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Nonspecific oral immunotherapy with bacterial lysates in the prevention of recurrent urinary tract infections: mechanisms, clinical evidence and implications for physically active adults

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Abstract

Background. Women and older adults and patients with neurogenic lower urinary tract dysfunction experience rUTIs as a common and troublesome condition which causes pain and sleep disturbances and psychological issues and life quality deterioration and multiple antibiotic treatments. The increasing threat of antimicrobial resistance and microbiota disruption has led scientists to explore alternative preventive methods which do not involve antibiotics like OM-89 (Uro-Vaxom®) bacterial lysates.

Aim. The research examines rUTIs pathogenesis and treatment limitations through an analysis of OM-89 oral bacterial lysate immunological effects and clinical data on rUTI prevention in physically active adults and athletes.

Material and methods. The research team conducted a narrative review of published studies through database searches of PubMed Scopus Web of Science and Google Scholar from 1989 to 2025. The search terms used for this review included “bacterial lysate” and “OM-89” and “Uro-Vaxom” and “urinary tract infection” and “recurrent UTI” and “immunotherapy” and “mucosal immunity” and “non-antibiotic prophylaxis” and “athletes” and “physically active adults”. The research evaluated oral and sublingual lysates and Escherichia coli extracts through randomized controlled trials and observational studies and laboratory mechanistic papers and high-quality reviews to determine their ability to stop infections and control immune system

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responses. The research team combined study findings through a narrative approach which spanned from biological mechanisms to medical applications and athletic performance.

Results. Experimental studies show that oral bacterial lysates enhance host defence by activating antigen-presenting cells, increasing secretory IgA and systemic IgG and inducing trained immunity. Clinical trials and real-world studies demonstrate that OM-89 reduces rUTI episodes, prolongs infection-free intervals, lowers antibiotic use and improves quality of life, with a favourable safety profile. Evidence for other urinary bacterial lysates is promising but less robust, and data specific to athletes are still lacking, although reduced recurrence and antibiotic exposure may support training continuity and competition readiness.

Conclusions. The protected non-antibiotic solution OM-89 in oral bacterial lysates serves as a preventive treatment for rUTI because it strengthens host defenses instead of directly eliminating pathogens. The method produces its highest results for physically active adults and athletes because it creates lasting health benefits through decreased antibiotic consumption. The development of sports medicine research must establish quantitative measures for training availability and time-loss illness and performance impact while creating optimal preventive strategies for athletes.

Key words: urinary tract infection, bacterial lysate, OM-89, immunotherapy, non-antibiotic prophylaxis, athletes, physically active adults.

1. Introduction

The clinical condition of recurrent urinary tract infections (rUTIs) affects women and older adults and patients who have neurogenic lower urinary tract dysfunction [1,2,3,4,5]. The occurrence of three or more infections yearly or two within six months results in pain and sleep disturbances and anxiety and social withdrawal and work performance reduction [3,4]. The antibiotic treatment of rUTIs results in multiple hospital visits and additional laboratory tests which drive up healthcare expenses while endangering susceptible patients through potential hospitalization from systemic complications [6,3,7,4].

The treatment of rUTIs has relied on antimicrobial therapy since its introduction as the primary management approach [6,3,7]. The short-term effectiveness of antibiotic treatment creates long-term microbiota changes which lead to drug-resistant bacterial growth and raises the chances of adverse reactions and treatment noncompliance [6,3,7]. The present guidelines allow antibiotic treatment only for proven infections but they advise against standard antibiotic prevention and recommend different non-antibiotic treatment options [3,7]. Bacterial lysate oral immunotherapy has become more appealing as a non-antibiotic solution for preventing respiratory and urinary tract infections because researchers now use host defense-enhancing methods [7,8,9–13].

