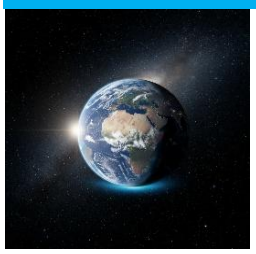
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The Paradox of the Pouch: A Systematic-Narrative Hybrid Review of Snus and Nicotine Pouch Use on Athletic Performance, Prevalence, Health Outcomes, and Regulatory Status in Sport

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Abstract

Background. Oral nicotine products, including traditional snus and tobacco-free nicotine pouches (ONPs), are increasingly common among elite athletes [11, 15, 21]. They bypass the respiratory route via sublabial administration and are rapid and concentrated [5, 20]. Athletes use them as cognitive enhancers and stress and appetite suppressors [18, 30]. Nevertheless, a paradox remains: athletes consume ONPs seeking an ergogenic advantage despite no evidence and substantial health risks [17, 31].

Aim. This review combines current knowledge on the prevalence of ONPs in sports, critically reviews their effects on physical and cognitive performance, and examines associated health, toxicological, and regulatory implications.

Materials and methods. Relevant literature from sports science, toxicology, and public health was reviewed, focusing on health and regulatory impacts of oral nicotine in athletic and general populations [6, 27]. The search used Google Scholar, PubMed, and other databases to evaluate recent developments comprehensively.

Results. Evidence shows nicotine does not enhance physical performance and may impair cardiovascular readiness, anaerobic capacity, and physical endurance [18, 30, 31]. Perceived cognitive improvements stem from relief of nicotine withdrawal symptoms [17, 30]. Furthermore, ONPs risk oral damage, systemic cardiac strain, and addiction [4, 9, 24]. The unclear regulatory status of nicotine in sports, with aggressive marketing that exploits "tobacco-free" legal loopholes, demand updated anti-doping policies [8, 16, 25].

Conclusion. ONPs may serve as a harm-reduction tool for adult smokers [1, 19, 23], spread among nicotine-naïve athletes poses a novel and growing public health threat [7, 27]. Educational interventions, along with more extensive screening by sports governing bodies, are essential for athletes welfare.

Keywords: snus, nicotine pouches, smokeless tobacco, oral nicotine products, athletic performance, oral mucosal changes.

1. Introduction

The use of psychotropic substances in elite sports often balances uncertainty on the fine line between personal recreation, self-medication, and intentional performance enhancement [11]. While global public health initiatives have successfully driven down the rates of combustible cigarette smoking in the general population, the sports world is observing a contrary and alarming trend. Recently, a shift towards the consumption of oral nicotine products, especially classic Swedish snus and its modern synthetic derivatives: tobacco-free nicotine pouches (ONPs) [13, 26]. Nicotine pouches, on the contrary to classic Swedish snus, do not contain raw tobacco leaf or plant matter, they rather contain crystallized or synthetic nicotine, food-grade flavorings, pH adjusters, and plant-based fillers, enabling highly discreet oral absorption [14, 27].

When placed between the gum and the upper lip, the nicotine is rapidly absorbed through the highly vascularized oral mucosa. This pathway allows the substance to bypass the respiratory system entirely and enter directly into the systemic bloodstream [2, 5]. Once it reaches the brain, nicotine acts as a potent central nervous system stimulant. It binds to nicotinic acetylcholine receptors, starting a cascade of neurotransmitter release—most notably dopamine, norepinephrine, and serotonin—which induces immediate sensations of pleasure, sharpens transient focus, and mitigates acute anxiety and stress [11, 30].

Although ONPs are promoted by the tobacco industry as harm-reduction alternatives to combustible cigarettes, their adoption into the athletic lifestyle creates an intricate physiological paradigm [19, 23]. Athletes perform in settings distinguished by extreme physical demands, significant psychological pressure, and strict anti-doping regulations. Throughout history, performance enhancing substances such as anabolic steroids or erythropoietin were used to directly increase physiological output. In contrast, the contemporary athletic environment imposes substantial demands on cognitive functioning, rapid decision-making, and psychological endurance in chronic stress. As a result, substances perceived to provide neuro-enhancement or rapid anxiolytic effects have gained considerable popularity among athletes worldwide [21, 31].

