



Recommendations of the Spanish Society of Pulmonology and Thoracic Surgery (SEPAR)

Guidelines on Asthma in Extreme Environmental Conditions

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ABSTRACT

Asthma is a highly prevalent chronic disease which, if not properly controlled, can limit the patient's activities and lifestyle. In recent decades, owing to the diffusion of educational materials, the application of clinical guidelines and, most importantly, the availability of effective pharmacological treatment, most patients with asthma are now able to lead normal lives.

Significant social changes have also taken place during the same period, including more widespread pursuit of sporting activities and tourism. As a result of these changes, individuals with asthma can now participate in certain activities that were inconceivable for these patients only a few years ago, including winter sports, underwater activities, air flight, and travel to remote places with unusual environmental conditions (deserts, high mountain environments, and tropical regions). In spite of the publication of several studies on this subject, our understanding of the effects of these situations on patients with asthma is still limited. The Spanish Society of Pulmonology and Thoracic Surgery (SEPAR) has decided to publish these recommendations based on the available evidence and expert opinion in order to provide information on this topic to both doctors and patients and to avert potentially dangerous situations that could endanger the lives of these patients.

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Guía del asma en condiciones ambientales extremas

RESUMEN

El asma es una enfermedad crónica de alta prevalencia que puede condicionar la vida del paciente si no se logra un control adecuado. En las últimas décadas, gracias a la difusión de los programas de educación, la aplicación de las guías clínicas y, fundamentalmente, la aparición de fármacos efectivos, la mayoría de los pacientes logra llevar un régimen de vida normal.

Por otra parte, en estos mismos años se han producido importantes cambios sociales, como la generalización de la práctica deportiva y del turismo. Ambas situaciones permiten al paciente asmático realizar determinadas actividades que hace sólo unos años parecían impensables, como los deportes de invierno, las actividades subacuáticas y los viajes a lugares remotos con condiciones ambientales inusuales (desierto, alta montaña, trópicos o vuelos en avión). A pesar de la publicación de algunos estudios, el conocimiento de las consecuencias de estas situaciones en el paciente con asma es limitado. La Sociedad Española de Neumología y Cirugía Torácica (SEPAR) ha decidido publicar estas Recomendaciones, basadas en la información disponible y/o en consejos de expertos, en un intento de facilitar la información a médicos y pacientes, con el fin de evitar situaciones peligrosas que puedan poner en peligro la vida de los pacientes.

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Introduction

Asthma attacks disrupt and alter the lives of asthmatic patients' and those who live with them. The intensity of such attacks is a measure of the severity of the patient's condition and determines the treatment approach and management of the disease. In recent decades, asthma control has improved thanks to advances in the diagnosis, management, and treatment of this disease. At the same time, the closing decades of the 20th century witnessed far-reaching social changes that included the more widespread pursuit of sporting activities and tourism. Today, as a result of these changes, patients with asthma may travel—whether for business or pleasure—to parts of the world with extreme environmental conditions, such as deserts or mountains, and may even participate in underwater activities and other challenging sports. In view of the general interest in the prevention and management of asthma, the Spanish Society of Pulmonology and Thoracic Surgery (SEPAR) considered it to be a timely moment to focus on these new circumstances, which could give rise to very difficult and dangerous situations.

The present recommendations provide basic information about our current understanding of asthma and the rationale behind the management and monitoring of this condition taking into account situations that could arise in unlikely and inhospitable places or unusual circumstances. The specific objectives were as follows: to raise awareness among patients and those around them concerning the importance of controlling asthma; to identify situations of risk for asthmatic patients exposed to extreme conditions; to discuss the prevention and treatment of asthma symptoms in unusual situations; to propose resources for preventing and treating an attack in extreme environments; and to reduce the morbidity and mortality associated with this disease. To achieve these aims, the guidelines address the problems associated with the management and prevention of asthma during intense exercise and in extreme conditions or polluted, hypoxic, or hyperbaric environments and places with extreme temperatures or humidity. We have classified these environments according to the place where the professional or leisure activity takes place. The case of exercise undertaken by elite athletes is dealt with in a section apart, and the other sections are as follows:

- Hypoxic/hypobaric environments: high altitudes, powered and unpowered flight.
- Cold dry environments: winter sports and mountain sports.
- Hot dry environments: deserts.
- Warm humid environments: tropical regions.
- Highly polluted environments: large cities, public places, areas affected by natural disasters.
- Hyperbaric environments: underwater activities.

Physical Exercise

As a result of the increases in minute ventilation and mouth breathing that occur during exercise, various kinds of contaminants in the air inhaled may penetrate the most distal regions of the bronchial tree. It is clear that this phenomenon has an effect on asthmatic patients and athletes who have a heightened bronchoconstrictor response (hyperreactivity). Cross-sectional studies have shown that the prevalence of asthma, exercise-induced asthma, and bronchial hyperresponsiveness is high among competitive athletes.¹ A number of different mechanisms are responsible for this phenomenon: the inhalation of cold and/or dry air, pneumoallergens, or airborne contaminants, a higher prevalence of infections caused by respiratory viruses; and the increase in parasympathetic tone.²⁻⁵

Exercise-induced asthma should be suspected in the presence of coughing, dyspnea, or chest tightness during exercise in patients

with a medical history of asthma, atopy, or rhinitis, and individuals who have been diagnosed with bronchial hyperresponsiveness. The symptoms of exercise-induced asthma usually peak 5 to 15 minutes after exercise, and in some cases there is a refractory period during which symptoms either disappear or diminish substantially; these attacks resolve spontaneously after 20 minutes, but some patients (30%-60%) experience a delayed bronchoconstriction between 4 and 12 hours after exercise.³ The preferred diagnostic method is an exercise challenge despite the low specificity of this test, which has an index of reproducibility of only 10%-20%.⁴ A differential diagnosis should be developed based on other conditions with diverse etiologies that can cause dyspnea (cardiac, metabolic, hematological, and otorhinolaryngological diseases).