Bacterial lysates in oral immunotherapy serve as a non-antibiotic treatment method which shows promise for stopping recurrent respiratory and urinary tract infections [14,7,8,15]. The mucosal immune system develops enhanced innate and adaptive defenses through standardized bacterial components in these preparations which lead to increased production of secretory IgA and systemic antibodies [8,9,11–13]. The lyophilized Escherichia coli lysate product OM-89 (Uro-Vaxom®) stands as the most researched product for treating recurrent urinary tract infections [1,2,14,7,4,5].

The condition of recurrent urinary tract infections primarily affects older adults and people at high risk but it also occurs in physically active adults who engage in athletic activities [3,4]. The combination of high-intensity training with travel and dehydration and local mechanical stress makes athletes more vulnerable to developing lower urinary tract symptoms and infections which results in training and competition absences. The use of antibiotics for prevention becomes problematic for this population because there are no established evidence-based preventive measures for physically active individuals who need to avoid antibiotic treatment [6,3,7].

The review article aims to assess bacterial lysate oral immunotherapy as a therapeutic approach for stopping recurrent urinary tract infections. The review begins by describing the pathophysiological mechanisms of rUTIs and their unmet clinical needs before it explains OM-89 mechanisms of action and assesses its safety and effectiveness for physically active adults and athletes. The review establishes critical research domains which require study to create successful preventive measures for physically active adults and athletes.

2. Materials and Methods

Search strategy.

The literature search was performed in PubMed, Scopus, Web of Science and Google Scholar. Searches covered the period from 1989 to 2025. The following keywords and Boolean combinations were used: “bacterial lysate”, “OM-89”, “Uro-Vaxom”, “polyvalent bacterial lysate”, “Escherichia coli extract”, “urinary tract infection”, “recurrent UTI”, “immunotherapy”, “mucosal immunity”, “non-antibiotic prophylaxis”, “athletes”, “physically active adults”. Additional articles were identified through manual screening of reference lists of relevant publications.

Eligibility criteria.

Eligible studies included: (1) randomized controlled trials, cohort studies, case–control studies, laboratory mechanistic papers and high-quality reviews; (2) research assessing oral or sublingual bacterial lysates or E. coli extracts in the context of infection prevention or immune modulation; (3) studies involving adults, adolescents or validated animal models providing mechanistic insight. Exclusion criteria comprised: conference abstracts without full text, case reports unless mechanistically informative, narrative articles lacking data, and papers not available in English.

Data extraction and synthesis.

Information extracted from the included studies comprised type of study, characteristics of participants or experimental model, type and duration of bacterial lysate intervention, comparator, immune parameters assessed, clinical outcomes, recurrence rates of UTIs, and safety findings. Due to heterogeneity in methodology, outcome metrics and formulations of bacterial lysates, a structured narrative synthesis was employed. Findings were grouped into mechanistic domains (innate immunity, mucosal immunity, adaptive immunity), clinical outcomes (frequency of recurrence, antibiotic use), and relevance to physically active adults.

Use of artificial intelligence.

No artificial intelligence tools were used at any stage of this study. All procedures involving search, screening, selection of publications, data extraction, interpretation and manuscript preparation were performed manually by the authors.

Analytical approach.

Because of substantial methodological diversity across the included studies, no formal meta-analysis was conducted. Descriptive comparisons were made, including relative and absolute changes in UTI recurrence, percentage differences in immune parameters, and patterns of clinical effectiveness. Mechanistic data from experimental studies were used to contextualize observed clinical effects.

3. Results

3.1 Pathophysiology and unmet needs in recurrent urinary tract infections

Development of recurrent urinary tract infections results from multiple factors which include uropathogens and urogenital mucosa interactions with host defense systems [3,7,15]. Most UTI episodes result from uropathogenic Escherichia coli (UPEC) bacteria which use their adhesins and fimbriae and virulence factors to bind to uroepithelial cells and move upward through the urinary system [3,7,15,18]. Bacteria penetrate superficial epithelial cells to form intracellular bacterial communities which protect them from being eliminated [3,7,15]. Dormant bacteria remain stored in the bladder wall after symptoms disappear and urine tests show no infection until these bacteria become active to produce new symptoms [3,7,15].

