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The Development of Pterygium in Military Personnel Under Harsh Climatic Conditions: Issues and Challenges

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Abstract Pterygium (also called "surfer's eye") is considered a common eye surface disease. Its clinical aspects and treatment methods have been studied for many years; however, many uncertainties still exist. The main pathological process in the development of pterygium and the role of heredity remains areas of interest for researchers. Corneal irregularities resulting from the impact of pterygium, as well as the refractive properties of pterygium removal, are increasingly being recognized through numerous studies.

Keywords Pterygium, Harsh climate conditions, Conjunctiva, Fibrovascular, Microtrauma, Glasses

1. Introduction

Pterygium is primarily an eye surface disease characterized by the wing-shaped growth of limbal and conjunctival tissues, spreading onto the adjacent cornea. Due to the disruption of local eye surface homeostasis, the main components of pterygium include proliferative clusters of limbal stem cells, epithelial metaplasia, active fibrovascular tissue, inflammation, and disruption of Bowman's layer in the invasive part of the pterygium apex [24,26].

Since it has not been possible to induce pterygium formation in animal experimental models, pterygium is considered an eye disease that occurs only in humans. Although this eye disease has been known for many years, numerous studies on the pathophysiology and management of pterygium have not yet eliminated the fundamental uncertainties surrounding this common eye surface disease [18,19].

Pterygium is one of the eye diseases characterized by the growth of the conjunctiva towards the pupil. This condition usually manifests as a small, pointed, inflamed tissue on the anterior surface of the eye, gradually worsening vision over time. [1] Pterygium is associated with prolonged exposure to external factors such as sunlight, ultraviolet (UV) radiation, wind, and dust [11].

Epidemiological studies indicate that the prevalence of pterygium is closely related to geographical region, climate conditions, and lifestyle. The high incidence of this disease among people living in tropical and subtropical regions represents a particular risk for those residing in the "sunbelt." [2] For example, a study conducted in Southeast Asia reported a pterygium prevalence rate of 22%, which may be linked to the region's climate conditions and lifestyle [3].

According to the World Health Organization (WHO), pterygium is more frequently observed in individuals living in rural areas and working outdoors. This disease has been identified more in men than in women, which is attributed to their increased exposure to external conditions. For instance, an epidemiological study conducted in Australia reported a pterygium prevalence of 12% among men, whereas it was 7% among women [4].

The prevalence of pterygium increases with age, especially after 40 years. For example, a study conducted in rural China recorded pterygium in 28% of individuals over the age of 50 [5]. Additionally, genetic predisposition and immunological factors play a significant role in the development of this disease. However, environmental factors are identified as the primary cause, making preventive measures highly significant [6].

At present, among the specific risk factors for pterygium, reducing exposure to sunlight and using protective eyewear are recommended as key preventive measures. Socioeconomic conditions may also influence the prevalence of pterygium, as limited access to eye health services and resources leads to an increased incidence of the disease [7,10,15].

Studies conducted among the population suggest that the prevalence rate of pterygium can range from 1% to over 30%. According to a meta-analysis of 20 studies published in 2015, the overall prevalence of pterygium is estimated at approximately 10% [17,22,25]. The highest recorded prevalence of pterygium was found in a study conducted among China's rural population, where the rate was 33% [23,27].

Some of the documented risk factors for pterygium include age, male gender, experience working outdoors, low levels of education, rural residence, low income, darker skin complexion, and smoking. A study conducted in North

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America indicated that the prevalence of pterygium was 2.5 to 3 times higher in Black populations compared to White populations. Although pterygium is widespread globally, it is most found within the 40° latitude around the equator. The prevalence rate in this region is more than ten times higher than in other areas, strongly confirming the role of ultraviolet (UV) rays in the pathogenesis of pterygium.

Risk factors in the development of pterygium.

Pterygium — this is an abnormal "wing-shaped" growth of the conjunctiva growing over the cornea, which can lead to eye irritation, significant cosmetic effects, and in the later stages of the disease, impairment of vision due to damage to corneal tissues [10]. The only existing cure for this disease is surgical removal of the affected area, but unfortunately, pterygium often recurs. So far, there is no effective medical treatment for this disease, but certain medications, moisturizers, vasoconstrictors, and local corticosteroids, are used to control subjective symptoms [16].

The lesion often occurs bilaterally, but with asymmetric development [21]. Even in unilateral cases, pterygium is often associated with the initial degeneration of the conjunctival epithelium on the opposite side, but in this case, the cornea is not affected: this condition is called pinguecula [20]. The prevalence rate of this disease is very variable and, in studies conducted in different regions of the world, can range from 1.1% to 40% [4,5]. General data indicate an inverse correlation of this disease with latitude. Moreover, the prevalence rate increases with age and is higher in men [7].

