Consideraciones prácticas para el entrenamiento y la salud del atleta extremo: una revisión de literatura

Practical considerations for the training and health of the extreme athlete: a literature review

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RESUMEN

Objetivo: Este trabajo revisa consideraciones prácticas esenciales para el entrenamiento y la salud de los atletas en disciplinas como el trail running, el surf, las carreras de aventura, el ciclismo de montaña, los deportes aéreos, el snowboard, el esquí, el rafting, el kayak y el buceo.
Metodología: Se efectuó un estudio documental de revisión bibliográfica. Se abordan estrategias de hidratación, prevención de lesiones, riesgos fisiológicos y programas de entrenamiento estructurados, destacando la importancia de un enfoque integral que garantice la seguridad y el rendimiento.
Conclusión: Esta revisión ofrecer una guía útil para atletas, entrenadores y profesionales de la salud en el ámbito de los deportes extremos.

Palabras clave: deportes extremos, entrenamiento, prevención de lesiones, hidratación, salud del deportista.

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ABSTRACT

Objective: This paper reviews essential practical considerations for the training and health of athletes in disciplines such as trail running, surfing, adventure racing, mountain biking, aerial sports, snowboarding, skiing, rafting, kayaking, and diving.
Methodology: A literature review was conducted. Hydration strategies, injury prevention, physiological risks, and structured training programs are addressed, highlighting the importance of a comprehensive approach that ensures safety and performance.
Conclusion: This review offers a useful guide for athletes, coaches, and healthcare professionals in the field of extreme sports.

Keywords: extreme sports, training, injury prevention, hydration, athlete's health.

Introduction

The so-called extreme sports are those types of sports that carry with them some risk factor or that directly or indirectly can affect the physical integrity of those who practice them, or in more serious cases, contemplate death as a consequence of a small error in the preparation or execution of the same[1].

In today's world, extreme sports have taken on a prominent role in both sports culture and society at large. These challenging disciplines, which often involve significant risks and the pushing of physical and mental limits, have captivated a diverse audience, especially among younger generations. Extreme sports offer a unique and exciting experience that appeals to those seeking thrills and a sense of adventure, which has led to their growing popularity and recognition worldwide[2].

In addition to their emotional appeal, extreme sports have also had a significant influence on culture and industry. They have inspired technological advancements in equipment and techniques, and generated opportunities for sponsorship and marketing. The values of self-improvement, courage, and resilience promoted by these sports have transcended the slopes and mountains, inspiring people to set challenging goals in their everyday lives. In short, extreme sports play an important role in today's dynamic by enriching the sports offerings, influencing culture, and fostering a self-improvement mindset in society[3].

Regarding the risk associated with these sports, it is mentioned that the injury rate in the practice of extreme sports is 1/60 people, which is why it is argued that extreme or adventure sports are not significantly riskier than activities or sports practiced in everyday life, the probability of injury is also higher in sports such as rugby, basketball, or physical contact sports[4].

Within the wide range of extreme sports, some subdivide them into classifications such as lifestyle sports or natural sports, which are performed in environments where nature plays a very important role in their execution. These sports have a more sociological approach that delves into the connection and relationship between nature and the environment with the athlete and their goals[5].

In addition, these types of sports are currently impacting the economic sphere of many regions, since the adventure tourism market has had a significant growth in the last decade, generating an amount of approximately 444,859 million dollars globally in 2016, so its popularity benefits various regions around the world, thus contributing to the economy of the population and in turn generating a wider number of job opportunities and leisure venues[6].

Regarding the group of people who practice these sports, the population that mostly practices extreme sports is young people, which is based on the need and preference of young people for risky behaviors and is a consequence of the constant search to experience strong emotions that provide heightened sensations[7].

This review highlights basic considerations that lay the foundation for training in the most popular extreme sports. These initial considerations are crucial to ensuring a solid, safe approach to preparing for and participating in extreme sports. By establishing these pillars, we aim to provide a solid foundation for athletes and extreme sports enthusiasts to develop their skills and carry out their activities responsibly and effectively. The aim of this study was to critically analyze and synthesize the available scientific evidence on practical considerations for the training and health of the extreme athlete, integrating physiological, metabolic, neuromuscular, and psychosocial aspects, to identify risks, preventive strategies, and applied recommendations that optimize performance while preserving health in high-demand training and competition contexts.

Methodology

This work was designed as a narrative literature review to synthesize current knowledge on training and health considerations in extreme sports. The review did not follow systematic review protocols (e.g., PRISMA) and therefore did not involve formal study selection or risk-of-bias assessment. Instead, it focused on identifying, summarizing, and critically discussing relevant empirical evidence and conceptual frameworks. No publication date restrictions were applied.

Literature Search

A comprehensive search of scientific literature was conducted across the databases PubMed, Scopus, Web of Science, and Google Scholar, covering publications available up to June 2025. Search terms included combinations of keywords related to extreme sports (e.g., *"extreme sports", "adventure sports", "trail running", "surfing", "mountain biking", "snowboarding", "skiing", "paragliding", "rafting", "kayaking", "scuba diving"*) and training- and health-related concepts (e.g., *"training", "health", "injury prevention", "hydration", "performance"*).

Titles and abstracts were screened to identify publications relevant to training load, physiological stress, health risks, injury patterns, and performance considerations in extreme or adventure sport contexts. Full texts were consulted when necessary to clarify relevance. The final selection of articles was based on relevance to the topic, conceptual contribution, and applicability to extreme athlete training and health.

Eligibility Criteria

Publications were included if they met at least one of the following criteria:

Addressed physiological, health-related, or training aspects of extreme sports.

Reported injury risks, hydration, or performance optimization strategies in relevant populations. Provided theoretical, narrative, or empirical insights applicable to athletes, coaches, or health professionals.

No restrictions were placed on study design, allowing the inclusion of original research articles, reviews, case studies, theses, and consensus papers. Literature in English, Spanish, and Portuguese was considered.

Data Extraction and Synthesis

Relevant information was extracted regarding sport-specific risks, physiological demands, injury epidemiology, hydration strategies, and training recommendations. Evidence was synthesized thematically across different extreme sport disciplines, highlighting both shared principles and unique considerations. Special emphasis was placed on practical applications and preventive strategies. As this review was narrative in nature, the numbers reported are intended to provide transparency regarding the literature exploration process rather than a formal study selection flow.

Limitations

As a narrative review, this work does not claim to provide an exhaustive or systematic analysis of all available studies. Instead, it aims to offer a structured synthesis of key literature and practical recommendations to guide athletes, coaches, and health professionals.

Results

The literature search identified 2,751 records across all databases, with Google Scholar yielding the highest number of results, likely due to its broader indexing coverage (Table 1).

Table 1. Literature search process and article selection.

