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BOTULINUM NEUROTOXIN TYPE A IN THE MANAGEMENT OF HYPERHIDROSIS: IMPLICATIONS FOR PHYSICAL PERFORMANCE, COMFORT, AND QUALITY OF LIFE IN ATHLETES – A LITERATURE REVIEW

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ABSTRACT

Background: Hyperhidrosis is defined as a chronic disorder characterized by excessive sweat production beyond physiological requirements for thermoregulation.This condition may significantly impairs patients' quality of life, including individuals engaged in physical activity. Botulinum toxin injections serve as an effective and safe treatment for primary hyperhidrosis by inducing chemodenervation of sweat glands.
Purpose: The aim of this study was to review the current scientific literature on the use ofbotulinum toxin in the treatment of primary hyperhidrosis, to discuss its mechanism of action and role in therapy, and to evaluate its impact onphysical performance, comfort, and quality of life in athletes.
Materials and Methods: A narrative literature review was conducted based on a systematic search of PubMed and Google Scholar databases, including publications from 2015 to 2026 mostly.
Results: The existing literature indicates that botulinum toxin is an effective and safe treatment for severe focal hyperhidrosis. Therapy leads to a significant reduction in sweat production, whichcontributes to an improvement in daily functioning and increased comfort during physical activity.
Conclusions: Botulinum toxin is an effective and minimally invasive treatment for hyperhidrosis, offering significant clinical benefits. However, the effects are only temporary, so repeated treatments are required to maintain the desired results.

KEYWORDS
Primary Hyperhidrosis, Sweat Glands, Botulinum Toxin, Athletes

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Introduction

Botulinum toxin (BoNT) is a neurotoxin produced by the anaerobic bacterium Clostridium botulinum. Structurally, it is a protein complex consisting of two distinct components: a neurotoxic element and additional proteins crucial for its function. Seven types of botulinum neurotoxin are described in the literature, from A to G. However, only types A and B have clinical applications. The primary mechanism of action involves blocking exocytosis at the neuromuscular junction [23]. Local injections of BoNTs have limiteddiffusion, and their effects are reversible.

Currently, botulinum toxin is widely used in aesthetic medicine. However, it also has several other clinical indications in the treatment of medical conditions approved by the FDA. One of the important clinical applications of botulinum neurotoxin is the treatment of primary hyperhidrosis [10,30].

Hyperhidrosis (HH) is a dermatologic disorder characterized by sweating that exceeds what is required to maintain normal body temperature regulation [1-3]. Studies indicate that a significant proportion of the population is affected, with the average age of onset of primary hyperhidrosis being 14-25 years [3,4]. It mostly occurs as primary focal hyperhidrosis, affecting the axillae (underarms), palms, soles, and craniofacial areas [1]. The underlying cause of hyperhidrosis is a malfunction in the sympathetic nervous system, leading to elevated levels of cholinergic stimulation within the eccrine sweat glands [5,6].

The severity of hyperhidrosis can range from mild dampness to severe dripping, which can substantially impair patients' quality of life [14,15]. It has been associated with emotional distress, social anxiety, and reduced self-confidence [14,28]. This includes impairments in professional work and daily functioning, as well as in social relationships and physical well-being, and limitations in physical activities. For physically active individuals, sweating is crucial for thermoregulation during exercise [18,19]. Athletes may experience additional difficulties related to equipment handling, personal comfort, and overall performance [17,19].

Hyperhidrosis remains widely underdiagnosed and undertreated [3]. Although the physiological mechanism of BoNT-A is well-established, the intersection between dermatological treatment and athletic ergonomics is still a niche area of research. The aim of this study was to synthetize clinical evidence and analyze the role of botulinum toxin in the management of hyperhidrosis and to evaluate its impact on physical performance, comfort, and quality of life in athletes.

Results

Hyperhidrosis – definition and mechanisms

The human body has about 4 million sweat glands, of which 75% are eccrine [6]. They are controlled by the sympathetic nervous system via cholinergic fibers, which transmit signals to regulate body temperature during physical activity or emotional stress [6]. Under normal conditions, these fibers release acetylcholine, which binds to muscarinic receptors on the eccrine glands to initiate perspiration. The pathophysiology of hyperhidrosis is characterized by hyperactivity of the sympathetic nervous system, leading to excessive release of acetylcholine and increased sweat production [6,22,31].

In this condition, sweat glands are not histologically different in size, number, or structure compared to those of people without the disorder. However, studies indicate that the sympathetic ganglia in these patients are usually larger than normal [6]. This supports the theory that hyperhidrosis is a disorder characterized by excessive cholinergic stimulation rather than a problem with a primary dysfunction of the eccrine glands [5,31].