In most cases, exercise-induced asthma can be prevented by administering either β_2 -agonists or cromones.⁶ In patients with more severe asthma, administration of both drugs a few minutes before starting exercise will prevent an attack in approximately 90% of cases, and ipratropium bromide can be added to the prescription for those who do not respond to this combination.⁵ Other measures that can be used to prevent exercise-induced asthma attacks are exercising for short periods at a time, doing a good warm-up routine, avoiding cold or dry air, and avoiding sporting activities during exacerbations.⁷ Drugs that control asthma by modulating inflammation, such as corticosteroids and antileukotrienes, raise the onset threshold of exercise-induced asthma attacks and allow the patient to exercise with greater safety (Table 1).^{6,8}

High Performance Athletes

Elite athletes who have heightened hyperreactivity, whether or not they have been diagnosed with asthma, may have to train or compete in some of the extreme environments described in these guidelines. The stimulus by which hyperpnea triggers an asthma attack is dehydration of the periciliary fluid in the airways, which triggers an increase in the osmolarity of this fluid.⁹ In this respect, the dryness of the air is a more important factor than the low temperature.¹⁰ While this effect is obvious in asthmatic patients, it appears that in elite athletes it is complemented by an additional factor, the increase in vagal tone, which causes gradual onset of minor bronchoconstriction.¹¹ In cold environments, bronchoconstriction reaches a peak after the individual has stopped exercising,¹² making a gradual cooling down period advisable to allow the temperature of the airway lumen to return to normal.¹³

Athletes with asthma require a permit (Authorization for Therapeutic Use) if they are to use aerosol medication without fear of being sanctioned for doping. This authorization specifies the athlete's current clinical situation, the results of a bronchial challenge test, and the current treatment regimen. Further information regarding this certificate can be found on the web

Table 1
Prevention and Treatment of Exercise-Induced Asthma

Control and treat baseline asthma
Avoid physical exercise when asthma is not controlled
Avoid physical exercise in environmental conditions that could trigger an attack (pollution, contamination, cold air, etc) and cannot be modified or controlled
Use preventative medication (bronchodilator and/or cromones)
Do a long intense warm-up session before exercising (>15 min)
If possible:
Exercise in a warm and humid environment
Choose sports and games in which effort is not continuous (team sports)
Choose sports in which effort is submaximal and not highly sustained
After strenuous exercise in cold environments, decrease exercise intensity gradually
Asthmatic athletes should be treated as patients likely to be exposed to situations that could trigger an attack
Therapeutic Use Exemption certificates should be updated regularly for athletes who need such certification

Table 2.
Positive Cut-off Values for the Bronchial Challenge Tests Used to Assess Asthmatic Athletes Who Apply for a Therapeutic Use Exemption for Prohibited Substances

Test	Spain/International	Variation in FEV ₁ With Respect to Reference Value	Comment
Bronchodilator	Sp/Int	>12%	Salbutamol or terbutaline
Exercise	Sp/Int	>10%	With or without cold dry air
IHV	Sp/Int	>10%	
Saline solution	Sp/Int	>10%	
Mannitol	Sp/Int	PD ₁₅ FEV ₁ <635 mg	
Methacholine	Sp	PD ₂₀ FEV ₁ <8 mg/mL	
	Int	PD ₂₀ FEV ₁ <2 mg/mL	In patients who have not been treated with corticosteroids
	Int	PD ₂₀ FEV ₁ <13.2 mg/mL	In patients who have been treated with corticosteroids

Abbreviations: FEV₁, forced expiratory volume in the first second; IHV, isocapnic hyperventilation; Int: cutoff values specified by the international standard, 2008-2009 season; Sp: cut-off values used in Spain, 2008-2009 season; PD_xFEV₁, bronchoconstrictor dose causing a reduction in baseline FEV₁ of *x*%.

pages of the World Anti-doping Agency,¹⁴ the Consejo Superior de Deportes (the Spanish National Sports Council),¹⁵ and the different sports federations. The authorization must be submitted to the appropriate federation, which will then authorize or prohibit the use of the indicated medication for 1 year. To obtain an Authorization for Therapeutic Use, athletes must have a positive result on a bronchial responsiveness test using the criteria shown in Table 2.

Mountain Environments

A wide range of sporting activities are practiced in the mountains. While most people enjoy mountain walks of varying difficulties (hiking), there are many other mountain sports, such as rock climbing, mountain climbing, mountain biking, canyoning, trail running, caving, and paragliding. Expeditions or trekking in remote mountain ranges may also involve exercise at high altitudes in areas where medical care and rescue services are less available or more rudimentary.