This entire process depends on proper immune system function which operates at both local and systemic levels [3,7,8,9–11,13]. A combination of urine flow and intact epithelial barriers and Toll-like receptor activation and neutrophil recruitment protects healthy people from bacterial growth [3,7]. Immune responses at mucosal surfaces depend on Secretory IgA and other components to remove pathogens and prevent new infections from developing [8,9–11,13]. Defense systems of patients with recurrent UTIs fail to function properly because their

epithelial tissue suffers damage and they experience hormonal changes and develop comorbidities and neurogenic bladder problems and need to use catheters [1,2,3,7,15,5]. Formation of bacterial biofilms on uroepithelial surfaces together with foreign objects establishes protective barriers which block host immune cells and antimicrobial drugs from accessing the bacteria [3,7,15,5].

Current treatment methods for rUTIs focus on killing planktonic bacteria during acute symptoms but they do not completely solve the underlying disease mechanisms [6,3,7,4,5]. Free-floating bacteria in urine require short antibiotic treatment but this method does not eliminate bacteria which hide inside cells or form biofilms [6,3,7,15,5]. Existing rUTI treatment methods that focus on symptomatic care and prevention do not restore mucosal defense functions and bacterial populations recur after antibiotic completion [6,3,7,4,5]. Use of antibiotics for extended periods leads to antibiotic resistance development and microbiota disruption and increases the chances of adverse reactions [6,3,7].

Existing rUTI treatment strategies fail to meet patient needs because they only target bacterial elimination without providing any solution to improve immune system function and mucosal and systemic defense capabilities against future infections [6,3,7,8,4,5,13]. Oral bacterial lysate immunotherapy represents a fresh therapeutic method because it attacks core immune system functions to address the underlying reasons for persistent urinary tract infections [1,2,14,7,8,15,9–11,13].

3.2 Mechanisms of action of oral bacterial lysates

Standardized bacterial lysates used in clinical practice contain inactive bacterial fragments from pathogens that cause respiratory and urinary tract infections [7,8]. Because mechanical or chemical lysis breaks down complete bacterial cells into various components including cell wall structures and membrane pieces and proteins and lipopolysaccharides and nucleic acids, these preparations provide a broad spectrum of antigenic stimuli [8]. After oral or sublingual administration, the body receives these antigens, leading to immune system activation in gut-associated and oropharyngeal lymphoid tissue by dendritic cells and macrophages binding to these antigens [8,9,13]. Activation of T and B lymphocytes depends on major histocompatibility complex (MHC) molecules which process and present bacterial antigens [8,9].

APCs become activated through pathogen-associated molecular patterns in lysates, resulting in increased co-stimulatory molecule expression and cytokine production including interleukins and tumour necrosis factor [8,9,11,12]. Signals generated by APCs stimulate T cells and B cells, leading to the development of effector cells and memory cells and B-cell activation [8,9]. Increased secretory IgA is produced in mucosal tissues along with systemic IgG antibodies which recognize common bacterial antigens [8,9,11,13]. Secretory IgA helps fight pathogens through neutralization, prevents epithelial adhesion and establishes protective immune barriers [11,12]. IgG antibodies contribute to pathogen identification, enabling subsequent destruction through complement activation in body tissues [8,9].

Bacterial lysates also trigger innate immune cells to develop trained immunity responses which perform similar functions to adaptive immune system responses [8,11,13]. Repeated exposures to microbial patterns induce new patterns of gene expression and metabolic function in

monocytes and macrophages and innate lymphoid cells [8,12]. As a result, lysate treatments generate a universal defense response which produces beneficial effects against different infectious agents regardless of their antigen specificity [8,15,13].