Stage of the review process	Number of records (n)
Records identified through database searching	
PubMed	412
Scopus	685
Web of Science	534
Google Scholar	1,120
Total records identified	2,751
Duplicate records removed	1,094
Records screened by title and abstract	1,657
Records excluded after screening (low relevance)	1,409
Full-text articles assessed for eligibility	248
Full-text articles excluded (scope, population, context)	200
Articles included in the narrative synthesis	*48*

Table 2., provides a synthesized overview of health- and training-related considerations across adventure and nature-based sports.

Across adventure and nature-based sports, the relevance of each core domain (hydration, health risks, injury exposure, and training specificity) was established through a structured narrative synthesis guided by three complementary criteria. First, emphasis in the literature was evaluated by examining the frequency, depth, and consistency with which each domain was addressed, including the presence of dedicated sections or repeated discussion within narrative reviews, epidemiological studies, and consensus statements. Domains that were consistently highlighted across multiple sources were considered more relevant.

Second, the consequences of inadequate management were considered, focusing on the

Table 2. Narrative synthesis of hydration, health risks, injury patterns, and training considerations across adventure and nature-based sports.

Sport	Hydration	Health considerations	Injury profile	Training focus
Trail running	Planned hydration with packs/bottles; intake adjusted to environmental load; electrolytes recommended (8–11).	Environmental exposure: atrial fibrillation, acute kidney injury, and integumentary issues reported (12,13).	Ankle sprains, knee injuries, and overuse-related conditions (14–16).	Trail-specific running, lower-limb strength, uphill/downhill conditioning, periodization (12–14,17,18).
Surfing	High dehydration risk; pre-session hydration is essential as rehydration is not feasible during practice (19,20).	Solar exposure, water quality–related infections; risk influenced by age, experience, and surgical history (21,22).	Shoulder, spinal, and knee injuries; lacerations and contusions from board impacts (22,23).	Cardiovascular conditioning, core and shoulder strength, balance, and recovery (24–26).
Adventure racing	Transported fluids required: carbohydrates, protein, and caffeine support prolonged effort (27,28).	Thermal stress, skin lesions, and fatigue-related complications; medical screening advised (29,30).	Sprains, strains, overuse injuries, and trauma related to terrain and navigation (31–34).	Multidisciplinary endurance, functional strength, navigation skills, and periodization (34,35).
Mountain biking	Regular hydration before/during/after rides; electrolyte replacement in heat (36–38).	Solar radiation, dust, and airborne particles affect skin and respiratory health (39,40).	Abrasions, contusions, knee and lumbar overuse injuries (41,42).	Cardiovascular fitness, whole-body strength, technical skills, flexibility, periodized recovery (43–47).
Aerial sports (skydiving, base jumping, paragliding, hang gliding)	Hydration secondary but supportive pre-activity (implicit).	Barotrauma, vestibular disturbance, and high landing-phase risk; variable injury and mortality rates (48–53).	Severe injuries mainly to lower limbs, spine, and upper extremities during landing (50–54).	Technical proficiency, progressive exposure, cognitive control, and decision-making (49–53).
Snowboarding & skiing	Hydration relevant during prolonged cold exposure.	Cold stress affects cardiovascular, neuromuscular, and cognitive function (56,57).	Wrist injuries (snowboarding) and ACL injuries (skiing); falls and impacts are predominant (52,56).	Lower-limb strength and power, neuromuscular control, and aerobic recovery capacity (56,57).
Rafting & kayaking	Variable hydration demands depending on environment and duration.	River conditions require physical and mental preparedness (58,59).	Acute sprains/strains and traumatic injuries; chronic lumbar pain in experienced paddlers (58).	Core and upper-limb strength, lumbar stability, technical skill, and psychological readiness (58,59).
Diving	Immersion-induced diuresis may lead to post-dive hypovolemia (60).	Cardiovascular, renal, and neurological stress; risk of arrhythmias, pulmonary edema, and cognitive effects (60,61).	Predominantly physiological and neurological complications (60,61).	Minimum aerobic fitness (VO_2max), stress control, progression, and medical evaluation (60,61).

severity of potential outcomes when a given domain was insufficiently addressed. Domains associated with substantial risks to athlete safety, health, or performance, such as acute medical events, severe injuries, or pronounced performance decrements, were assigned higher relevance compared with domains linked primarily to secondary or supportive outcomes.

Third, sport-specific dependency was assessed by determining the extent to which each domain was intrinsic to the safe and effective practice of the sport. Domains that represented non-negotiable requirements for participation, where failure to address them would markedly compromise safety or feasibility, were classified as highly relevant.

The integration of these three criteria enabled the classification of each sport–domain combination into ordinal relevance levels (low, moderate, or high), as shown in Figure 1.

Sport	Hydration	Health Risk	Injury Exposure	Training Specificity
Trail running	●●○	●●○	●●●	●●●
Surfing	●●●	●●○	●●○	●●○
Adventure racing	●●●	●●●	●●●	●●●
Mountain biking	●●○	●○○	●●○	●●●
Aerial sports	○○○	●●●	●●●	●●●
Snowboarding & skiing	●○○	●●○	●●●	●●●
Rafting & kayaking	●○○	●●○	●●○	●●○
Diving	●●○	●●●	●○○	●●○

Figure 1. Icon-based synthesis of core hydration requirements, health risks, injury exposure, and training specificity across adventure and nature-based sports. Domain relevance is represented using ordinal icon intensity (low to high). This minimalist framework facilitates cross-sport comparison while maintaining print and accessibility compatibility. Low (●○○), moderate (●●○), or high (●●●) relevance based on the convergence of the following criteria.

This approach facilitated cross-sport comparison while preserving the qualitative nature of the evidence and highlighting both shared and sport-specific priorities across outdoor and adventure disciplines.

Trail running

Trail running presents unique challenges for runners. To fully enjoy the experience and safeguard participants' well-being in events of this type, it is essential to consider hydration, health maintenance, common injuries, and a well-structured training program.

Proper hydration is essential for trail running, where access to water sources can be limited. Dehydration can lead to fatigue, impaired performance, and even serious health problems[8,9]. Carrying an adequate supply of water and planning hydration stops along the route is essential. Some participants opt for a hydration pack or handheld bottles for added convenience. Tailor your fluid intake to the demands of the trail, considering factors such as temperature, elevation, and, above all, physical load[10]. Electrolyte-rich beverages can replenish essential minerals lost through sweat, ensuring optimal performance and minimizing the risk of dehydration-related complications[11].

Trail runners should be aware of potential health issues associated with their activity. A common concern is exposure to the elements, from intense sunlight to variable weather conditions. Protecting yourself with appropriate clothing, sunscreen, and sunglasses is critical. Also, consider the impact of trail running on respiratory health, especially in areas with poor air quality. If you have preexisting health conditions, consult with a healthcare professional to ensure trail running aligns with your fitness goals without compromising your well-being. Some of the most frequently reported issues are atrial fibrillation, acute kidney injury, and integumentary problems[12,13].