Winter sports are not always practiced at high altitudes. All types of skiing, snow boarding, snow shoeing, and ice climbing are practiced at many different altitudes. In all of these sports, the ambient temperature drops by about 1°C for each 150 meters of altitude gained. This means that the air gradually becomes colder and drier and the hyperventilation associated with exercise is exacerbated by the effect of hypobaric hypoxia as well as the inhalation of cold dry air, favoring the onset of exercise-induced bronchospasm.

Cold and hypoxia can cause nasal congestion.¹⁶ This reaction can occur in healthy individuals with no history of rhinitis or asthma, but is more marked in patients with a history of these conditions. The resultant congestion has a negative impact on the correct humidification, filtering, and warming of inhaled air, which in turn favors the development of respiratory infections that increase inflammation and bronchial hyperresponsiveness.

Medical advice for these patients about what they should do in a mountain environment will depend on the altitude, the patient's physical condition, the terrain, and the proximity of appropriate medical assistance. While no consensus exists, it is reasonable to suppose that uncontrolled asthma is a relative contraindication for spending time on mountains at altitudes over 3000 meters. A case-by-case assessment is needed that takes into account not only the overall control of the disease, but also the patient's physical and psychological state, the level of activity planned, and the objectives of the sporting activity.¹⁷

Moderately High Altitudes

Altitudes under 2500 meters do not provoke any significant changes in the lung function of healthy individuals.¹⁸ Traditionally, physicians have recommended that patients allergic to mites should spend time at moderately high altitudes (between 1000 and 3000 m)¹⁹ because mites cannot survive above 1500 m.²⁰ Clinical

improvement is accompanied by a decrease in bronchial hyperresponsiveness,²¹ allergen specific immunoglobulin E,²² and inflammatory parameters.²³ Moreover, the drug doses required to control the disease are lower.²⁴

There are other benefits associated with mountain environments, such as lower levels of pollutants and allergens because of a reduction in airborne fungi levels and a shorter pollen season. The beneficial effects of altitude have also been observed in nonallergic asthmatic patients and have been linked to a possible immunomodulatory or hormonal effect in these patients.^{25,26} In general, sporting activities in the mountains are not only safe for asthmatic patients, but also recommendable.

High Altitudes

Asthma triggered by cold or exercise is a relative contraindication for spending time at high altitudes. The advisability of such stays should be evaluated on a case-by-case basis taking into account the physical and psychological state of the patient, the planned activity, and the altitude of the destination.²⁰ Above 3000 meters, some individuals may experience acute mountain sickness. The incidence of this syndrome depends on the speed of ascent, altitude reached, and the susceptibility of the individual. The symptoms, which include cough and dyspnea, may erroneously be attributed to poorly controlled asthma. The presence of other symptoms should raise suspicion of a diagnosis of acute mountain sickness.

It has been postulated that patients with poorly controlled asthma are more susceptible to acute mountain sickness, but no scientific evidence has been adduced to support this hypothesis.²⁶ As with nonasthmatic individuals, prophylactic treatment with 250 mg/8-12 h of acetazolamide at least 2 days before and after exposure to altitude prevents episodes of acute mountain sickness and improves oxygen saturation in patients with asthma.²⁵ Mountaineers who ascend to altitudes above 4500 to 5000 m should have considerable experience and knowledge of mountaineering, the mountain environment, and their own limitations.

Differential Diagnosis

Cough and dyspnea are symptoms of asthma, but their presence does not always indicate asthma. Since diagnostic means may be limited, the differential diagnosis can be complicated. Coughing can develop in healthy individuals with progressively greater frequency as altitude increases. Some 60% of mountain climbers who do not cough at sea level, do so at altitudes near 7000 m.²⁷ One factor that has been cited as a possible cause of this phenomenon is hyperventilation with cold and dry air at high altitude; other factors cited include hypoxia, which would act through central mechanisms,²⁸ and the presence of subclinical pulmonary edema. Upper and lower airway infections are also possible causes of coughing and are more common in these conditions because of the inhalation of cold dry air, which is not adequately conditioned by the

upper airway to produce the temperature and humidity conditions ideal for gas exchange.

In patients with concurrent dyspnea or chest tightness, the possibility of acute mountain sickness or pulmonary edema should be considered. The diagnosis of altitude sickness is clinical, and there are generally other concurrent symptoms, including headache, insomnia, anorexia, nausea, general malaise, instability, vertigo, and reduced diuresis.²⁷

At extremely high altitudes the risk of thromboembolism is higher because of increases in platelet count and various procoagulant factors, the inhibition of fibrinolysis, slower circulation secondary to polycythemia, and occasionally inactivity or tight clothing.^{29,30} The differential diagnostic process involving other entities, such as pneumothorax, pneumonia, and acute coronary syndrome, is generally easier because of the presence of precipitating factors, a pertinent medical history, indicative findings on physical examination, and symptoms not found in patients with asthma.