Oral bacterial lysates operate based on principles which scientists also study in adaptogens to understand their stress resistance and performance enhancement effects. These interventions function as regulatory network modulators which enable the organism to respond better to external stressors but they do not provide direct antimicrobial or symptomatic relief [7,8]. While bacterial lysates work directly with mucosal and systemic immune systems, adaptogens affect neuroendocrine–stress pathways to create indirect effects on the immune system [7,8]. Both intervention methods illustrate a progression from treating specific pathogens to enhancing host immune function for preventing future infections [7,8]. (Table 1)

3.3 Clinical evidence for OM-89 in prevention of recurrent UTIs

Prospective clinical trials show that OM-89 treatment results in substantial reductions of symptomatic cystitis episodes when compared to pre-treatment periods and control groups in women who have experienced prolonged cystitis [14,4]. Patients in these studies had experienced numerous annual infections despite receiving standard treatment approaches [14,4]. During OM-89 treatment and after its completion, the number of UTIs decreases while patients experience longer infection-free periods and need fewer antibiotic prescriptions [14,4]. Patients who experience occasional infections show better symptom management through dysuria and frequency and urgency improvement [14,4]. Real-world evidence supports the effectiveness of OM-89 because open-label and observational studies show decreased UTI recurrence and antibiotic prescription rates [7,4].

OM-89 delivers clinical value because it enables patients to improve their life quality [4]. People who get UTIs multiple times develop anxiety because their daily activities become limited due to sleep problems and they show symptoms of depression and social withdrawal [3,4]. Research shows that OM-89 prophylaxis treatment leads to better quality-of-life results and improved psychological test performance for several months while decreasing the number of infections [4]. These findings show that immunoprophylaxis treatment produces both physical health benefits and emotional well-being improvements which matter to people who want to continue their daily activities and maintain their work and family responsibilities and physical exercise [7,4].

Scientific literature has not yet provided enough studies about OM-89 treatment for neurogenic lower urinary tract dysfunction but researchers continue to discover new information [1,2,5]. Research studies using spinal cord injury patients and other neurological bladder dysfunction patients have conducted pilot randomized placebo-controlled trials to evaluate treatment safety and infection rate effects [1,2]. Findings demonstrate OM-89 safety for this high-risk group while showing possible UTI rate control or decrease but the studies had small participant numbers and generated conflicting results [1,2]. Upcoming multicenter observational research will study OM-89 as one of multiple non-antibiotic prophylactic treatments for patients who perform intermittent self-catheterization because experts now view immunotherapy as an essential long-term management tool for neurogenic bladder patients [7,5].

Multiple expert groups and regional guideline panels now recognize OM-89 as the most extensively studied non-antibiotic prophylactic treatment for recurrent UTIs [6,3,7]. Expert groups suggest oral E. coli lysate should serve as the primary treatment for women with

uncomplicated recurrent cystitis and for particular high-risk populations who require prophylaxis [6,7]. Evidence for OM-89 faces multiple challenges because different studies use different methods and define outcomes differently while mostly studying female and adult participants [14,7,4]. Recent reviews identify OM-89 as a bacterial lysate immunotherapy agent for respiratory and urinary infections because it demonstrates superior safety features with few side effects [6,7,8].

Scientific basis for OM-89 treatment in athletes and physically active people exists although no specific clinical trials have been conducted on these populations [14,7,8,4]. Occurrence of recurrent UTIs among physically active people creates training disruptions which result in competition absences and force them to take multiple antibiotic courses [6,3,4]. Implementation of OM-89 prophylactic treatment would enable athletes and active adults to protect their health status and training schedule through reduced infection occurrence and severity and lower antibiotic usage [14,6,7,4]. Current lack of research on OM-89 treatment for physically active people requires future studies to establish effective non-antibiotic prevention methods for this population [14,7,8,13].

3.4 Other bacterial lysates, effectiveness and safety profile

As a bacterial lysate preparation, OM-89 serves as the main treatment for preventing future urinary tract infections among patients who experience recurrent infections [3, 4, 6, 7, 14]. StroVac, a vaccine containing inactivated whole-cell suspensions or lysates from multiple uropathogenic strains, is used for intramuscular injections with possible additional booster shots [5]. Sublingual and oral multibacterial vaccines Uromune and similar products use E. coli together with other common uropathogens to provide expanded antigenic protection [7, 8, 13]. Available evidence shows these products help women with recurrent cystitis and high-risk populations experience fewer symptomatic episodes, but the evidence quality is lower than OM-89 studies [5, 7, 14]. Animal model research shows that urinary lysates containing various bacterial strains trigger immune system activation to fight bladder infections [15, 17].