The appeal of smokeless nicotine in sports is multi-dimensional. First, it eliminates the respiratory harms associated with smoking, consequently preserving lung function, which is essential for aerobic capacity and the prevention of musculoskeletal overuse injuries linked to traditional smoking [3, 20]. Second, the discreet design of modern pouches—requiring no spitting, producing no smoke or odor, and remaining concealed under the lip—enables continuous, undetected use during team travel, tactical meetings, and even active gameplay. Third, introducing fruit and mint flavors masked the harshness of nicotine, increasing its tolerability among younger, previously tobacco-naïve individuals [10]. However, widespread use of these products is mostly based on false beliefs about their physiological effects. This review carefully evaluates the "Paradox of the Pouch," in which athletes increasingly use a highly addictive substance with uncertain ergogenic benefits and established systemic health risks, consequently challenging current perspectives on athlete welfare and sports medicine. By studying the relationship between nicotine neurobiology, its physiological effects on the cardiovascular system, and the sociological factors driving its use in sports, this review delivers an extensive synthesis of the current literature.

2. Materials and methods

2.1. Study design

A systematic, narrative review design was adopted to synthesize the available evidence on the use of snus and nicotine pouches in athletic populations. This format was selected due to the substantial heterogeneity of study designs, sample populations, and outcome measures in the existing literature. The data cover multiple disciplines, including sports medicine, public health, behavioral psychology, and cellular toxicology, making strict meta-analytic pooling mathematically unfeasible but conceptually important for a complete understanding of the topic.

2.2. Literature search strategy

To ensure an exhaustive evaluation of both past context and recent developments, comprehensive searches were carried out across Google Scholar, PubMed, Consensus, Scopus, and other specialized academic research databases. The search strategy included scientific articles post-2015 to accurately reflect the modern rise and market dominance of tobacco-free nicotine pouches, although fundamental studies on traditional smokeless tobacco were included when deemed essential for pathophysiological context and historical precision [17, 18]. Article

selection was guided by relevant search terms including: ("snus" OR "nicotine pouches" OR "smokeless tobacco") AND ("athletic performance" OR "elite athletes" OR "sports medicine"), "smokeless tobacco" AND "World Anti-Doping Agency", and "nicotine pouches" AND ("toxicity" OR "oral mucosal changes" OR "cardiovascular risk").

2.3. Inclusion and exclusion criteria

The studies were reviewed and considered for their eligibility if they met at least one of the following criteria: (1) randomized controlled trials examining the acute or chronic effects of nicotine administration on physical or cognitive performance variables; (2) systematic reviews on smokeless tobacco use exclusively within sports or athletic study groups; (3) large-scale observational or epidemiological studies exploring prevalence, demographic trends, and health outcomes in athletes or the young adult general population; and (4) legal or policy studies examining regulatory structures and marketing strategies surrounding ONPs or their derivatives. Studies focused exclusively on combustible tobacco smoking without any comparative reference to smokeless or alternative oral nicotine delivery systems were actively excluded to maintain topic focus.

2.4. Data synthesis

The extracted data were organised narratively due to the variable and heterogeneous nature of the study design. To build a comprehensive and cohesive understanding of the subject addressed, studies were assessed, categorised, and compared across several core dimensions to precisely evaluate their relevance. The core dimensions addressed were: epidemiological prevalence in various sports, physiological and cognitive performance effects (the core of the paradox), localized oral and systemic cardiovascular health outcomes, the more extensive socio-cultural regulatory issues, and the aggressive marketing tactics facing modern sports.