Patient Monitoring

Lung function should be tested using a spirometer or peak flow meter. All measurements must be corrected for altitude. The most accurate measurements are those taken with fixed orifice turbine devices because open systems and devices with a variable orifice underestimate flow values and closed spirometers overestimate flow values because of the lower density of air at altitude.³¹⁻³⁴ The presence of acute mountain sickness and/or pulmonary edema also give rise to reductions in forced expiratory volume in 1 second, forced vital capacity, and peak expiratory flow values.

Measurement of oxygen saturation at base camp using pulse oximetry is useful to monitor possible cardiopulmonary disease, but peripheral vasoconstriction must be avoided because it gives rise to erroneous measurements. Altitude-corrected normal values should be taken into account (hypobaric hypoxia).

General Rules That Should Be Observed in Mountain Environments (Table 3)

All those who expose themselves to an adverse environment must be properly prepared and have adequate resources and equipment.

A first aid kit should always be carried during prolonged stays at high altitude and in areas where medical assistance is not easily accessible. In addition to the drugs recommended in the pertinent

Table 3

General Guidance for Asthmatic Patients Undertaking Mountain Sports
Consult a Specialist With the Schedule for the Planned Activity

<p>Asthma must be controlled before the patient takes part in these activities</p> <p>Always carry medication and know how to use it</p> <p>Comorbid conditions that could affect asthma control (rhinitis, respiratory tract infections, etc) must be treated and controlled</p> <p>Appropriate preparation, resources, and equipment are essential</p> <p>The nose and mouth should always be protected from low temperatures with a special mask or balaclava</p> <p>A basic emergency first-aid kit must be carried</p> <p>Proper diet</p> <p>Drink at least 4-5 L of water</p> <p>Companions must be informed about medical condition</p> <p>For patients taking part in a trekking expedition or traveling to remote places at altitudes greater than 4000 m:</p> <p>Medical examination to confirm that asthma is well controlled</p> <p>Plan and carry out proper acclimatization</p> <p>Treat acute mountain sickness immediately upon experiencing even minor symptoms</p> <p>Carry a portable supply of oxygen</p> <p>Include a portable turbine spirometer and a pulse oximeter in the first-aid kit</p> <p>Test results should be corrected for altitude</p>

guidelines, this kit should include antiasthma medication including bronchodilators, anti-inflammatory drugs (inhaled corticosteroids, antileukotrienes), parenteral corticosteroids, adrenaline in the form of 1:1000 solution in prefilled syringes, and antihistamine drugs.

Mountaineers must be careful to consume adequate food and liquids. The baseline daily energy intake of 1600-2000 kcal should be supplemented by an additional 350 kcal for each hour of exercise. Fluid intake should be 4-5 L of water or isotonic liquids because water balance is always negative in the mountains. Drinking small amounts of fluid frequently is the best method, and very cold liquids should be avoided as these tend to facilitate the acquisition of oropharyngeal infections. The best way to check hydration is to monitor urine: fluids should be taken until urine is almost transparent. Energy drinks may be consumed. However, since tea, coffee, and chocolate drinks are diuretics these beverages should be excluded from the calculation of the quantity of liquid consumed.

Pharmacotherapy for Asthma and Other Disorders Presenting in the Mountain Environment

Asthma. Dry powder inhalers are the preferred method of delivery for asthma medication because very little information is available about the effect of altitude on pressurized aerosols. At low temperatures, pressurized inhalers emit smaller particles, producing a lower dose per actuation, less output pressure, and a lower respirable mass.³² Inhalers should be carried in a place protected from the ambient temperature and close to the body if possible, or else they should be warmed before use. Although all β_2 -agonists probably have the same prophylactic effect against the onset of altitude-induced pulmonary edema at high altitudes, this effect has only been confirmed in clinical studies for salmeterol.³³

Inflammatory diseases of diverse origin (osteoarticular, rhinosinus, etc). Patients unable to tolerate nonsteroidal anti-inflammatory drugs and those who do not know whether they can tolerate these agents should not take cyclooxygenase-1 inhibitors.

Headache. While headache is a common symptom of acute mountain sickness, the drugs most often used to treat this symptom (aspirin and ibuprofen) should not be taken. The recommended alternative is paracetamol, although it should be noted that 20% of asthmatic patients who cannot take nonsteroidal anti-inflammatory drugs experience adverse reactions to paracetamol, although these are generally mild. While tramadol can serve as an alternative treatment for headache, there is no experience with such use at high altitudes. Opiates are not advisable except when a very powerful analgesic is required because they depress the respiratory system. However, the best treatment for headache is prophylaxis and treatment of the acute mountain sickness. Treatment of this syndrome is based on avoiding heavy meals, drinking abundant fluids, gradual acclimatization, and avoiding, as much as possible, transport directly to altitudes above 2750 m. When it is impossible to avoid transport to a high altitude, exertion should be limited during the first few days after arrival. At altitudes above 3000 meters, climbers should not increase sleeping elevation more than 300-500 m on 2 consecutive nights. In patients with asthma, the administration of acetazolamide at a dose of 250 mg/8 h for 2 days prior to and at least 2 days following stays at high altitudes will prevent episodes of acute mountain sickness and improve oxygen saturation. Lower doses (125-250 mg/12 h) can be effective, as has been shown in individuals without asthma. The medication should be taken in the morning and afternoon to prevent nocturnal diuresis. The recommended alternative treatment for patients allergic to sulfonamides who cannot tolerate acetazolamide is dexamethasone (8 mg/d in 2 or 4 daily doses). The drawback of this alternative regimen is that while dexamethasone alleviates the

