.[44,45] Improved outcomes following traumatic brain injury have similarly been reported in children and adolescents receiving supplementation.[46]

Table I: Pre-supplementation assessment checklist for creatine use in adolescents

Domain	Key considerations	Reference
Age and supervision	Adolescence defined as 10-19 years (WHO); parental awareness is recommended	2, 5, 8
Indication	Most evidence in high-intensity, repeated effort sports	2, 25
Medical history	Screen for underlying renal disease or relevant risk factors	2, 5
Concurrent medications	Assess use of nephrotoxic medications or agents affecting renal haemodynamics	5
Dietary intake	Vegetarian diets may be associated with lower baseline creatine stores	2
Training load	Structured and consistent training is required to drive benefit	2, 5

Table II: Medicines and supplement combinations requiring caution with creatine supplementation

Category	Examples	Clinical concern	Reference
Nephrotoxic medications	Chronic non-steroidal anti-inflammatory drugs (NSAIDs); aminoglycosides; high-dose antivirals	Potential additive renal stress in individuals with pre-existing risk factors	2, 5
Agents affecting renal perfusion	Angiotensin-converting enzyme (ACE) inhibitors; angiotensin II receptor blockers (ARBs)	Altered renal haemodynamics may complicate renal monitoring in higher-risk individuals	5
Stimulant-containing supplements	High-caffeine pre-workout products; sympathomimetic agents	Increased risk of dehydration and heat-related complications during intense training	2
Excessive protein stacking	High-dose protein supplementation combined with creatine	May affect hydration balance and increase gastrointestinal discomfort	2

Regulatory assessments further support the safety profile of creatine. The United States Food and Drug Administration (FDA) classify creatine as Generally Recognized as Safe (GRAS) for its intended use, reflecting expert consensus that available evidence supports its safety under specified conditions, including in older children and adolescent populations.[1]

Available evidence does not demonstrate a direct association between creatine supplementation and eating disorders, and no adverse effects have been identified in individuals with psychiatric conditions.[47] A recent prospective study reported an association with muscle dysmorphia symptomatology in adolescents and young adults.[48] However, these findings are limited due to reliance on self-reported data and non-probability sampling.

Finally, Simpson et al.[49] observed a trend towards increased markers of airway inflammation and responsiveness in adolescent elite soccer players following creatine supplementation, suggesting a potential adverse effect on airway function. As this finding is limited to a single investigation, further research is required before definitive conclusions can be drawn.

Overall, although adolescent-specific evidence is limited, current data suggest that creatine supplementation is generally safe and well tolerated when used appropriately. Further high-quality, long-term studies are needed to better define its safety profile in this population.

Pharmacist counselling and monitoring considerations

Pharmacists are frequently consulted regarding creatine supplementation and are well positioned to provide evidence-based guidance. In adolescent populations as previously stated 10–19 years), pharmacists play a critical role in structured assessment, appropriate counselling, product selection, monitoring, and referral where necessary.[2,5] Creatine use in this age group should not be casual or unsupervised. Assessment must precede recommendation.[2,5]

Structured assessment framework

Creatine supplementation is most evidence-based in activities requiring short-duration, high-intensity, repeated efforts including sprinting, resistance training, and soccer.[2,25] It has limited relevance in endurance-only sports including triathlon (Ironman) marathon, ultra-marathon, and mountain biking.[2] Moreover, adolescents should be engaged in structured, progressive training before supplementation is considered.[2,5] Table I outlines a practical checklist to guide pharmacists during counselling.

Medication and supplement interaction screening

Although direct pharmacokinetic drug-creatine interactions are uncommon, the potential cumulative renal load should be considered.[2,5] Adolescents with pre-existing renal disease or identifiable risk factors should be referred for medical evaluation prior to initiating supplementation.[5] In addition to Table I, Table II provides a practical cross-reference tool to support screening for medicine and supplement combinations requiring caution with creatine.

Dietary considerations

Baseline dietary creatine intake influences response to supplementation. Individuals consuming low meat or vegetarian diets may have lower intramuscular creatine stores and demonstrate greater responsiveness to supplementation.[2] However, supplementation does not compensate for inadequate caloric or protein intake. Creatine is most beneficial when combined with structured resistance training and adequate nutrition.[2,5]

Counselling messages for adolescents and parents/guardians

Pharmacists should emphasise that creatine supplementation supports an endogenous energy system.[2] Benefits are most evident in short-duration, high-intensity activities.[2,25] Importantly, creatine does not replace training or proper nutritional practices,[5] and it should not be viewed as a rapid cosmetic intervention. Typical dosing strategies include an optional loading phase followed by a maintenance dose of 3–5 g/day to maintain elevated intramuscular stores.[2] Consistency in training and dosing is more important than aggressive supplementation strategies.[2]

Product selection

Creatine monohydrate remains the most extensively studied and evidence-supported form.[2] Pharmacists should recommend single-ingredient creatine monohydrate products that have undergone quality testing to ensure purity and avoid proprietary blends. Gastrointestinal discomfort may occur in some individuals. However, this can be minimised by dividing the daily dose and consuming it with meals.[2]

Monitoring during use and referral

Monitoring of adolescent creatine users should include periodic review of gastrointestinal symptoms, evaluation of dosing adherence and duration of use, and confirmation that supplementation aligns with structured training practices. Reassessment every 3–6 months is advisable in this population.[2,5] Referral should be considered if renal symptoms develop, if inappropriate supplement stacking or excessive stimulant use is identified, or if underlying medical risk factors are present. Referral is also recommended for adolescents with pre-existing renal disease or concerning supplement-use behaviours.

Conclusion

In conclusion, creatine use among adolescents is increasing, particularly among males and in elite or strength-oriented sporting contexts. Current evidence suggests that creatine supplementation may improve muscular power and fatigue resistance and is generally well tolerated when used appropriately. However, evidence supporting its use for cognitive enhancement remains limited. Although adolescent-specific data remain minimal, available studies do not indicate significant safety concerns. Long-term, high-quality, and adequately powered trials are needed to support safety and efficacy in both athletic and non-athletic adolescent populations. Similar requirements are needed for the evaluation of cognitive outcome. Until such data are available, access to accurate, evidence-based information remains essential, with pharmacists playing a central role in counselling, risk assessment, and guiding safe supplementation practices.

Conflict of interest

The authors declare no conflict of interest.

Funding source

No funding was required.

Ethical approval

This article does not contain any studies with human or animal subjects.

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