3. Results

3.1. Prevalence and Patterns of Use in Elite Sports

The consumption of smokeless tobacco and ONPs has surged exponentially in elite sports, evolving from a regional, culturally isolated habit in Nordic winter sports to a ubiquitous global

phenomenon across professional team sports [15]. First observations in the early 2000s primarily documented high rates of snus use among Scandinavian ice hockey and ski athletes. However, contemporary data paints a vastly broader picture, indicating deep penetration into global sports like professional football, rugby, baseball, and basketball.

A landmark, extensive analysis of 60,802 in-competition anti-doping urine samples collected across 90 different sports in Italy between 2012 and 2020 revealed an overall nicotine positivity rate of 22.7% [29]. This massive dataset provides one of the most objective measures of nicotine prevalence, bypassing the inherent biases of self-reported surveys. Notably, the data reveal that nicotine use is heavily sport-dependent. Team sports, characterized by intermittent high-intensity efforts and highly social locker-room cultures (such as football, rugby, and ice hockey), show significantly higher positivity rates (31.4%) compared to primarily endurance or individual sports (14.1%) [12, 15, 29].

These data are validated by recent sports-specific latent class analyses. For instance, an extensive cross-sectional survey of 628 male and 51 female professional football players in England found that 18% of male and 22% of female footballers reported current snus or nicotine pouch use, with lifetime prevalence rates rising to 42% and 39%, respectively [22]. The study efficiently categorized users into distinct behavioral classes—occasional, daily, and habitual—highlighting that initiation is heavily driven by peer socialization, boredom during extensive travel, and the immense psychological pressure of elite competition [21, 22].

Demographic analysis across both athletic and general population surveys further indicates that young adult males are disproportionately more likely to be active users compared to their female counterparts, though the gap is closing rapidly with the advent of lifestyle-branded synthetic pouches [13, 26]. The discreet nature of the modern pouch enables continuous, undetected use in highly regulated environments, fostering rapid normalization of the behavior within team subcultures.

3.2. Cognitive vs. Physical Effects: The Ergogenic Illusion

The physiological testing of nicotine yields highly polarized results, forming the crux of the "Paradox of the Pouch." Athletes actively seek an edge, but the empirical data regarding nicotine's ergogenic potential is filled with contradictions.

Neurological and Cognitive Implications:

Experimental neurological data suggest that in strictly nicotine-naïve athletes, the acute administration of snus can act as a potent stimulant. It has been shown to increase cerebral oxygenation in the prefrontal cortex, along with enhancing cortico-motor excitability during submaximal exercise protocols [31]. The rapid influx of nicotine binds to nicotinic acetylcholine receptors, stimulating the release of dopamine, norepinephrine, and serotonin. This neurochemical surge could transiently improve vigilance, selectively sharpen attention, and acutely reduce the perception of pain and fatigue [11, 30]. For an athlete facing a high-pressure penalty kick or a split-second tactical decision, this recognized cognitive sharpening is immensely attractive.

However, neurobiologists and sports researchers heavily caution that these perceived cognitive benefits are dangerously skewed by the user's underlying dependency status [17]. Much of the observed "benefit" documented during complex decision-making tasks under high stress actually occurs in habituated users. In these instances, the athlete is merely reversing the debilitating physiological and psychological impairments of acute nicotine withdrawal [17, 30]. They are not achieving superhuman focus; they are simply medicating themselves back to a baseline state of normality.

Physical Performance Parameters:

When evaluating tangible physical performance measures—such as muscular strength, peak power output, and maximal aerobic endurance (VO2 max)—systematic reviews indicate highly contradictory or entirely non-existent benefits [18]. Among numerous performance variables tested across decades of rigorous, double-blind, crossover studies, the vast majority show no statistically significant ergogenic effect.

In fact, some studies indicate overt ergolytic (impairing) effects, particularly on sustained cardiovascular output and anaerobic threshold maintenance [18]. While acute oral administration of nicotine (e.g., a 5 mg dose) can transiently increase peak anaerobic power output in naïve users, this is entirely driven by a massive sympathomimetic spike [17]. The subsequent spikes in heart rate and circulatory pressure observed post-administration often serve to exhaust the athlete prematurely by increasing the basal metabolic cost of the activity, rather than enhancing sustainable baseline output [9, 17]. Furthermore, clinical field data collected from elite professional football players unequivocally demonstrate that snus intake actually increases the athlete's overall psychological strain, considerably reduces their

perceived physical readiness, and alters their heart rate variability, denoting a state of heightened autonomic nervous system stress rather than an optimal state of athletic readiness [21, 31].