Clinical features and diagnosis of hyperhidrosis

Hyperhidrosis tends to occur in areas where there is a higher concentration of eccrine glands, such as the armpits,soles, andpalms [2,26]. The diagnosis is established by clinical evaluation, with quantitative assessment scales for sweat production providing additional information. When localization is unclear, an iodine-starch test can be helpful in identifying the affected areas.

Diagnostic criteria for primary hyperhidrosis [16,26]:

- Frequency: at least one episode per week
- Sweating involves the axillae, palms, soles, and/or face
- Sweating is bilateral and symmetric
- Decreased or no sweating at night

- Sweating episodes occur at least once a week
- Onset before the age of 25
- Positive family history
- Impairment of daily living activities

In clinical practice, the Hyperhidrosis Disease Severity Scale (HDSS) is widely used as a subjective criterion [27]. It is an easy-to-understand, 4-point scale that assesses the severity of primary axillary hyperhidrosis based on its impact on patients' daily activities.

Score	How would you rate the severity of your sweating?	Severity
1	My sweating is never noticeable and never interferes with my daily activities	Mild
2	My sweating is tolerable but sometimes interferes with my daily activities	Moderate
3	My sweating is barely tolerable and frequently interferes with my daily activities	Severe
4	My sweating is intolerable and always interferes with my daily activities	Intolerable

An objective criterion carried out before treatment application is the Minor's test, which is used to visualize the location and extent of the hyperhidrotic area [25,26]. The test involves applying an iodine solution to the skin area being tested, followed by the application of starch powder once it has dried. Sweat causes the mixture to turn dark brown; the affected hyperhidrotic area is then identified [25]. This ensures precise targeting of the injections, minimizing the dose and the risk of diffusion to underlying muscles.

Botulinum Toxin in the treatment of hyperhidrosis

Botulinum toxin type A (BoNT-A) is regarded as one of the most biologically active substances known; however, its controlled clinical application has significantly transformed the management of autonomic and neuromuscular disorders [7-9].

BoNT-A is considered the gold standard in the treatment of primary hyperhidrosis due to its prolonged duration of action and favorable safety profile [10,11,13].

In the management of hyperhidrosis, botulinum toxin is delivered exclusively via intradermal injections [10,25]. This technique ensures that the toxin remains within the superficial layer of the skin, where the eccrine gland bulbs are located. It is critical to maintain this anatomical precision to avoid diffusion into deeper tissues, thereby preventing unintended effects on underlying skeletal muscles. The required injection depth varies depending on the anatomical site. The dermal-subcutaneous junction, for instance, is around 2 mm deep in the axillary region, but extends to 4.5 mm in the plantar region [26].

OnabotulinumtoxinA (Botox®) was approved by the U.S. FDA and EMA for the treatment of severe primary axillary hyperhidrosis in patients who are inadequately responsive to topical therapy [10,16]. However, its use in other body areas, such as the palms, soles, face, and trunk, remains off-label, despite its widespread and successful clinical use.

The BOTOX® solution is then administered in doses of 50-200U, using a 30G needle [13]. The dose is divided into 10-15 aliquots injected at spatial intervals of approximately 2 cm, covering the entire affected area. To minimize patients' discomfort, the procedure is often preceded by local analgesia. In clinical practice, the application of anesthetic cream (EMLA) under occlusion is commonly used. Injections into the armpits are usually well tolerated without anesthesia. In contrast, injections into the soles can be very painful and are consequently most effectively carried out under local anesthesia.

The anhidrotic effect of BoNT-A is usually observed within 7 to 10 days after application and persists for approximately 6 to 10 months [13,33,35]. Overall, botulinum toxin is considered a safe and effective therapeutic option for the management of hyperhidrosis.

Functional and sports-related implications

Clinical evidence suggests that the effects of botulinum toxin therapy extend beyond merely alleviating symptoms [12,30,32]. In addition to reducing sweating, the treatment may improve functional capacity and psychosocial well-being, offering potential benefits in sports, ergonomics, and athletic performance.

In sports that require high levels of precision and manual control, such as tennis, rock climbing, gymnastics, and shooting, palmar hyperhidrosis (PHH) can be a significant limiting factor. Excessive moisture on the palms reduces friction between the skin and equipment, increasing the likelihood of slippage [1]. Consequently, athletes may overcompensate by increasing muscle tension, which can lead to premature fatigue. A common concern among athletes is the potential risk of localized muscle weakness following BoNT-A injections. Available data indicate that, when administered via intradermal injection, BoNT-A does not significantly impair maximum grip strength or overall fine motor skills [33,35], making it a viable intervention for professional competitors. However, rare cases of transient diffusion to the intrinsic muscles of the hand have been reported. This can lead to a temporary, mild impairment of fine motor function, including subtle changes in finger dexterity. Importantly, these effects typically resolve spontaneously within a few weeks without compromising overall motor performance [33,36].