While trail running offers a truly engaging experience, it is not without inherent risks. Common injuries include ankle sprains, knee problems, and overuse injuries. Strengthening exercises that target the lower body, particularly the ankles and knees, can help mitigate these risks. Trail runners should also incorporate dynamic warm-ups before running and dedicate time to stretching and flexibility exercises afterward[14]. Regularly assessing footwear wear is essential, as worn shoes can contribute to injury. If injuries occur, treat them promptly with adequate rest, rehabilitation exercises, and, if necessary, seek professional medical advice[15,16].

Trail runners seeking peak performance and injury prevention. Incorporate a variety of workouts into your regimen, including trail-specific runs, strength training, and cross-training activities. Hill repeats can improve your uphill running capabilities, while downhill intervals prepare your muscles for descents[17]. It's essential to build recovery time into your training program, as trail running can be particularly demanding on muscles and joints. Periodization, which alternates between phases of intense training and recovery, is a proven strategy for optimizing performance and minimizing the risk of burnout or overtraining[12,13].

Consistency is key in training. Gradually increase your mileage and elevation gain to build endurance and adapt to the demands of trail running. Integrate trail-specific elements into your workouts, such as lateral movements and balance exercises, to improve agility and stability on uneven surfaces[18]. Prioritize hydration to maintain your energy, be aware of potential health issues, address and prevent common injuries, and implement a well-structured training program. By approaching trail running holistically, you can unlock the participant's full potential while safeguarding your health and well-being on the trails[14].

Surfing

Surfing isn't just a sport; it's a lifestyle embraced by those who enjoy riding the waves. Whether you're an experienced surfer or a beginner seeking your first waves, understanding the practical considerations for surfing training and health is crucial to enhancing your experience and overall well-being in the water.

Being surrounded by water may give the illusion of constant hydration, but surfing is an intense physical activity that demands special attention to fluid intake. Dehydration can occur rapidly due to sun exposure, salt air, and the physical exertion of paddling and wave riding[19]. Results from some studies suggest that prolonged

surfing at high ambient temperatures in participants with a high body mass index resulted in significant body water deficits. Since there is no opportunity to rehydrate during a surf session, surfers should adequately hydrates before surfing to avoid the detrimental effects of dehydration[19,20].

Surfing exposes individuals to unique environmental factors, and understanding how these factors can impact health is crucial. Prolonged sun exposure can lead to sunburn, skin damage, and an increased risk of skin cancer[21,22]. Applying water-resistant sunscreen, wearing protective clothing, and using surf hats or rash guards can mitigate these risks. Additionally, surfers should be mindful of water quality, as polluted waters can lead to ear and sinus infections[22]. Competitive status, limited surfing experience, older age, and a history of previous surgical injuries are risk factors for surfing injuries. The most common types, anatomical locations, and mechanisms of injury appear to be similar between recreational and competitive surfers[21,22].

Surfing is a dynamic, physically demanding activity, and injuries are common. Sprains, strains, and overuse injuries often affect surfers, especially in the shoulders, back, and knees[23]. Bumps and collisions with the board or other surfers can lead to cuts, bruises, and more serious injuries[22]. To reduce your risk of injury, incorporate strength and flexibility training into your routine, with a focus on core stability and joint mobility. Proper warm-up and cool-down sessions, including stretching, can prepare your body for the demands of surfing and aid in recovery.

An effective training program for surfers goes beyond simply riding waves. It should encompass cardiovascular fitness, strength training, and targeted exercises focused on balance and agility. Cardiovascular fitness is crucial for endurance during long paddles and catching multiple waves in a session. Activities such as swimming, running, and cycling can improve cardiovascular health[24]. Strength training, especially focusing on the core, shoulders, and legs, is crucial for surfers. Core strength improves balance and stability, while strong shoulders and legs aid paddling, board maneuvering, and wave riding. Balance and agility exercises, such as yoga or stability ball balance exercises, are valuable additions to a surf training program. These activities mimic the dynamic movements required in surfing and improve overall coordination[25,26].

It's essential to tailor your training program to your skill level and the unique demands of surfing. Consistency is key but allows for rest and recovery days to avoid overtraining and reduce the risk of burnout or injury.

In conclusion, surfing training and health considerations are closely intertwined to ensure a satisfying and sustainable surfing experience. Prioritize hydration, address potential health issues, consider common injuries, and design a comprehensive training program. By incorporating these practical considerations, you'll not only improve your surfing performance but also cultivate a healthier and more enjoyable connection with the waves.

Adventure race

Adventure racing is the ultimate test of endurance, combining trail running, mountain biking, paddling, and navigation skills across a variety of challenging terrains. To excel in this demanding sport and safeguard your health, it's essential to prioritize practical hydration considerations, address potential health issues, prevent common injuries, and design a comprehensive training program tailored to the unique demands of adventure racing.

Proper hydration is crucial for adventure racers who cover long distances in diverse environments. Dehydration can lead to fatigue, impaired cognitive function, and increased susceptibility to injury. Because adventure races often take place in remote locations, racers should plan and transport their water supply[27]. Hydration packs or flasks designed for endurance sports are essential equipment.

There is considerable evidence supporting the use of sports drinks, gels, and bars as convenient, portable sources of carbohydrate for exercise, training, and competition. Similarly, protein and amino acid supplements may help meet increased protein requirements during periods of increased activity. Caffeine can be used as an ergogenic aid to help competitors stay awake for prolonged periods, enhance glycogen resynthesis, and improve endurance performance[28].

Adventure runners face several health issues due to the demanding nature of the sport[29]. Exposure to varying weather conditions, from scorching heat to cold nights, requires appropriate clothing and equipment to prevent hypothermia or heat-related illnesses. Additionally, runners may experience blisters, chafing, and skin abrasions. Rigorous hygiene practices and carrying a basic first aid kit can address these concerns. Pre-race medical checkups and consultations are recommended, especially for runners with pre-existing health conditions[30].

The unpredictable terrain and multidisciplinary nature of adventure racing make participants susceptible to a variety of injuries. Running on uneven trails, mountain biking on rough terrain, and paddling in challenging waters can lead to sprains, strains, and overuse injuries[31,32]. Navigation errors can lead to falls or collisions. To minimize injury risk, racers should incorporate strength and flexibility training into their preparation. Focusing on the core, lower body, and specific muscle groups used in each discipline can enhance stability and reduce the risk of injury. Proper warm-ups and cool-downs, along with regular rest days, are crucial components of injury prevention[33,34].

Creating a comprehensive training program is paramount for adventure racers, given the diverse physical demands they face. The program should encompass cardiovascular fitness, strength training, endurance, and navigation skills. Cardiovascular fitness is the foundation of adventure racing. Participate in activities such as trail running, mountain biking, and paddling to build endurance and acclimate your body to the diverse demands of racing. Strength training, focusing on the core, legs, and upper body, is crucial for overall stability and power. Functional movements that simulate running, such as lunges, squats, and rowing, should be integrated into the program. This is because these factors are often decisive when carrying weight[35].