Safety records from all research studies about urinary and respiratory bacterial lysates show positive results [8, 9, 10, 11, 13, 14]. The majority of reported adverse events consist of mild short-term reactions which include gastrointestinal problems and low-grade fever and headache and minor injection site reactions for parenteral vaccines [8, 9, 10, 11, 14]. Severe treatment-related adverse events occur rarely to patients who continue their medication because side effects do not make them stop taking their medication [8, 9, 10, 11, 13, 14]. Immunological tests reveal no signs of autoimmune diseases or immune system problems which would endanger patients during or following this product treatment [9, 11].

In comparison with long-term antibiotic prophylaxis, the safety profile of OM-89 outperforms because it does not have the same risks [3, 6, 7]. Both methods share a common goal to decrease recurrent infections but antibiotic prophylaxis leads to gastrointestinal problems and candidiasis and drug interactions and Clostridioides difficile infections and antibiotic resistance development [3, 6]. OM-89 treatment shows excellent tolerance in patients and it prevents antibiotic resistance and maintains healthy microbiota without causing severe disruptions [4, 6, 7, 8, 14]. Consequently, the combination of OM-89 and other bacterial lysates provides an excellent non-antibiotic prevention approach for patients who want to reduce their antibiotic usage [5, 6, 7, 8, 14].

3.5 Potential implications for physically active adults and athletes

Repeated occurrence of urinary tract infections creates major difficulties for physically active adults who compete in sports [3, 4, 22]. Symptoms of uncomplicated lower UTIs including dysuria and urinary frequency and suprapubic discomfort and fatigue prevent athletes from performing at their best during training sessions and technical or tactical drills [3, 4]. Development of nighttime symptoms disrupts sleep patterns which leads to longer recovery times and decreased athletic performance during intense training sessions [3, 4]. A combination of pelvic discomfort and frequent need to urinate makes it impossible for endurance athletes to complete their training sessions or competitions [3, 4]. Athletes who participate in weight-bearing and contact sports face difficulties because their core activations cause pain and their body experiences impacts during sports activities.

Incidents produce effects which reach further than the boundaries of individual training programs. Medical visits and diagnostic procedures and short antibiotic treatments force athletes to stop their training schedule because they need to visit the doctor [3, 4, 6, 7]. Athletes need to decrease their training intensity and spend multiple days resting after each acute infection occurrence which disrupts their fitness and skill development throughout the season [3, 4]. Elite athletes face career threats when they need to leave competition or training because of symptoms or antibiotic side effects or doping control medication concerns [3, 4, 6].

Effectiveness of non-antibiotic prophylaxis methods stands as the main focus according to this perspective [3, 6, 7]. Athletes who receive OM-89 oral bacterial lysate immunotherapy for UTI prevention develop fewer symptoms and longer periods without infection while requiring fewer antibiotic prescriptions [1, 2, 4, 5, 7, 13, 14]. Reduction of antimicrobial exposure helps athletes avoid gastrointestinal and systemic side effects while maintaining their gut and urogenital microbiota which supports recovery and energy availability and immune function in sports [4, 6, 7, 8, 14]. Athletes who stay healthy can continue their training program without breaks while their coaches follow their periodization plan and check their athletes' readiness for major competitions.

Available research data about sports-specific benefits of this treatment approach is extremely limited. Existing research about OM-89 and other bacterial lysates has focused on studying general adult populations and women with recurrent cystitis and older patients and patients with neurogenic bladder dysfunction [1, 2, 3, 4, 5, 7, 14]. Current literature lacks research that evaluates sports medicine-specific outcomes which include training availability and time-loss injury equivalents and competition participation and performance metrics [7, 8, 13]. Studies have not examined how intense training practices impact energy availability and hydration methods and mucosal immune system responses in athletes who receive immunotherapy [7, 8, 13].