symptoms it does not favor acclimatization. If clinical symptoms do not improve following treatment with acetazolamide and paracetamol, the climber should descend at least 500 meters. A hyperbaric chamber should be used if available, otherwise supplemental oxygen treatment should be started (2-4 L/min) using nasal cannula or a mask, and dexamethasone should be added to the acetazolamide regimen. If improvement is noted, oxygen flow can be reduced to 1-2 L/min. In some Andean countries, infusions of coca leaves are traditionally used to treat the symptoms of mountain sickness. There is no scientific evidence concerning the efficacy of this remedy, but it is the most widely used and accepted method of prevention and treatment in countries such as Bolivia and Peru.

Hypertension. Mountain climbers receiving treatment with β -blockers should discontinue this medication because it favors the onset of bronchial obstruction and acute mountain sickness. Diuretics such as acetazolamide and calcium channel blockers can be used instead. Moreover, both of these treatments also protect against the development of pulmonary edema.

Pyrosis. Hyperacidity is a common problem at high altitudes. Patients with a clinical history of acid reflux and asthma should start treatment with H_2 antagonists or proton pump inhibitors.

Cough. In the presence of a persistent cough that does not respond to β_2 -agonists, codeine should be added to the regimen and a balaclava or face mask should be used for protection.

Respiratory infection. Respiratory infections should be treated according to the guidelines that apply at normal altitudes. Antibiotics should be used with caution since they may disrupt the intestinal flora and cause diarrhea, a more common condition in this environment due to the consumption of contaminated food or water.

Insomnia. Insomnia is common at high altitudes because of the effect of hypoxia on the central regulation of sleep and respiration. Although some mountain climbers favor the use of tranquilizers and sedatives to aid sleep, there are risks associated with the use of these drugs in a mountain environment for a number of reasons (the increase in the number and duration of central apneas during sleep, reduction in central respiratory impulses, and overlap with the symptoms of incipient cerebral edema among others). At altitudes below 5000 meters, persistent insomnia causing substantial weakness can be treated with zolpidem 10 mg/d because this drug does not depress ventilation.³⁴

Contraceptives. While there is no definitive evidence on this topic, many authors favor the discontinuation of contraceptive medication during any stay over 4000 meters for longer than 3 weeks because of the increased risk of thrombosis.²⁰

Winter Sports

Exercising in a cold environment triggers an increase in the neutrophil and macrophage populations in the bronchoalveolar lavage of healthy individuals, and asthma-like symptoms in athletes (for example, Nordic ski asthma) although no increase in proinflammatory mediator release³⁵ or bronchial hyperresponsiveness³⁶ has been demonstrated. In most asthmatic patients, however, inhalation of cold dry air stimulates a series of biochemical events in the airway epithelium that triggers a cascade of reactions that tend to increase inflammation, bronchial hyperresponsiveness, and bronchoconstriction.³⁷

The principal factors that influence this phenomenon are temperature, humidity, and the type of exercise.¹⁷ The prevalence of asthma symptoms in the United States Olympic team at the Nagano Olympics was 22%. The result of an exercise challenge test was positive in 23%, and over 18% of the athletes were taking or had taken asthma medication. The prevalence of asthma was considerably higher among speed skaters (<1000 m) and athletes

competing in the cross-country and Nordic combined events than among those competing in downhill skiing, skating (>1000 m), snow boarding events, curling, bobsleigh, ski jumping, luge, and biathlon. The air inside ice rinks and ice sports arenas is rich in ozone and ON_2 , a composition that favors bronchospasm in the athletes who take part in skating and ice hockey events.³⁸ Inhalation of pollen allergens when practicing a sport outdoors can also be a precipitating factor for asthma in sensitive individuals during the pollen season.

No data are available on the effect of these activities in a normal population of asthmatic patients who practice these sports sporadically or during vacations, although the available clinical data would appear to indicate that the effects are of only slight clinical relevance. However, this may be due to the fact that these patients understand and correctly treat their condition and/or avoid or moderate the level of exercise they undertake to minimize their symptoms (Table 4).

Special Natural Environments

Dry Heat: Deserts

Unlike cold air, hot air per se does not appear to provoke asthma attacks.³⁹ Rather, the level of humidity of this hot air or the ambient conditions in terms of pollutants or components may provoke an acute attack or exacerbate asthma.⁴⁰ The archetypal hot dry environment is the desert, which is defined as a region that receives very little precipitation and where water loss through evaporation and transpiration can be even greater than water gain. This makes the desert an extremely dry environment that has a significant effect on both general hydration status and mucous membrane hydration. In asthmatic patients, these effects can provoke an asthma attack.⁴¹ Although the chief characteristic of the desert is its aridity, life abounds in many of the world's desert regions. Desert vegetation adapts to the low level of humidity, and the animals generally remain hidden during daylight hours to conserve moisture. The presence of life in the desert means that at certain times of the year these regions are affected by airborne spores and pollen, which may be either blown in from surrounding areas or produced by the native flora, for example in steppe environments. Patients traveling to steppe areas, whether for work or pleasure, should be aware that these areas are dominated by grasslands and, unlike more classic desert environments, are neither particularly hot or arid, but rather have a cold dry climate.