Endurance training is crucial for sustaining the effort required in adventure racing. Incorporate long-distance runs, bike rides, and paddling sessions to prepare your body for the rigors of prolonged physical exertion. Navigation skills are a critical aspect of adventure racing. Practice map reading, compass navigation, and route planning regularly to improve your ability to navigate efficiently during the race. Periodization, which involves alternating cycles of intense training and recovery, is crucial. Plan your training program to gradually increase intensity around race time, then allow sufficient recovery to avoid burnout and overtraining[34].

In conclusion, adventure racing is a physically and mentally demanding sport that requires meticulous preparation. Prioritizing hydration, addressing potential health issues, preventing common injuries, and designing a comprehensive training program tailored to the demands of the race will contribute to a safer and more successful adventure racing experience. As you embark on the exciting journey of adventure racing, let these practical considerations guide you toward achieving your goals while safeguarding your health and well-being.

Mountain biking

Mountain biking is a stimulating and physically demanding sport that combines the thrill of speed with the challenges of varied terrain. As riders blast through trails and overcome obstacles, it's essential to prioritize practical training and health to ensure a safe, enjoyable experience.

Proper hydration is crucial for mountain bikers, particularly during extended rides in various conditions. Dehydration can lead to fatigue, impaired performance, and an increased risk of injury[36]. Cyclists should carry a hydration pack or water bottles on their bikes to ensure a convenient and accessible water supply. In hot, humid conditions, the need for hydration becomes even more pronounced, and electrolyte-rich drinks can help replenish essential minerals lost through sweating[37]. Establishing a regular hydration routine before, during, and after rides is crucial for maintaining optimal performance and preventing dehydration-related complications[38].

Mountain biking exposes cyclists to various health considerations, primarily related to the physical demands of the sport and environmental factors[39]. Prolonged sun exposure can lead to sunburn and heat-related illnesses, emphasizing the importance of sunscreen, appropriate clothing, and strategic riding schedules[40]. Additionally, cyclists should be aware of trail conditions that may include allergens, dust, and airborne particles.

Protective eyewear can protect the eyes, reducing the risk of irritation and injury.

Mountain biking, with its dynamic movements and challenging terrain, carries inherent risks of injury. Common injuries include abrasions, bruises, and cuts resulting from falls or contact with obstacles. Overuse injuries, such as tendonitis or muscle strains, can also occur, particularly in areas such as the knees and lower back[41]. Protective equipment, including helmets, gloves, and knee pads, is crucial for minimizing the impact of falls and reducing injury severity. Cyclists should also focus on body position and technique to improve control and stability on the bike, reducing the likelihood of accidents[42].

A well-structured training program is crucial for mountain bikers seeking to enhance their skills, endurance, and overall performance. The program should encompass cardiovascular fitness, strength training, technical skills, and flexibility.

Cardiovascular fitness is critical for sustained performance during long rides. Engage in activities such as cycling, running, or interval training to improve cardiovascular health and endurance[43]. Strength training, focusing on the lower, core, and upper body, is essential for achieving optimal power and stability on the bike. Incorporate exercises such as squats, lunges, and core exercises to build strength and resilience[44]. Technical skill training is vital for navigating challenging terrain and conquering obstacles. Practice maneuvers such as cornering, jumps, and descents in controlled environments before tackling more advanced trails[45,46].

Flexibility is crucial for adapting to the dynamic movements required in mountain biking. Regular stretching and mobility exercises can improve flexibility and reduce the risk of muscle strains or imbalances[47]. Periodization, which incorporates cycles of intense training and adequate rest, is crucial for preventing burnout and overtraining. Plan training phases to align with specific riding goals and allow for sufficient recovery between challenging rides.

In conclusion, mountain biking offers an exciting blend of adventure and physical exertion; however, riders must prioritize their health and training to fully enjoy the experience. Prioritizing hydration, addressing potential health issues, preventing common injuries, and implementing a comprehensive training program tailored to the sport's demands will contribute to a safer and more rewarding mountain biking experience. As riders tackle trails and overcome obstacles, these practical considerations serve as guidelines for a successful and health-conscious journey on two wheels.

Skydiving, Base Jumping, Paragliding, Hang Gliding

Skydiving has seen a significant increase in participation rates and popularity in recent years. In 36 countries, the number of licensed skydivers increased from 0.3 million to 1.5 million between 1996 and 2017. A total of 519,620 licenses has been issued between 2010 and 2019; 5.1% were awarded to students, 27.9% at the experienced level, and the remaining 67% in tandem jumps (with an instructor). The American Hang Gliding and Paragliding Association (USHPA) has around 10,000 members. The British Hang Gliding and Paragliding Association (BHPA) has approximately 6,729 members, and the USHPA has around 4,500 active members who practice paragliding[48].

Brief exposure to altitude and the resulting dramatic changes in gas volume and pressure pose physiological challenges. While several sports (skydiving, base jumping, paragliding, hang gliding) involve rapid descents from high altitudes to face immediate changes in air pressure, as ambient air pressure decreases and gases in these spaces attempt to expand, ascending to altitude before a jump can result in reverse contractions and compressions of the middle ear and sinuses during the rapid change in altitude during free fall, and barotrauma can cause pain, imbalance, and severe disorientation[49].

An approximate analysis of 10 million jumps, with an average of 610,000 per year, found that 0.044% posed a risk of injury and 0.0011% posed a risk of fatality. The most common types of injuries suffered in skydiving occur mostly in lower extremities (51%), upper extremities (19%), and spine (18%), respectively. Through trauma registries and analysis of demographic data, it was identified that 66% of serious injuries correspond to skydiving, and the main causes are attributed

to errors in calculating landing speed and altitude. The highest incidence of injuries in skydiving and the main causes of death occur in the landing phase (87.9%), exiting the aircraft (2%), free fall (2.7%), and parachute opening (7.4%)[50].

Mortality rates in the last decade have decreased and equaled the number of reported deaths, according to reports compiled by the Deutscher Fallschirmsportverband (DFV), 0.0005%, the United States Parachute Association (USPA), 0.0007% and the British Parachute Association (BPA) 0.0003%[51]. Between 2010 and 2019, it reported about 35 skydiving-related deaths; 29 (82.9%) of the deceased were experienced skydivers, 32 (91.4%) were male, and there were no records of tandem deaths. Leaving a mortality rate of 0.57 per 100,000 jumps, 0.54 per 100,000 jumps in student skydivers and 0.63 per 100,000 jumps in experienced skydivers[52].

People who practice base jumping commonly do so from buildings or cliffs, 97% of the participants who had very severe injuries were men. It has a very low injury rate, out of every 1000 jumps there are 2 serious injuries (0.2%) and the mortality rate is approximately 0.4 deaths per 1000 jumps[53].