Research evidence about this topic remains scarce which has established a clear knowledge gap. Research studies must track endurance athletes and team athletes throughout an entire sports season to establish if bacterial lysate immunotherapy stops training interruptions and antibiotic use and performance deterioration. Scientists can create evidence-based prevention methods through sports medicine research combined with urology and immunology studies to protect physically active adults and competitive athletes.

4. Discussion

Research studies about oral E. coli lysates and OM-89 have proven their ability to stop urinary tract infection recurrence and they have been shown to be safe for human consumption [1, 2, 4, 6, 7, 14]. Evidence demonstrates that OM-89 taken as a preventive treatment helps people experience fewer annual symptomatic episodes and longer periods without infection, while also reducing the need for antibiotics [1, 2, 4, 7, 14]. This form of prophylaxis provides patients with better symptom control and improved life quality in addition to its microbiological benefits [4, 14]. Current research supports immune system modulation instead of pathogen elimination as its primary mechanism [7, 8]. Bacterial lysates enable the immune system to develop defenses against uropathogens, allowing patients to control their infections without antibiotic treatment [7, 8, 9, 14, 15].

Immunological responses induced by oral lysates follow established scientific knowledge about trained immunity and mucosal immune priming [8, 9, 11, 13, 15, 18]. Standardized bacterial fragments activate antigen-presenting cells, enhance secretory IgA and systemic IgG production, and regulate cytokine networks to reduce urinary tract infection recurrence [8, 9, 11, 13, 15]. These immune effects show similarities to respiratory medicine lysate treatment, yet they operate through direct immune pathway activation [8, 9, 10, 11, 13]. Such a host-centered approach appeals to physically active adults and athletes because it helps maintain health and resistance levels throughout a sports season rather than focusing solely on treating each infection with short antibiotic courses [3, 4, 6, 7].

OM-89 serves as a preventive measure that exists between behavioral treatments and extended medication prevention strategies [3, 6, 7]. Long-term low-dose antibiotic therapy remains the most effective method to prevent recurrent UTIs in high-risk patients, but this approach comes with multiple adverse effects including gastrointestinal problems, candidiasis, drug interactions, Clostridioides difficile infection and antimicrobial resistance development [3, 6, 7, 21]. Evidence regarding cranberry extracts and D-mannose for UTI recurrence prevention remains unclear because most studies used small groups with different characteristics [6, 7]. Restoration of protective microbiota through probiotic use shows promise, although researchers have not established the optimal strains, dosages or administration methods [6, 7]. Prevention of recurrent UTIs begins with behavioral and local methods such as proper hydration, post-coital voiding, spermicide avoidance and genital hygiene practices, but these measures fail to stop rUTI in most cases [3, 6, 7].

Bacterial lysates containing OM-89 function as antibiotic-free prevention methods through standardized treatment protocols that provide better results than most dietary supplements while reducing antibiotic side effects [3, 4, 6, 7, 8, 14]. Current evidence requires more complete evaluation because multiple limitations exist in the available data [4, 5, 7, 8, 14]. Studies investigating OM-89 for UTI prevention vary in their findings because they used different patient groups and treatment protocols and monitored participants for different durations [1, 2, 4, 5, 7, 14]. Research includes mostly female and elderly participants, while many studies have small sample sizes and focus on symptomatic reports instead of microbiological outcomes [1, 2, 3, 4, 5, 7, 14]. Data on patients with neurogenic bladder, catheter users and individuals with multiple comorbidities remains insufficient [1, 2, 5]. The scientific community still lacks enough research to determine which non-antibiotic strategy performs better than OM-89 [5, 6, 7, 8, 14]. Evidence specifically addressing sports-related outcomes is also missing, preventing researchers from evaluating training availability, time-loss illness, competition participation or performance indicators [7, 8, 13, 14]. Because of these limitations, no strong conclusions can be drawn about athletic populations [7, 8, 13, 14].