3.3. Cardiovascular and Systemic Health Outcomes

From a strict harm-reduction perspective, avoiding combustible tobacco undeniably protects athletes from carbon monoxide-induced hypoxia, impaired peripheral blood flow, and the subsequent elevated risk relating to musculoskeletal overuse injuries heavily associated with classic smoking [3]. For highly addicted adult smokers, the transition to ONPs significantly decreases exposure to tobacco-specific toxicants and carcinogens, functioning as a legitimate and statistically measurable harm-reduction strategy [1, 23].

However, oral nicotine is far from a benign substance, particularly for the young, otherwise healthy athlete. Nicotine exerts a powerful sympathomimetic effect independently. It artificially increases the resting heart rate, elevates systemic blood pressure via vasoconstriction, and increases myocardial oxygen demand, thereby creating a sustained and unnatural hemodynamic load on the athlete's heart [9, 20]. For an elite athlete whose cardiovascular system is already pushed to its absolute physiological limits during training and competition, the addition of a chronic pharmacological stressor is highly counterproductive.

Long-term epidemiological studies tracking exclusive users of traditional snus have demonstrated a modestly increased, but statistically significant, risk of cardiovascular disease mortality [4]. Furthermore, chronic nicotine exposure alters metabolic pathways, inducing increased insulin resistance and the subsequent onset of type 2 diabetes [4]. There is also continuing debate regarding potentially specific gastrointestinal, esophageal, and pancreatic cancers linked to the swallowed effluent of traditional snus [28]. While modern ONPs remove the tobacco leaf and greatly reduce tobacco-specific nitrosamines (TSNAs), independent toxicological screening has occasionally detected trace carcinogens in synthetic products, challenging their claims of absolute safety [14]. The strong inflammatory response and endothelial dysfunction induced by chronic nicotine exposure remain regardless of the delivery mechanism [9].

3.4. Oral Mucosal Changes and Toxicity

Despite their aggressive marketing as "clean," "white," and "tobacco-free," ONPs pose major and direct risks to localized oral health. Systematic reviews of dental literature and clinical oral examinations reveal that an alarming 70% to 90% of chronic pouch users develop distinct oral mucosal changes [24].

These clinical manifestations present as white, uniform, leathery lesions—diagnosed clinically as smokeless tobacco keratosis—at the exact anatomical site of pouch placement [6, 24]. These lesions are driven by chronic chemical irritation, leading to parakeratosis, intercellular edema, and thickened squamous epithelium. Prolonged placement of pouches against the gums is also strongly associated with localized gingival recession, chronic soreness, mucosal blisters, and severe dry mouth [24].

Furthermore, the pharmacokinetics of ONPs display unique toxicological challenges. Unlike the rapid pulmonary absorption of a cigarette (T{max} approx. 5–8 minutes), the delayed peak plasma concentrations of oral mucosal absorption (T{max} averaging 22–26 minutes) can frequently lead to inadvertent acute toxicity [2, 5]. Users, particularly novices seeking an immediate dopamine rush, may sequentially consume multiple high-strength pouches because they do not feel the immediate "hit." This rapid stacking of doses can result in acute nicotine poisoning, characterized by severe nausea, intense tremors, disorientation, and dangerous spikes in hypertension [6, 7]. Advanced screening approaches, such as Real-Time Cell Analysis (RTCA), have further demonstrated the acute cytotoxic potential of modern oral products, underscoring that varying nicotine strengths and flavor profiles considerably influence baseline toxicity [10].