Paragliding was the leading cause of injuries in aerial sports (79.6%), followed by skydiving (10.5%) and base jumping (6.1%). All types of paragliding have an annual injury rate of 10.8 injuries per 1,000 participants. The mortality rate is approximately 0.46 per 1,000 people at risk, with the mean age at injury ranging from 30.7 to 44.5 years. Injuries primarily occurred in the lower extremities[54]. The hang gliding injury rate (injuries/1,000 participants/year) was 10.4 and the mortality rate (deaths/1,000 participants/year) was estimated at 40.4 between 2010 and 2014[48].

Snowboarding and Skiing

A total of 4,571,008 participants were analyzed over 18 seasons (1988–2006), 3,787,913 (82.9%) were skiers and 783,795 (17.1%) were snowboarders. The prevalence of snowboarders compared to skiers gradually increased from percentages below 5% in participation rates to as high as 34% in the 2000–2001 season and then decreased to around 20% in the later years of the study52 (52). Between 2000 and 2020 the number of annual visits by skiers, snowboarders, and other downhill activities has remained stable at approximately 400 million[55].

Anthropometric variables of elite snowboarders, firstly the average height in athletes is 165.7 and 183.4 cm, elite Italian snowboarders have an average of 76 kg in body mass, the average body mass of Canadian athletes is 86 kg in men and 64 kg in women, expert snowboard participants have a body fat percentage between 12 and 14%, physical training can be crucial for snowboard performance, helping to control actions such as quick turns, reception, edge changes and overcoming obstacles[56].

The force of acceleration and the relative velocity of a snowboarder body with respect to their body weight can directly affect muscle loads during alpine skiing. The lower extremity muscle strength and power of snowboarders, particularly in the quadriceps, have been measured. This problem is because injuries (primarily knee injuries) are common in elite snowboarders; lack of strength in the quadriceps muscles can make snowboarders unable to withstand extreme forces and loads during high-performance activities[56].

Cold stress reduces the cost of submaximal oxygen consumption[57]. Efficient aerobic training is critical for recovery between competitive runs; in snowboarding, heart rate is a valid and reliable method for monitoring exercise intensity during training sessions. Aerobic fitness is beneficial in terms of training and recovery; snowboarding performance is not directly influenced by aerobic fitness[56].

The cardiovascular system's ability to deliver oxygen to the muscle, the metabolism's ability to produce sufficient energy, primarily from stored substrates, the proper functioning of the neuromuscular system, and focused psychological skills (e.g., cognitive function, motivation, pain resistance) are some of the factors that affect athletic performance. These factors can be affected by cold exposure, which can impair athletic performance[57].

Skiers have an average annual injury incidence of 345 and 400, respectively. Since 2001, there have been increases in snowboarding injuries and decreases in skiing. The most common accident

mechanisms are falls and impacts with the snow (90-92%) and jumps (33.7%) in general. The most common injuries are wrist injuries, 1258 have occurred among snowboarders, while anterior cruciate ligament (ACL) injuries are the most common injury among skiers, accounting for 2332 injuries[52].

Rafting and Kayaking

With over 18 million people in the United States estimated to participate in canoeing, stand-up paddleboarding (SUP), rafting, and whitewater kayaking combined, paddle sports remain a popular form of outdoor recreational activity. Approximately 2.6 million people in the United States engage in strong current kayaking, with 3.4 million participants annually. Whitewater rafting remains the most popular activity in the United States, with the majority of its participants being commercial passengers[58].

Participating in aquatic activities involves great responsibility. Athletes must maintain optimal physical fitness. Their swimming discipline and skills must be able to accommodate the physical challenges they are likely to face. Factors such as speed, wind direction, current size, water temperature, and river flow are very important pieces of information to consider when participating in your activity for your safety and health[59].

Training programs focused on working on strengthening the trunk and main rowing structures (upper extremities) have proven to be effective for kayaking and rafting athletes with respect to their sports performance, strength development work in the main core muscles promotes better control in the lumbar motor area and mainly to have good postural hygiene, the main problems of chronic/acute pain in the lumbar area can be prevented through adequate training prescription[58].

Athletes must be mentally prepared to face the most challenging situations and develop strategies to maintain their own safety, just as they would in other natural environments. The decision rests solely with the athlete; they must consider not only the risks to their own health, but also the risks they could pose to potential rescuers if they encounter problems in the water[59].

Fifty-eight percent of injuries in various strong current paddling disciplines are acute, with the most common being sprains and strains. Serious injuries frequently require hospitalization or medical treatment; collisions with other people's paddles and even with the raft itself are common, as are serious traumatic injuries when paddlers are thrown from the raft and hit rocks, logs, and underwater objects. Chronic injuries are primarily related to a higher frequency of practice and repetition of symmetrical movements, are associated with expert paddlers, and account for 42% of musculoskeletal injuries[58].

Injury rates among recreational participants are quite low overall, at about 4.5 per 1,000 paddler-days in whitewater rafting and 26.3 per 100,000 paddlers in rafting. Mortality rates are lower in rafting than in kayaking, with drowning and immersion accounting for 94% of deaths. Mortality rates in the United States have shown rates of 2.9 deaths per 100,000 paddlers per year[58].

Diving

Since 1976, the Professional Association of Diving Instructors (PADI) has issued more than 28 million diving certifications worldwide, representing 60% to 70% of the global diving market[60].

The exercise intensity of recreational divers resulted in an average relative to maintaining an exercise capacity of 7 METs, a maximum oxygen consumption (VO2max) between 24.5 ml/kg/min in men and 22.4 ml/kg/min in women, which is adequate for recreational diving practice. Professional diving organizations (police, firefighters, and military) require an exercise capacity of 13 METs (VO2max 40 ml/kg/min). Before starting to dive, physical fitness should be improved. People are recommended to dive with a VO2max of 25 to 40 in men and 25 to 35 in women; those with lower ranges should not perform diving activities[60].

Immersion has a significant impact on the cardiovascular, renal, respiratory, endocrine, and central nervous systems. It increases hydrostatic pressure in healthy individuals, causing fluid to shift into the central circulation and thereby increasing left ventricular preload and cardiac output via the Frank-Starling mechanism. This volume loading of the ventricles causes right atrial and ventricular

dilation, and natriuretic peptide secretion increases to compensate. This will gradually increase urine output during the immersion period, leading to a relatively hypovolemic state at the end of the dive[60].

Studies show that diving can damage the central nervous system, in addition to physiological stress, exercise as a form of physical exertion, the mixing of inhaled air and its rapid ascent can affect a diver's safety underwater. Factors such as cold, water currents, visibility, stress and claustrophobia can affect cognitive functions. Environmental factors (water temperature and visibility) can negatively affect the diver's ability to adequately assess underwater situations, cold as an environmental stress has an impact on cognitive functions and disorders[61].