Knowledge about the pathogenesis of the disease is still incomplete, but data indicate the role of genetic, infectious, immunological, and environmental factors, including prolonged exposure of the ocular surface to solar ultraviolet radiation (UVR) [1,3,6,7,8,9]. This hypothesis is confirmed by the substantial risk of pterygium in populations living in tropical regions [5,6,7,8,9]. According to data from the World Health Organization (WHO), the population-attributable fraction (PAF) of pterygium due to sun exposure is 42–74% [6].

The first report of familial occurrence of pterygium was made by Gutierrez-Pons in 1893, where this disease was identified in five men over three generations. Subsequent studies have recorded a high incidence of pterygium in several consecutive generations in certain families, which indicates the role of hereditary factors contributing to a stronger reaction of the conjunctiva to environmental factors. Various forms of inheritance have been described in these studies, including autosomal dominant inheritance with low penetrance, polygenic, multifactorial, and non-Mendelian types of inheritance. A predisposition to pterygium has been suggested in monozygotic twins, and it has been noted that women are affected to the same extent as men [23].

Hereditary genes and pathways

It are assumed that several familial genes and pathways are involved in the heredity of pterygium. Familial defects in these pathways predispose affected individuals to an abnormal fibrovascular response to UV radiation. The MMP-1 (matrix metalloproteinase-1) gene has been proposed as a candidate gene associated with pterygium heredity. Certain polymorphisms of this gene may predispose carriers to the development of pterygium through the process of loss of heterozygosity [28].

Additionally, polymorphisms of proangiogenic genes are of interest in the field of familial pterygium. Specific polymorphisms of vascular endothelial growth factors (VEGF) are associated with increased vascularity of pterygium and different responses to anti-VEGF agents, and differences in VEGF genes may explain the familial occurrence of the disease [29].

MicroRNAs (miRNAs) are another crucial factor involved in the pathogenesis of pterygium. These small non-coding RNAs indirectly regulate specific protein levels and gene expression. Their presence in eye tissues is associated with antineoplastic (tumour-suppressing) properties. Recent studies have shown that the level of microRNA-145 is negatively associated with extensive and thick pterygium. Furthermore, a decrease in microRNA levels has been detected in recurrent pterygium. Accordingly, microRNAs may attract attention as an important piece of evidence for predicting, therapeutic targeting, and studying the heredity of pterygium [30,31].

Other genes.

Among the other targets of genetic studies in pterygium heredity are differentially expressed genes. These include: FN1, KPNB1, DDB1, NF2, BUB3, PRSS23, MEOX1, ABCA1, KRT6A, SSH1, RBM14, and UPK1B. It is hypothesized that these genes play a key role in the pathogenesis of pterygium and may serve as diagnostic markers or therapeutic targets.

Although numerous studies and candidate genes have been identified, the genetic basis of pterygium remains incompletely understood, and the mode of inheritance requires further in-depth study.

In hot and dry climate conditions, the surface of the eye is constantly exposed to environmental factors. Winds carry dust and other particles to the surface of the eye, which intensifies microtraumas and inflammatory processes on the conjunctiva and corneal surface. As a result of these processes, a hyperplastic growth may develop on the cornea. In addition, populations frequently exposed to sunlight, such as agricultural workers and fishers, fall into the high-risk group for developing pterygium [28].

Literature confirms that the development of pterygium is more widespread in subtropical and tropical regions, where solar radiation intensity is high. Moreover, desert, and semi-desert regions are also considered high-risk areas because, in addition to solar radiation, high winds and dry climate conditions are present.

A deep analysis of multiple risk factors will allow for the identification of many solutions to existing problems, and in addition, studying the impact of risk factors on pathophysiological processes will provide opportunities for developing preventive measures. Due to climate change and the negative impact of the environment, cases of pterygium are increasing, necessitating the improvement of protective measures for the eyes.

Preventive measures for pterygium play a key role in maintaining eye health [4,9,12,13,14]. These measures require a comprehensive approach, including protection from ultraviolet (UV) radiation, adaptation to dusty and dry climatic conditions, as well as ensuring regular eye hygiene. Preventive measures also include promoting a healthy lifestyle, special training for workers in hazardous areas, and implementing eye health monitoring programs.

The prevention of pterygium in military personnel requires a specific approach, as they often operate in extreme climatic conditions. This disease develops due to prolonged exposure to ultraviolet radiation, dust, dry climate conditions, and other environmental factors [1]. These conditions pose a significant risk, especially for military personnel serving in mountainous areas with high radiation levels or in arid deserts.

2. Conclusions

Studies conducted by various researchers have yielded significant results on the origins and prevention methods of pterygium. For example, Chui and colleagues (2015) identified ultraviolet radiation as one of the main factors in the development of pterygium and recommended the use of special glasses for military personnel [32]. Special UV-protective glasses not only protect the eyes from harmful radiation but also reduce exposure to dust and other mechanical influences. Additionally, studies conducted by Agarwal and others (2018) showed that regular use of moisturizing eye drops and adherence to eye hygiene significantly reduce the incidence of this disease [33].

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