3.5. Marketing Appeal and Regulatory Issues

The global regulatory setting for smokeless synthetic nicotine is dangerously fragmented and currently unable to handle the explosion of the ONP market. A comprehensive review of 67 countries found massive legislative inconsistencies, with many developed nations leaving ONPs completely unregulated, treating them neither as tobacco products nor as pharmaceuticals [8].

Manufacturers continuously exploit a major semantic and legal loophole by aggressively marketing synthetic pouches as "tobacco-free nicotine" (TFN) [27]. Because the nicotine is synthesized in a laboratory rather than extracted from a tobacco plant, it frequently bypasses legacy tobacco control laws. This distinct terminology effectively reduces perceptions of risk

among youth, young adults, and amateur athletes, thereby increasing product appeal, curiosity, and susceptibility to initiation [16, 27].

Aggressive marketing campaigns heavily infiltrate sports and youth culture. Utilizing "alibi marketing" in major global sports—such as prominent, slightly altered branding on Formula 1 cars in countries with advertising bans—the industry maintains powerful brand associations without strictly violating the letter of the law [25]. Furthermore, harnessing online influencer alliances, event sponsorships (such as music festivals and e-sports tournaments), and lifestyle branding on unregulated social media platforms such as TikTok, the industry successfully targets nicotine-naïve demographics under the deceptive guise of athletic lifestyle branding and wellness [25].

In elite sports governance, the regulatory status of nicotine is equally ambiguous. Nicotine remains conspicuously absent from the World Anti-Doping Agency (WADA) Prohibited List. It has existed solely on the WADA Monitoring Program for over a decade, ostensibly because it does not meet the strict triad of criteria required for an outright ban (increasing performance, posing a health risk, and violating the spirit of sport) to the agency's satisfaction [18, 29]. However, this ongoing lack of definitive regulation creates profound clinical ambiguity. Without a firm regulatory stance from governing bodies, it is exceptionally difficult for medical practitioners to enforce club-wide bans, educate resistant players, or secure institutional funding for in-depth cessation programs [21].

4. Discussion

The comprehensive synthesis of the literature shows that the "Paradox of the Pouch" is deeply entrenched in a misunderstanding of neurobiology, compounded by intense sociological pressures throughout elite sports.

The Withdrawal-Reversal Hypothesis

Athletes consistently self-report using nicotine products as functional tools: to prevent dry mouth during competition, to suppress appetite for strict weight control, and most importantly, to facilitate relaxation or targeted cognitive arousal in high-pressure environments [18, 30]. However, the core argument of this review is that the ergogenic benefits of nicotine are largely an illusion born from addiction.

Regular snus-using athletes report significantly higher levels of satisfaction, calm, and enjoyment from the product compared to occasional users, pointing to a strong addiction and sustaining psychological reward loop [30]. When these athletes enter competition or training, the stress of the environment accelerates nicotine metabolism. As plasma nicotine levels drop, the athlete enters a state of acute withdrawal, characterized by irritability, brain fog, and anxiety. The administration of a nicotine pouch rapidly alleviates these withdrawal symptoms, restoring baseline cognitive function. To the addicted athlete, this restoration feels like an enhancement, supporting the belief that the substance is critical to their performance [17, 30]. The reality, however, is that they have simply medicated a deficit created by the substance itself.

The Physiological Cost of Addiction

The physiological and metabolic cost of maintaining a severe nicotine dependence frequently outweighs any transient, localized neuro-stimulation. The rapid onset of this severe dependence ultimately compromises total athlete welfare. Nicotine acts as a major disruptor of sleep architecture, reducing deep REM sleep and increasing sleep latency [21]. For an elite athlete, where nocturnal recovery is critical for muscle tissue repair and cognitive consolidation, chronic sleep disruption directly undermines physical performance. Furthermore, relying on a potent exogenous stimulant to manage occupational anxiety prevents athletes from developing healthy, endogenous psychological coping mechanisms [11].