Stress, when uncontrolled, can cause underwater incidents. It's no surprise that inexperienced divers are unable to control their reactions and panic, even their cognitive reactions, when their survival instincts are primarily at play. However, the diver's personality and ability to adapt to new circumstances have not yet been clearly established; these factors directly impact the prevention of diving accidents[61].

Diving, especially when frequent, can have long-term detrimental effects on the nervous system and cognitive function. It is essential to note that chronic effects do not typically appear until three months after diving. Middle-aged divers who make regular and frequent dives (100 dives/year) to depths greater than 40 meters are more likely to experience long-term effects on cognitive functions, manifested in spatial disorientation and memory impairment[61].

Immersion causes peripheral vasoconstriction, which increases systolic blood pressure and ventricular afterload, even in tropical waters. The diving reflex will be stimulated by exposing the trigeminal nerve to cold water. This will cause bradycardia (60% decrease in heart rate), prolongation of the QT interval, and vasoconstriction by inhibiting the cardiorespiratory center in the medulla oblongata. This could cause fatal arrhythmias in vulnerable hearts, such as those with hypertrophy, ischemia, preexisting arrhythmias, and channelopathies[60].

Hemodynamic alterations caused by diving may disrupt previously tolerated cardiac status in patients with cardiovascular disease. Volume shifts may cause cardiac decompensation and immersion pulmonary edema (IPE), particularly in patients with decreased right or left ventricular systolic function, restrictive diastolic function, or moderate to severe valvular disease. In patients with depressed left or right ventricular systolic function resulting in decreased cardiac output, the development of diving reflex bradycardia might be especially relevant[60].

Conclusions

Extreme sports have become an integral component of the contemporary sports landscape, characterized by high physical and psychological demands. Their growing popularity, particularly among younger populations, is driven by the pursuit of challenge, performance, and personal limits. Beyond sport, these disciplines influence culture, technological innovation, and economic development, particularly through sport tourism. However, their expansion has raised increasing concerns regarding athlete safety and health. Consequently, there is a growing need for evidence-based training, risk management, and health-oriented strategies to balance performance demands with long-term athlete well-being. Some core recommendations for the practice of extreme sports are given in Figure 2.

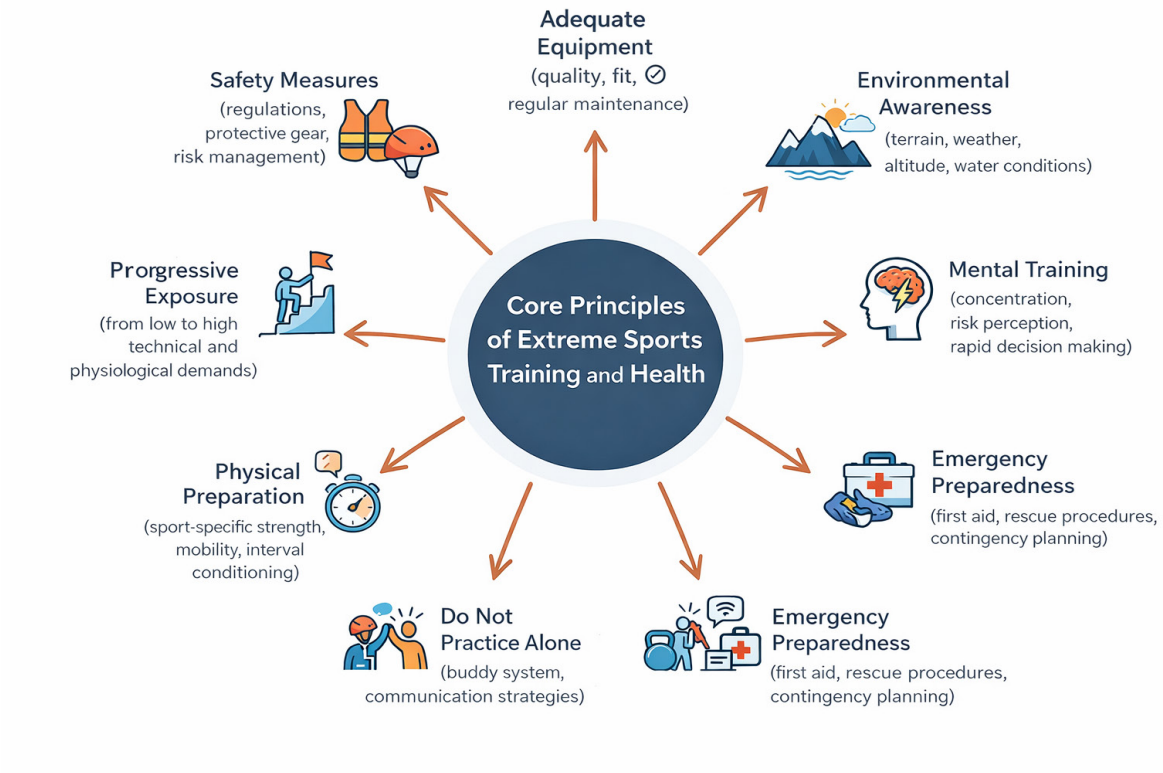

Figure 2. Core principles of training and health in extreme sports.

Future research lines

Future research in extreme sports should address the physiological, psychological, and environmental complexities that characterize these disciplines. Although evidence has advanced in areas such as injury epidemiology and hydration, longitudinal and interdisciplinary studies are still needed to understand how chronic exposure to extreme conditions, such as altitude, temperature variation, hypoxia, and immersion, affects multisystem adaptation and recovery. Integrating physiological, biomechanical, and psychophysiological measures could elucidate the mechanisms underlying resilience and performance sustainability. Moreover, the use of wearable sensors, biomarkers, and artificial intelligence represents a promising avenue for real-time monitoring of load, fatigue, and safety during training and competition. Psychological dimensions, including emotional regulation, decision-making under pressure, and risk perception, also warrant deeper exploration to prevent accidents and enhance performance. Additional emphasis should be placed on nutrition and hydration strategies adapted to environmental stress and prolonged exertion, as current recommendations remain generalized. Future work should include sex- and age-specific analyses to account for hormonal and developmental differences in adaptation and recovery. Finally, as participation in extreme sports continues to grow, research should evaluate their ecological and ethical implications, promoting sustainable practices and athlete welfare. Overall, advancing the scientific understanding of extreme sports requires collaborative, technology-driven, and holistic approaches that bridge physiology, psychology, and environmental science to optimize performance while preserving health and safety.

Bibliographic References

1. Brymer G. Extreme dude! A phenomenological perspective on the extreme sport experience. Univ Wollongong Thesis Collect 1954-2016 [Internet]. 1 de enero de 2005; Disponible en: https://ro.uow.edu.au/theses/379

2. Verdejo DM. Deporte: cultura y contracultura. Un estudio a través del modelo de los horizontes deportivos culturales. Apunts Educ Física Deport. 31 de marzo de 2002;1(67):6-16.