Winds and sandstorms can cause an asthma attack,⁴² either directly through the mechanical effect of the grains of sand, or because of the difficulty of breathing and humidifying inhaled air

Table 4

Recommendations That Should Be Followed by Patients With Asthma Who Practice Winter Sports

Asthma should be controlled before such activities are undertaken
The patient should always carry medication and know how to use it
If there is comorbid rhinitis, this condition should be treated
Always warm up before exercising and increase exercise intensity gradually
Before exercising, the patient should inhale a bronchodilator that will provide protection against exercise-induced bronchospasm
The patient should always wear appropriate clothing and take into account possible variations in temperature
Cover mouth and nose when temperatures are low to prevent inhalation of very cold air
Eat enough to ensure adequate energy intake
Drink sufficient water depending on the amount of exercise undertaken (4-5 L/d)
Prevention of acute mountain sickness:
Avoid large meals and drink plenty of fluids
Acclimatize gradually
Patients with a history of acute mountain sickness should be prescribed acetazolamide

during the storm, or because of hyperventilation. Hyperventilation can also be the result of a panic attack provoked by the respiratory difficulties. It has been reported that under special conditions—in the context of military operations—the irritant effect of sand can predispose individuals to exacerbation of their asthma following administration of pyridostigmine as a pretreatment against possible exposure to chemical warfare.⁴³

Hot and Humid Environments: The Tropics

The hot humid environment typical of the tropics and certain tropical rain forests should not provoke any respiratory difficulties in patients with asthma other than those that might be experienced by healthy nonasthmatic individuals. Both groups will find it difficult to lose body heat owing to the high ambient humidity and will experience a sensation of heavier sweating, very often further increased by excess fluid intake. A humid environment favors the presence of mites and mold in poorly ventilated spaces, and sudden extreme changes in temperature can facilitate upper respiratory tract infections that would undoubtedly adversely affect asthmatic patients. Table 5 lists recommendations for exercising in a hot environment.

Natural Disasters: Fires

The active participation of both professionals and volunteers forms an integral part of the response to natural disasters and disasters, such as fires, affecting inhabited areas. Fires produce a high level of airborne pollution in the form of smoke and soluble particles that can cause respiratory and cardiovascular inflammation. The incidence of asthma attacks and exacerbation in these circumstances varies, but it can be as high as 70% of the population with asthma depending on the level of exposure and the type of fire.⁴⁴ When a disaster of this type occurs patients with asthma are advised to avoid all contact with smoke, to remain indoors, to take anti-inflammatory medication, and to wear a particle filter mask. Table 6 shows the basic guidelines that should be followed in the event of a fire in the mountains.

Remote Places

Patients with asthma must always be prepared to deal with an attack in any situation. If they are to enjoy their trips they must, among other things, assess the state of their asthma before leaving,

Table 5
Recommendations for Exercising in Hot Environments (Prevention of Dehydration and Heat Stroke)

<p>General</p> <ul style="list-style-type: none"> Maintain good physical condition Acclimatization can be stimulated by prior training for 1-1.5 h/day in hot conditions before the event (3-10 days is sufficient) A 7-day stay at constant high temperature During exercise, drink beverages with electrolytes (sports drinks) before noticing thirst and continue even after thirst has been quenched Avoid alcohol and caffeine <p>Increase heat loss</p> <ul style="list-style-type: none"> Wear light colored loose clothes and cover as much of the body as possible, shielding it from the sun Maintain hydration to allow sweating Look for places where air circulates <p>Reduce heat gain</p> <ul style="list-style-type: none"> Avoid exercise when temperatures and humidity are high Wear protective clothing Look for shade when temperatures are at their highest Do not touch hot objects Do not sit or lie directly on the ground <p>Be aware of warning symptoms: headache, nausea, cramps, tachycardia</p> <p>Protect mouth when environment is polluted (sand storm, trade winds, etc)</p>

consider what medication they can and should take with them, ascertain whether their medication can be obtained in the destination. They should also obtain information about nearby facilities that can provide first aid, the location of the closest population centers, and the availability of facilities for an urgent evacuation (not necessarily for an asthma attack). Table 7 lists the considerations that travelers should take into account when visiting sparsely populated regions,⁴⁵ and the situations that could make evacuation to a hospital necessary.

Environmental Pollution

Many chemical compounds, alone or in combinations, adversely affect the respiratory system, reducing or altering its function. These substances all have, to a greater or lesser degree, repercussions on our health and physical performance depending on a number of factors, including the levels present in the environment, ventilation, the prior state of the patient's airways, and the combination with other factors, such as temperature, humidity, etc. Each increment of 10 µ/m³ in airborne particulate matter, particularly in the case of particles smaller than 1 µm, causes a mean increase of 3% in lower airway symptoms and of 0.7% in upper airway symptoms.⁴⁶ Damage to the airways caused by these noxious contaminants is most intense in highly polluted cities, which are obviously those with a high concentration of industry, a high density of road traffic, and places where the atmospheric conditions increase the negative effects of these byproducts of progress. Exposure to ozone, the most