Harm Reduction vs. Novel Addiction

The public health dialogue surrounding ONPs is complex. Prominent researchers argue that for heavily addicted, adult combustible tobacco users, ONPs serve as a game-changing harm-reduction tool [19]. By moving away from the tar and carbon monoxide of cigarettes, users significantly lower their risk of severe pulmonary and cardiovascular diseases [1, 23]. In this context, ONPs save lives.

However, applying this harm-reduction logic to the athletic population is fundamentally flawed. The vast majority of athletes initiating ONP use are completely tobacco-naïve [22, 27]. They are not switching to pouches to save their lungs; they are adopting pouches under peer pressure, stress, and aggressive marketing. Therefore, in the athletic context, ONPs do not represent harm reduction; they represent the introduction of a recent, highly addictive neurotoxin to a previously healthy population [7, 27]. The semantic manipulation of "tobacco-free" marketing plays a key role in enabling this initiation, creating a false sense of security [16].

The Role of Sports Governing Bodies

The ongoing hesitation by WADA to actively regulate nicotine use sends a tacit message of approval to athletes and club management [18, 29]. While governing bodies hesitate to ban a substance widely used in the general adult population, the high concentration of nicotine in modern pouches, coupled with intent-to-enhance-performance usage patterns, inherently challenges the spirit of sport. The lack of leadership at the international level leaves club medical staff isolated. Physicians and physiotherapists are forced to manage an epidemic of addiction within their squads without the backing of formal anti-doping regulations, making educational interventions and cessation programs difficult to mandate [21, 22].

5. Future Directions

Different important research gaps should be addressed to further the understanding of this topic and derive a more comprehensive, evidence based policy.

Firstly, there is a glaring need for **Independent Toxicological Data**. A significant portion of current literature on ONPs stems from industry-funded research. Independent, peer-reviewed longitudinal studies are urgently required to assess the true cytotoxicity, biomarker reduction (such as NNAL), and systemic health impacts of tobacco-free pouches [14, 23].

Secondly, future studies must focus **on Methodological Product Differentiation**. Researchers should establish clear methodological distinction between the classic form of snus which contains tobacco and the more synthetic ONPs. Making a clear delineation between the different forms will help in producing a more comprehensive understanding as their pharmacokinetic delivery profiles, carcinogen loads, and health implications differ significantly. Pooling these products under a general "smokeless tobacco" umbrella obfuscates precise toxicological outcomes [5, 10].

Thirdly, there is a significant deficit in research on **female and Youth Athletes**. Current sports-specific literature is overwhelmingly focused on adult male athletes in team sports. Epidemiological tracking of prevalence, motivations, and specific physiological effects in female athletic populations and youth academies remains severely under-researched, leaving these vulnerable demographics unprotected [12, 13, 22].

Finally, future clinical trials should pivot toward evaluating **Holistic Clinical Interventions**. The sports medicine community must move beyond merely documenting prevalence and begin

evaluating the efficacy of interdisciplinary cessation and mental health assistance programs within elite club environments. Education alone is insufficient; clubs must scientifically evaluate protocols that address the underlying sport-specific stressors driving the addiction in the first place [21, 31].

6. Conclusions

The growing, uncontrolled use of snus and modern nicotine pouches in elite sport presents a strong physiological and psychological paradox. Athletes constantly expose themselves to rapid and severe chemical addiction, localized oral mucosal damage, and long-term systemic cardiovascular damage to gain a cognitive edge that is largely an illusion mainly driven by the relief of withdrawal symptoms as opposed to improvements in cognitive functioning.

Addressing this modern paradox requires an approach that is variable. The research gaps highlighted in the future directions should be addressed by the research community, particularly those concerning independent toxicology and female athletic study groups. A transition from the rather passive approach to an active, evidence-based intervention, carried by the combined efforts of both sport scientists and international sporting federations such as WADA should be employed. Nicotine dependence should be reframed not solely as a personal lifestyle choice but as a major athlete welfare issue. Interventions have to prioritize holistic, interdisciplinary psychological support, focusing on underlying stress management and peer-group dynamics, rather than depending solely on repressive anti-doping regulation.

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