3. Scataglini S, Moorhead AP, Feletti F. A Systematic Review of Smart Clothing in Sports: possible Applications to Extreme Sports. Muscle Ligaments Tendons J. junio de 2020;10(02):333.

4. Monasterio E, Mei-Dan O, Hackney AC, Lane AR, Zwir I, Rozsa S, et al. Stress reactivity and personality in extreme sport athletes: The psychobiology of BASE jumpers. Physiol Behav. 1 de diciembre de 2016;167:289-97.

5. TFG_SergioAlvarezFernandez.pdf[Internet].[citado4deoctubrede2023].Disponibleen:https://digibuo.uniovi.es/dspace/bitstream/handle/10651/63145/TFG_SergioAlvarezFernandez.pdf?sequence=5

6. Brymer E, Schweitzer RD. Evoking the ineffable: The phenomenology of extreme sports. Psychol Conscious Theory Res Pract. 2017;4(1):63-74.

7. Daitzman R, Zuckerman M. Disinhibitory sensation seeking, personality and gonadal hormones. Personal Individ Differ. 1 de enero de 1980;1(2):103-10.

8. Rojas-Valverde D, Martínez-Guardado I, Sánchez-Ureña B, Timón R, Scheer V, Pino-Ortega J, et al. Outpatient Assessment of Mechanical Load, Heat Strain and Dehydration as Causes of Transitional Acute Kidney Injury in Endurance Trail Runners. Int J Environ Res Public Health. 28 de septiembre de 2021;18(19):10217.

9. Singh NR, Peters EM. Markers of hydration status in a 3-day trail running event. Clin J Sport Med Off J Can Acad Sport Med. septiembre de 2013;23(5):354-64.

10. Machado ÁS, Priego-Quesada JI, Jimenez-Perez I, Gil-Calvo M, Carpes FP, Perez-Soriano P. Effects of different hydration supports on stride kinematics, comfort, and impact accelerations during running. Gait Posture. septiembre de 2022;97:115-21.

11. Costa RJS, Knechtle B, Tarnopolsky M, Hoffman MD. Nutrition for Ultramarathon Running: Trail, Track, and Road. Int J Sport Nutr Exerc Metab. 1 de marzo de 2019;29(2):130-40.

12. Scheer V, Tiller NB, Doutreleau S, Khodaee M, Knechtle B, Pasternak A, et al. Potential Long-Term Health Problems Associated with Ultra-Endurance Running: A Narrative Review. Sports Med Auckl NZ. 20 de septiembre de 2021;

13. Scheer V, Rojas-Valverde D. Long-term health issues in ultraendurance runners: should we be concerned? BMJ Open Sport Exerc Med. 2021;7(3):e001131.

14. Scheer V, Krabak BJ. Musculoskeletal Injuries in Ultra-Endurance Running: A Scoping Review. Front Physiol. 2021;12:664071.

15. Viljoen C, Janse van Rensburg DCC, van Mechelen W, Verhagen E, Silva B, Scheer V, et al. Trail running injury risk factors: a living systematic review. Br J Sports Med. mayo de 2022;56(10):577-87.

16. Viljoen CT, Janse van Rensburg DC, Verhagen E, van Mechelen W, Tomás R, Schoeman M, et al. Epidemiology of Injury and Illness Among Trail Runners: A Systematic Review. Sports Med. 1 de mayo de 2021;51(5):917-43.

17. Pastor FS, Besson T, Varesco G, Parent A, Fanget M, Koral J, et al. Performance Determinants in Trail-Running Races of Different Distances. Int J Sports Physiol Perform. 1 de junio de 2022;17(6):844-51.

18. Vincent HK, Brownstein M, Vincent KR. Injury Prevention, Safe Training Techniques, Rehabilitation, and Return to Sport in Trail Runners. Arthrosc Sports Med Rehabil. enero de 2022;4(1):e151-62.

19. Atencio JK, Armenta RF, Nessler JA, Schubert MM, Furness JW, Climstein M, et al. Fluid Loss in Recreational Surfers. Int J Exerc Sci. 2021;14(6):423-34.

20. O'Neill B, Leon E, Furness J, Schram B, Kempsmith K. The Effects of a 2-hour Surfing Session on the Hydration Status of Male Recreational Surfers. Int J Exerc Sci. 2021;14(6):1388-99.

21. Kliniec K, Tota M, Zalesińska A, Łyko M, Jankowska-Konsur A. Skin Cancer Risk, Sun-Protection Knowledge and Behavior in Athletes-A Narrative Review. Cancers. 22 de junio de 2023;15(13):3281.

22. Monteiro CEM de P, Moreira-Pinto J, Queiroga AC. Injury patterns in competitive and recreational surfing: a systematic review. Inj Prev J Int Soc Child Adolesc Inj Prev. junio de 2022;28(3):280-7.

23. Szymski D, Achenbach L, Siebentritt M, Simoni K, Kuner N, Pfeifer C, et al. Injury Epidemiology of 626 Athletes in Surfing, Wind Surfing and Kite Surfing. Open Access J Sports Med. 2021;12:99-107.

24. Minghelli B, Paulino S, Graça S, Sousa I, Minghelli P. Time-motion analysis of competitive surfers: Portuguese championship. Rev Assoc Medica Bras 1992. 22 de julio de 2019;65(6):810-7.

25. Farley ORL, Harris NK, Kilding AE. Physiological demands of competitive surfing. J Strength Cond Res. julio de 2012;26(7):1887-96.

26. Farley ORL, Abbiss CR, Sheppard JM. Performance Analysis of Surfing: A Review. J Strength Cond Res. enero de 2017;31(1):260-71.

27. Birat A, Garnier YM, Bourdier P, Dupuy A, Dodu A, Grossoeuvre C, et al. Impact of long-duration adventure racing on hydration status, blood electrolytes and biomarkers of kidney function in trained adolescent athletes. J Sports Med Phys Fitness. noviembre de 2022;62(11):1552-9.

28. Ranchordas MK. Nutrition for adventure racing. Sports Med Auckl NZ. 1 de noviembre de 2012;42(11):915-27.

29. Birat A, Garnier Y, Dodu A, Grossoeuvre C, Dupont AC, Mucci P, et al. Changes in Pulmonary Function After Long-duration Adventure Racing in Adolescent Athletes. Int J Sports Med. julio de 2022;43(8):687-93.

30. Kohler MK. Adventure racing: Roles and protocols for the sports chiropractor. J Chiropr Med. 2003;2(1):1-7.

31. Birat A, Garnier YM, Bourdier P, Dupuy A, Dodu A, Grossoeuvre C, et al. Neuromuscular Fatigue After Long-Duration Adventure Racing in Adolescent Athletes. Pediatr Exerc Sci. 6 de mayo de 2021;33(3):103-11.