Table 6
Recommendations in the Case of Forest Fires

<p>Call for help</p> <p>Attempt to extinguish fire if: a) the blaze is small and it appears possible to limit its spread or extinguish it entirely; and b) there is a clear and accessible escape route</p> <p>Monitor the fire, be aware above all of possible changes in direction</p> <p>Remain in contact with any other people who are in the same situation or go to their aid</p> <p>Keep assessing escape routes in response to possible changes. Make sure you are not trapped by the fire</p> <p>Persons with asthma should take rescue medication</p> <p>Keep away from possible sources of combustion: dry grass, trees and shrubs, flammable material (blankets, fuels, etc)</p>

Table 7
Aspects to Be Considered When Preparing a Trip to a Remote Area

<p>Assess the state of your asthma before leaving (consult your specialist).</p> <p>Investigate the climate in the places where you wish to travel and discuss this aspect with the specialist</p> <p>Patients highly allergic to insect bites or specific drugs should wear a medical allergy pendant with the relevant information</p> <p>Before leaving obtain information about the closest population centers and how to call for help</p> <p>Always have an evacuation plan in case of an asthma attack or any other emergency</p> <p>Carry a supply of everyday and rescue medication, even when asthma is apparently stable</p> <p>Always carry rescue medication on your person and not in baggage</p> <p>Keep in regular contact with family members or friends</p> <p>Be careful</p> <p>In isolated and inhospitable environments, keep a close watch for situations that require a person with a respiratory disease to be evacuated to a hospital.</p> <p>Respiratory distress accompanied by 1 or more of the following symptoms: respiratory stridor, cyanosis, difficulty speaking, extreme fatigue, chills and fever, signs or symptoms of shock, pulse rate >130 beats/min</p> <p>Suspected pneumonia, acute bronchitis, or pulmonary embolism</p> <p>Evidence of heart disease (history, abnormal heart rhythm, suspicious chest pain, etc)</p> <p>An asthmatic patient who does not improve within 20 minutes of taking treatment or rescue medication</p> <p>Severe respiratory distress (irrespective of the cause) that does not improve with rest and supplementary oxygen</p>

common of these pollutants, gives rise to breathing difficulties, coughing, irritation of the throat and nose, dyspnea, difficulty in deep breathing, and consequently an increase in respiratory rate and a reduction in tidal breathing during exercise.⁴⁷ Ozone exposure also affects resting lung function, but not gas transport.⁴⁸ Furthermore, in environments polluted by the common contaminants found in city air (O₃, NO₂, and SO₂), we know that exercising increases both exposure and symptoms and leads to irritant inflammation of the airways and mucous membranes, conditions that can increase bronchial hyperresponsiveness. Although the individual's reaction will depend on the levels of these gases in the air, prior exposure to a cold or dry environment may increase sensitivity. Exposure to high concentrations of pollutants or prolonged exposure to lower concentrations also reduces resting lung function in both asthmatic and nonasthmatic individuals. The use of topical anti-inflammatory agents is recommended as a prophylactic measure. Anticholinergic agents and cromones are sometimes useful (SO₂ pollution). By contrast, β₂-agonists are generally not effective.

Table 8 shows the considerations that should be taken into account by the organizers of sporting events in highly polluted areas.

Underwater Activities

Diving is one of the sporting activities that has seen the greatest increase in popularity during the past decade. While a high level of fitness is not required for the practice of this sport, a sound knowledge of how the body adapts to depth and the changes that occur during a dive is essential, as is an understanding of the other key technical, biological, and meteorological aspects of the sport. Professional and recreational divers must always remain alert and aware of both their internal sensations and what is going on around them so as to be in a position to react to any emergency using the resources they have assimilated through practice and theoretical study.

The main underwater activities are 2 types of diving: freediving (breath hold or apnea) and self contained underwater breathing apparatus (SCUBA) diving. In both cases, a physician examining a person who wishes to dive must investigate the processes that limit pulmonary elasticity, such as emphysema and fibrosis, and pleural diseases, such as adhesions and pleural thickening. It is therefore advisable, after obtaining a good medical history, to order additional examinations, such as forced spirometry and inspiratory and

Table 8
Recommendations for Physical/Leisure Activities in a Polluted Environment

<i>Advice for event organizers</i>
Assess locations where competitions are to be held
Evaluate training sites
Schedule events so that they coincide with periods when pollution levels are lowest
Take appropriate measures to limit pollution when athletes are exercising (temperature, ventilation, nearby industrial installations, road traffic, etc)
<i>Advice for athletes and trainers</i>
Arrive at least 3 days before the event
Susceptible individuals should take medication to prevent exercise-related cough
The presence of possible contaminants should be assessed and, if necessary, hyperresponsive patients should take prophylactic medication to protect against bronchoconstriction, irrespective of whether or not they are asthmatic.
Evaluate the environment around the accommodation site
Consult pollen maps for the area where the competition is to be held for the time of year when the event is taking place
If pollution in the area is very high, the possibility of not competing should be considered, particularly in the case of sports with moderate-to-high intensity and duration (cycling, long-distance running events, walking, etc) and in the case of athletes who are more susceptible to attacks
Active carbon masks should be worn for protection in case environmental conditions become dangerous. When pollution levels are high, such masks should be worn even for moderate exercise and any outdoor