Further scientific progress requires broader investigation using multiple detection approaches [8, 13, 15, 16]. Future studies must include endurance athletes and team-sport athletes who experience recurring UTIs to determine whether OM-89 and similar lysates reduce time lost to illness, antibiotic consumption and performance disruptions during competitive seasons [1, 2, 7, 8, 13, 14, 15]. Valuable insights would come from linking sports performance indicators with training intensity records, hydration status and mucosal and systemic immune response data [3, 7, 8, 13, 15]. Research also needs to determine which bacterial lysate combinations work best with behavioral treatments, D-mannose, probiotics and antibiotic prophylaxis in patients who require prevention measures [3, 5, 6, 7, 8, 13, 14, 15]. Evaluation of cost-effectiveness together with extended safety monitoring will enable healthcare providers to make better decisions about patient care [5, 7, 8, 13].

Sports medicine practitioners who treat physically active patients need to develop a functional approach to integrate immunotherapy into existing prevention methods [3, 4, 6, 7]. Initial prevention should focus on modifying changeable risk factors and implementing behavioral strategies, accompanied by medical testing to exclude anatomical or functional abnormalities [3, 6, 7]. Standard three-month OM-89 treatment should be considered for individuals with recurrent UTIs despite behavioral measures and for those who experience problems with antibiotic tolerance or resistance [4, 5, 6, 7, 14]. This form of prophylaxis must be explained as an additional measure that does not replace standard acute care or scheduled follow-up examinations [3, 6, 7]. Selecting OM-89 for a given patient requires a collaborative approach that accounts for competition schedules, doping regulations, existing medical conditions and personal preferences [3, 4, 6, 7]. Bacterial lysate immunotherapy is likely to become a key element of comprehensive prevention programs that help athletes train consistently while protecting long-term health [6, 7, 8, 13, 14, 15].

(Table 2)

5. Conclusions

- Oral bacterial lysates, particularly OM-89, represent an effective and safe non-antibiotic strategy for reducing recurrent urinary tract infections by enhancing mucosal and systemic immune responses.

- This prophylactic approach reduces antibiotic consumption and its associated risks, including gastrointestinal side effects, dysbiosis and antimicrobial resistance.

- Physically active adults and athletes may particularly benefit from immunotherapy due to reduced training interruptions and lower reliance on antibiotics, although sport-specific evidence remains limited.

- Further research is needed to evaluate OM-89 in athletic populations, optimize combined prevention strategies and assess long-term safety, cost-effectiveness and performance-related outcomes.

6. Disclosure

The authors declare that they have no relevant financial or non-financial interests to disclose. No part of this work has been published previously, and the manuscript is not under consideration elsewhere.

7. Supplementary Materials

Table 1. Key immunological mechanisms induced by oral bacterial lysates

Mechanism	Description
Antigen delivery to mucosal immune tissue	Bacterial fragments from lysates reach gut-associated and oropharyngeal lymphoid tissue, where they are captured by dendritic cells and macrophages.
Activation of antigen-presenting cells (APCs)	Pathogen-associated molecular patterns stimulate APCs, increasing expression of co-stimulatory molecules and promoting cytokine release (IL-1, IL-6, TNF).
Stimulation of T and B lymphocytes	APCs present processed antigens via MHC molecules, activating T cells and inducing B-cell differentiation into effector and memory cells.
Increase in mucosal secretory IgA	Enhanced sIgA production neutralizes pathogens, limits epithelial adhesion, and strengthens mucosal barrier function.
Increase in systemic IgG antibodies	Production of IgG improves recognition of common bacterial antigens and supports complement-mediated pathogen elimination.
Induction of trained immunity	Repeated stimulation reprograms monocytes, macrophages and innate lymphoid cells, creating long-lasting, enhanced antimicrobial responses independent of antigen specificity.
Modulation of cytokine networks	Lysates support balanced immune activation, promoting protective responses without excessive inflammation.
Conceptual link to adaptogens	Both lysates and adaptogens act as regulatory network modulators: lysates enhance mucosal/systemic immunity, while adaptogens primarily influence neuroendocrine stress pathways with secondary immune benefits.