32. Greenland K. Medical support for Adventure Racing. Emerg Med Australas EMA. 2004;16(5-6):465-8.

33. Anglem N, Lucas SJE, Rose EA, Cotter JD. Mood, illness and injury responses and recovery with adventure racing. Wilderness Environ Med. 2008;19(1):30-8.

34. Sedgwick PE, Wortley GC, Wright JM, Asplund C, William OR, Usman S. Medical Clearance for Desert and Land Sports, Adventure, and Endurance Events. Wilderness Environ Med. 1 de diciembre de 2015;26(4, Supplement):47-54.

35. Fagundes A de O, Monteiro EP, Franzoni LT, Fraga BS, Pantoja PD, Fischer G, et al. Effects of load carriage on physiological determinants in adventure racers. PloS One. 2017;12(12):e0189516.

36. Ramos-Jiménez A, Hernández-Torres RP, Wall-Medrano A, Torres-Durán PV, Juárez-Oropeza MA, Solis Ceballos JA. Acute physiological response to indoor cycling with and without hydration; case and self-control study. Nutr Hosp. 2013;28(5):1487-93.

37. Holland JJ, Skinner TL, Irwin CG, Leveritt MD, Goulet EDB. The Influence of Drinking Fluid on Endurance Cycling Performance: A Meta-Analysis. Sports Med Auckl NZ. noviembre de 2017;47(11):2269-84.

38. Ferreira AMJ, Farias-Junior LF, Mota TAA, Elsangedy HM, Marcadenti A, Lemos TMAM, et al. Carbohydrate Mouth Rinse and Hydration Strategies on Cycling Performance in 30 Km Time Trial: A Randomized, Crossover, Controlled Trial. J Sports Sci Med. junio de 2018;17(2):181-7.

39. Mellion MB. Common cycling injuries. Management and prevention. Sports Med Auckl NZ. enero de 1991;11(1):52-70.

40. Greve M. Acute Cycling Injuries. Phys Med Rehabil Clin N Am. febrero de 2022;33(1):135-58.

41. Cohen GC. Cycling injuries. Can Fam Physician Med Fam Can. marzo de 1993;39:628-32.

42. Wanich T, Hodgkins C, Columbier JA, Muraski E, Kennedy JG. Cycling injuries of the lower extremity. J Am Acad Orthop Surg. diciembre de 2007;15(12):748-56.

43. Faria EW, Parker DL, Faria IE. The science of cycling: physiology and training - part 1. Sports Med Auckl NZ. 2005;35(4):285-312.

44. Bláfoss R, Rikardo J, Andersen AØ, Hvid LG, Andersen LL, Jensen K, et al. Effects of Resistance Training Cessation on Cycling Performance in Well-Trained Cyclists: An Exploratory Study. J Strength Cond Res. 1 de marzo de 2022;36(3):796-804.

45. Mujika I, Rønnestad BR, Martin DT. Effects of Increased Muscle Strength and Muscle Mass on Endurance-Cycling Performance. Int J Sports Physiol Perform. abril de 2016;11(3):283-9.

46. Vikmoen O, Rønnestad BR, Ellefsen S, Raastad T. Heavy strength training improves running and cycling performance following prolonged submaximal work in well-trained female athletes. Physiol Rep. marzo de 2017;5(5):e13149.

47. da Rosa Pinheiro DR, Cabeleira MEP, da Campo LA, Corrêa PS, Blauth AHEG, Cechetti F. Effects of aerobic cycling training on mobility and functionality of acute stroke subjects: A randomized clinical trial. NeuroRehabilitation. 2021;48(1):39-47.

48. Feletti F, Aliverti A, Henjum M, Tarabini M, Brymer E. Incidents and Injuries in Foot-Launched Flying Extreme Sports. Aerosp Med Hum Perform. 1 de noviembre de 2017;88(11):1016-23.

49. Lynch JH, Deaton TG. Barotrauma With Extreme Pressures in Sport: From Scuba to Skydiving. Curr Sports Med Rep. abril de 2014;13(2):107.

50. Barthel C, Halvachizadeh S, Gamble JG, Pape HC, Rauer T. Recreational Skydiving—Really That Dangerous? A Systematic Review. Int J Environ Res Public Health. enero de 2023;20(2):1254.

51. Barthel C, Halvachizadeh S, Gamble JG, Pape HC, Rauer T. Recreational Skydiving—Really That Dangerous? A Systematic Review. Int J Environ Res Public Health. 10 de enero de 2023;20(2):1254.

52. Kim S, Endres NK, Johnson RJ, Ettlinger CF, Shealy JE. Snowboarding Injuries: Trends Over Time and Comparisons With Alpine Skiing Injuries. Am J Sports Med. abril de 2012;40(4):770-6.

53. Bigdon SF, Hecht V, Fairhurst PG, Deml MC, Exadaktylos AK, Albers CE. Injuries in alpine summer sports - types, frequency and prevention: a systematic review. BMC Sports Sci Med Rehabil. 1 de mayo de 2022;14(1):79.

54. Bigdon SF, Hecht V, Fairhurst PG, Deml MC, Exadaktylos AK, Albers CE. Injuries in alpine summer sports - types, frequency and prevention: a systematic review. BMC Sports Sci Med Rehabil. 1 de mayo de 2022;14:79.

55. Bohyn C, Flores DV, Murray T, Mohr B, Cresswell M. Imaging Review of Snowboard Injuries. Semin Musculoskelet Radiol. febrero de 2022;26(01):054-68.

56. Vernillo G, Pisoni C, Thiébat G. Physiological and Physical Profile of Snowboarding: A Preliminary Review. Front Physiol [Internet]. 2018 [citado 25 de septiembre de 2023];9. Disponible en: https://www.frontiersin.org/articles/10.3389/fphys.2018.00770

57. Gatterer H, Dünnwald T, Turner R, Csapo R, Schobersberger W, Burtscher M, et al. Practicing Sport in Cold Environments: Practical Recommendations to Improve Sport Performance and Reduce Negative Health Outcomes. Int J Environ Res Public Health. enero de 2021;18(18):9700.

58. Spittler J, Gillum R, DeSanto K. Common Injuries in Whitewater Rafting, Kayaking, Canoeing, and Stand-Up Paddle Boarding. Curr Sports Med Rep. octubre de 2020;19(10):422.

59. Nathanson AT, Young JMJ, Young C. Pre-Participation Medical Evaluation for Adventure and Wilderness Watersports. Wilderness Environ Med. 1 de diciembre de 2015;26(4, Supplement):55-62.

60. Kauling RM, Rienks R, Cuypers JAAE, Jorstad HT, Roos-Hesselink JW. SCUBA Diving in Adult Congenital Heart Disease. J Cardiovasc Dev Dis. enero de 2023;10(1):20.

61. Sharma RI, Marcinkowska AB, Mankowska ND, Waśkow M, Kot J, Winklewski PJ. Cognitive Functions in Scuba, Technical and Saturation Diving. Biology. febrero de 2023;12(2):229.

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