expiratory chest radiographs. Under current Spanish legislation (Official State Journal [BOE] July 20, 1973), a person with asthma cannot obtain a license to participate in underwater activities. The theoretical justification for this decision is that the effect of decompression on a part of the lung obstructed by the disease (owing to mucous, inflammation, bronchoconstriction, edema, or other factors) could cause barotrauma due to the increase in intrathoracic pressure. If the channel connecting a bodily cavity, such as the lungs, the middle ear, or the frontal or paranasal sinuses, to the exterior is blocked, the gas inside the cavity would be compressed during descent and it is possible that the increase in internal pressure on ascent could not be adequately compensated.⁴⁹ However, we know that there are, in fact, a large number of people throughout the world with diving permits and even professional licenses who have asthma or have had asthma at some time in their lives.⁵⁰ Nevertheless, the fact that the asthma is stable prior to a dive is not a sufficient reason to rule out risk entirely. Factors that may lead to an asthma attack include anxiety, moderate exercise, hyperventilation, inhalation of cold dry air from the tank chilled by the depth, and the inevitable entry into the respiratory system of a certain amount of salt water at some point during the dive. Moreover, the fact that a patient has no symptoms does not necessarily mean that the small airway is completely free of obstruction or mucous. The danger is that such an obstruction might permit the passage of a certain amount of air into the distal lung, where the gas may then be trapped during the ascent, giving rise to excessive internal pressure in the lung. The risk is therefore twofold with the possibility of an asthma attack on one hand and of an accident involving excessive pulmonary pressure on the other.

There is, however, no scientific evidence to support the hypothesis that divers with asthma are more susceptible to such accidents,⁵¹ although some studies have found indications that asthma may have been a factor in certain fatal cases.⁵²

There are a number of guidelines and instructions that should not be forgotten when allowing an asthmatic patient to dive (Table 9). Patients with persistent moderate or severe asthma should not dive. In cases of persistent or intermittent mild asthma, the patient's medical history and cardiorespiratory adaptation to exercise should be taken into account. Physicians must also rule out exercise asthma and determine the basal state of the patient's airways by spirometry. The following are considered to be indispensable conditions for diving: airflow values of at least 80% of normal, absence of dyspnea for at least 1 week prior to diving (which implies an absence of wheezing during at least the same period), and absence of any infection of the airways that could give rise to increased mucous secretion. Patients who fulfill these criteria must, in addition to the normal preparations and precautions taken prior to diving, take the

Table 9
Recommendations for Divers Using Compressed Air Systems

<i>Permitted</i>
Diving is permitted in unmedicated asymptomatic asthmatic patients with normal lung function who are in good physical condition
Diving is permitted in symptomatic asthmatic patients who:
Tolerate exercise with no symptoms when taking appropriate medication
Do not require rescue medication in periods of stress or during physical exercise
Have lung function values within the normal range
Have a negative result on bronchial challenge
Have undergone a medical assessment by a specialist in underwater medicine
Asthma triggers should be clearly defined in each patient in order to prevent these attacks
<i>Not permitted</i>
Patients with severe and persistent asthma
Asthmatic patients whose symptoms are not controlled by maintenance medication
Patients who need to use rescue medication when they exercise or are exposed to the cold
Any asthmatic patients who are in an unsatisfactory physical condition

preventative medication prescribed by their physician. It is worthwhile measuring peak expiratory flow with a portable spirometer or, even more useful, forced expiratory volume in 1 second and forced vital capacity using a battery-powered device so that the data can be saved for comparison with future check-ups and evaluation by the specialist physician.

Asthmatic individuals who decide to dive must always keep in mind that their safety affects and can compromise that of all their diving companions. It is, therefore, essential that they react to any abnormal sensation when diving by taking the appropriate decision calmly and carefully for the good of the whole group. For obvious reasons, their diving companions must be aware of their asthmatic condition.

Powered and Unpowered Flight

Physicians should consult the appropriate SEPAR guidelines to resolve any doubts about flying and respiratory disease.⁵³

The sporting and leisure activities in which participants reach a certain altitude include ballooning and all kinds of gliding. The problem for individuals with asthma in the case of gliding is that an attack during a flight may endanger both the pilot's life and the lives of people on the ground. The mechanisms that can trigger an acute attack are similar to those cited in the case of high altitudes in the mountains because the environment is similar. One recommendation worth considering would be to assess the degree of control (not severity) of the disease monthly using a questionnaire such as the Asthma Control Test (ACT),⁵⁴ which is available from <http://www.asthmacontroltest.com>. Patients who have had an attack should not fly until a doctor's examination has confirmed that their disease is definitely under control. Under Spanish law, the class 2 medical certificate required to obtain or renew a flying license states that applicants who experience recurrent asthma attacks must be disqualified. A peak flow measurement below 80% of the predicted value is also grounds for disqualification. Class 2 certification can be considered if the patient's condition is considered stable after a lung function test and he or she is using medication consistent with flight safety (Spanish Ministerial Order dated March 21, 2000; BOE, March 11, 2000).

Finally, the use of supplemental oxygen using a mask or nasal cannula should be considered for any flight expected to exceed 3000 meters in altitude for more than 15 minutes.

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