Notes:
This table summarizes the main immunological pathways activated by oral bacterial lysates, including antigen presentation, mucosal and systemic antibody responses, cytokine modulation, and induction of trained immunity. The described mechanisms contribute to enhanced host defense against recurrent infections.

Table 2. Comparative characteristics of preventive strategies for recurrent urinary tract infections

Strategy	**Evidence for reduction of rUTI**	**Main advantages**	**Key limitations / risks**	**Potential role in physically active adults and athletes**
OM-89 (oral E. coli lysate)	Multiple trials and observational studies show fewer recurrences and reduced antibiotic use in adults with rUTI.	Non-antibiotic, good safety profile, standardised dosing, compatible with long-term use.	Heterogeneous study designs, limited data in men, neurogenic bladder and athletes.	Promising option to reduce illness-related time loss and antibiotics in athletes with established rUTI.
Chronic low-dose antibiotics	Strong evidence for short- to mid-term reduction of recurrences in high-risk patients.	High efficacy while treatment continues, well-known dosing regimens.	Resistance selection, gut and vaginal dysbiosis, adverse events, C. difficile risk, drug interactions.	Reserved for selected cases; generally undesirable for long-term use in athletes due to side effects and resistance concerns.
Cranberry products	Mixed results; some studies show modest benefit, others no significant effect.	Widely available, generally safe, over-the-counter.	Variable formulations and dosing, inconsistent evidence, possible GI intolerance at high doses.	Optional adjunct in low-risk athletes; unlikely to suffice as sole prophylaxis in established rUTI.
D-mannose	Early trials suggest reduced recurrence in some patients with uncomplicated rUTI.	Oral, non-antibiotic, good tolerability.	Limited number of high-quality studies, optimal dose and duration not fully defined.	Reasonable adjunct to behavioural measures; might be combined with immunotherapy in athletes.

Probiotics (oral / vaginal)	Some evidence for benefit, especially with specific vaginal lactobacilli; overall data remain inconsistent.	Potential restoration of protective microbiota, low systemic toxicity.	Strain-specific effects, non-standardised products, uncertain long-term efficacy.	Possible supportive measure, especially in women; should not delay evidence-based prophylaxis.
Behavioural and local measures	Consistently recommended as baseline prevention; modest effect when used alone in established rUTI.	No pharmacological side effects, low cost, broad health benefits (hydration, hygiene, post-coital voiding, topical oestrogen in postmenopausal women).	Often insufficient in patients with frequent recurrences; adherence may be variable.	Foundational for all athletes; should be optimised before and alongside pharmacological or immunological prophylaxis.

Notes:
This table summarises key characteristics of commonly used preventive strategies for recurrent urinary tract infections, highlighting their relative evidence base, benefits, limitations and potential application in physically active adults and athletes. Exact positioning of each intervention in clinical practice should depend on individual risk profiles, patient preferences and evolving evidence.

8. Author Contributions

Conceptualization, KP;
Methodology, KP;
Investigation, KP, MML, BL, MK, BSL, IP, MP, WN, ASV, AK;
Data curation, KP, MML, BL;
Formal analysis, KP;
Validation, KP, MML, BL;
Writing—original draft preparation, KP;
Writing—review and editing, KP, MML, BL, MK, BSL, IP, MP, WN, ASV, AK;
Visualization, KP;
Supervision, KP.

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10. Institutional Review Board Statement

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11. Informed Consent Statement

Not applicable

12. Data Availability Statement

No new data were created or analyzed in this study.

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14. Conflicts of Interest

The authors declare no conflicts of interest related to this work.

15. Declaration of AI

AI was not used in making of this work

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