It is also worth noting that hyperhidrosis creates a persistently moist environment, which may impair the skin's natural barrier. Persistent moisture promotes skin maceration, making it more susceptible to friction-related blisters and abrasions [26]. In sports such as marathons, excessive foot sweating (plantar hyperhidrosis) may represent an important factor contributing to withdrawal from competition. Athletes with hyperhidrosis are more prone to developing tinea pedis (athlete's foot) and bacterial infections, such as pitted keratolysis, due to the occlusive and moist environment created by sports footwear [37]. Treatment with botulinum toxin type A may help reduce this risk by maintaining a drier skin environment [10,13].

Psychological factors should also be considered, particularly in athletes exposed to competitive stress. Excessive sweating can lead to a loss of self-confidence and distraction during performance, partly due to the constant need to dry one's hands [14,21,28]. Treatment with botulinum toxin may reduce visible sweating and improve physical comfort, thereby enhancing confidence and reducing stress levels in physically active individuals. Athletes can then focus fully on their performance, rather than worrying about issues related to sweating, such as visible underarm stains, wet clothing, or slippery equipment [12,28].

Area	Problem	Effect of botulinum toxin
Hands	Grip impairment	Improved grip
Feet	Slipping, discomfort	Reduced sweating
Skin	Irritation	Improved condition
Psychological	Stress, anxiety	Improved confidence

Discussion

The findings of this review suggest that primary hyperhidrosis is a neurological condition resulting from an overactive sympathetic response, rather than a purely skin disorder involving abnormal sweat glands [6,22,31]. The results highlight that excessive sweating significantly impacts physical and psychosocial functioning and may affect comfort, daily activities, and quality of life [14,15,28]. It appears that botulinum toxin represents a gold standard therapeutic option, particularly in patients who have not responded to topical antiperspirants [10,13,16].

Clinical data support the use of botulinum toxin in hyperhidrosis management, particularly regarding efficacy and safety [11-13]. Its effects may extend beyond sweat reduction to improvements in daily functioning and overall well-being [12,30].

One of the most significant findings of this study is the effect of hyperhidrosis on athletic performance and ergonomics. In sports that require precision and manual dexterity, reducing palmar moisture is not just a matter of comfort, but also of safety and accuracy [17]. Reduction of sweat may prevent equipment slippage and reduce the risk of premature muscle fatigue [19]. While decreased sweating is associated with increased comfort, which may influence sports performance, direct evidence linking treatment with measurable improvements in athletic outcomes is limited [35].

Despite the promising results of BoNT-A use, this study acknowledges some limitations. Most studies focus on reducing symptoms and improving overall quality of life, rather than on objective measures of

physical performance [12,29]. Another issue is the variability in BoNT-A dosage (50–200 U); further studies should focus on establishing standardized dosing algorithms [16]. It may also be necessary to investigate whether the body eventually can develop neutralizing antibodies to the toxin [9]. Overall, botulinum toxin appears to be a promising therapeutic option, with potential benefits extending beyond symptom control to functional and psychosocial aspects [12,13,32].

Conclusions

1. Botulinum toxin type A (BoNT-A) is a highly effective and safe treatment for primary hyperhidrosis, providing a significant reduction in sweat production for a period of approximately 6 to 10 months.
2. The use of the subjective HDSS scale in conjunction with the objective Minor's test enables precise treatment planning, may maximize the anhidrotic effect, and my minimize the risk of complications, such as muscle weakness.
3. In physically active individuals, BoNT-A treatment may provide additional functional benefits by improving comfort and potentially supporting better performance conditions. It may have a positive effect on grip strength, postural stability, and may reduce the risk of injuries and skin infections.
4. Although the application of BoNT-A on the palms and soles remains an off-label procedure, its excellent safety profile and high patient satisfaction suggest that this method may be considered as a standard therapeutic option for patients in whom topical treatment has proved insufficient.
5. However, current evidence regarding the direct impact of treatment on objective measures of athletic performance remains limited.
6. Further research is needed to better understand the relationship between hyperhidrosis treatment and physical performance outcomes, particularly in athletes.

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Conceptualization: Martyna Bartela
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Writing-review and editing: Marcelina Malinowska
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