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The impact of paragliding on human health - literature review

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Abstract

Purpose of research: Paragliding is a popular extreme sport offering physical and mental benefits but posing significant injury risks. This study analyzes its health impact, focusing on benefits, risks, and epidemiological trends.

Research materials and methods: A literature review was conducted using PubMed, ResearchGate, and Google Scholar. Keywords included: “paragliding”, “health”, “epidemiology”, "injuries". Studies on injury patterns, fatalities, and health effects were analyzed.

Basic results: Paragliding enhances cardiovascular fitness, cognitive function, and stress resilience. However, the sport carries a high risk of injuries, primarily affecting the lower extremities and spine. Epidemiological studies show regional variations in accident rates, with fatalities often linked to pilot error and weather conditions.

Conclusions: While paragliding offers health benefits, its risks necessitate strict safety measures, training, and protective gear. Future research should focus on injury prevention, long-term health effects, and improved safety strategies to balance the sport’s benefits with risk management.

Keywords: paragliding; health; injuries; physical health; mental health

1. Introduction

Paragliding is a rapidly growing extreme sport that is gaining increasing popularity worldwide. It is estimated that around 127,000 pilots actively engage in the sport globally, with 16,798 registered members in the Swiss Paragliding Association in 2018 (Soldati et. al. 2022). This sport allows for free flight without the use of an engine while also posing challenges both physically and mentally (Wilkes et. al. 2018). Although its appeal stems from the accessibility of equipment and the ability to fly in diverse terrains, paragliding carries significant risks of accidents and injuries, particularly during takeoff, flight, and landing phases (Bohnsack and Schröter 2005, Rekand 2012).

The risk of injury varies by region, with different countries reporting distinct epidemiological trends. In Turkey, a study conducted in the Babadağ region, a popular paragliding site, found that between 2014 and 2021, there were 611 recorded accidents, with an annual incidence rate of 1.85 per 1,000 flights. The most common injuries included fractures of the lower extremities (39.2%) and spinal injuries (22.6%), with fatalities accounting for 2.8% of total accidents (Karakoyun and Golcuk 2003). Similarly, in Austria, between 2006 and 2015, 1,856 aviation sports crashes were recorded in mountainous regions, involving 2,037 individuals. Paragliding accounted for 88% of these incidents, with most injuries affecting the lumbar spine (32%) and multiple trauma occurring in 35% of cases (Ströhle et. al. 2020). These statistics highlight the considerable risks associated with the sport, particularly in regions with challenging topography and variable weather conditions.

Paragliding affects the human body in various ways. Pilots are exposed to high G-forces, extreme weather conditions, and reduced oxygen levels at high altitudes (Wilkes et. al. 2018). While the sport itself does not require intense aerobic effort, takeoff and landing demand physical strength and coordination (Wilkes et. al. 2018, Wilkes et. al. 2022). Engaging in paragliding can contribute to improved mental health by reducing stress and enhancing resilience in situations that require rapid decision-making (Bohnsack and Schröter 2005). However, the risk of injury is high—most commonly involving fractures of the lower limbs, spinal injuries, and head trauma (Feletti et. al. 2017, Lengwiler 2020). Fatal accidents are usually caused by pilot errors, adverse weather conditions, or the failure to deploy a reserve parachute in time (Wilkes et. al. 2022, Wilkes et. al. 2021). Paragliding offers a range of physiological and psychological benefits, making it an attractive activity for both recreational enthusiasts and professional athletes. While primarily considered an extreme sport, its unique characteristics provide various health advantages, including improvements in cardiovascular function, mental well-being, and physiological adaptation to environmental stressors.

2. Materials and methods

The objective of this study is to provide a comprehensive literature review on the effects of paragliding on the human body. The analysis will assess both the health benefits and risks associated with the sport, which may contribute to improving safety measures and further developing training procedures in this discipline. A review of the literature was carried out in the PubMed, ResearchGate, and Google Scholar databases. The search was conducted using the following keywords: "health", “paragliding”, „injuries”, “epidemiology”.

3. Results

Cardiovascular and Metabolic Benefits

Although paragliding is not a high-intensity aerobic activity, it still imposes certain cardiovascular demands, particularly during takeoff and landing. Wilkes et al. reported that heart rate (HR) is significantly elevated during these phases, with mean HR reaching 112 beats per minute (bpm) at extreme altitudes and 98 bpm at moderate altitudes, indicating increased cardiovascular activation (Wilkes et. al. 2018). These findings suggest that, despite its relatively low overall metabolic demand, paragliding can contribute to cardiovascular fitness by engaging the heart and circulatory system in intermittent bouts of exertion. Another study by Agirbas et al. investigated the acute effects of paragliding on serum lipid profiles. Although no significant changes in triglyceride (TG), high-density lipoprotein (HDL), or low-density lipoprotein (LDL) levels were observed after a single paragliding session, the results indicate that extreme sports like paragliding may still promote lipid metabolism and cardiovascular health over time (Agirbas et. al 2018). Regular exposure to moderate physical exertion during takeoff and flight control could contribute to long-term cardiovascular conditioning.

Psychological and Cognitive Benefits

Engagement in paragliding is associated with significant psychological benefits, primarily due to the combination of outdoor exposure, risk management, and decision-making under pressure. Wilkes et al. highlighted the cognitive demands of paragliding, particularly in navigating thermals, monitoring altitude, and responding to rapidly changing environmental conditions. The sport requires continuous spatial awareness, strategic thinking, and rapid reaction times, all of which may enhance cognitive function and resilience (Wilkes et al. 2017).

Moreover, exposure to natural landscapes and the sensation of flight have been linked to stress reduction and enhanced mental well-being. The meditative aspect of free flight, combined with the excitement of controlled risk, can lead to increased levels of endorphins and adrenaline, which are associated with improved mood and emotional stability. This aligns with previous research on adventure sports, which suggests that controlled exposure to risk and novelty can serve as an effective mechanism for reducing anxiety and enhancing psychological resilience (Wilkes et. al. 2018).

Physiological Adaptation to Environmental Stressors

Paragliding frequently exposes pilots to environmental conditions that challenge the body's physiological homeostasis. At higher altitudes, hypobaric hypoxia—a state of reduced oxygen availability—triggers adaptations in oxygen transport and utilization. Wilkes et al. found that pilots at extreme altitudes (up to 7,458 meters) experienced a significant increase in heart rate and respiratory frequency compared to those flying at moderate altitudes, suggesting an acute physiological response to hypoxia (Wilkes et. al. 2018). Over time, repeated exposure to such conditions may enhance the body's ability to adapt to lower oxygen levels, improve lung function, and increase red blood cell production, similar to the effects seen in high-altitude mountaineering and endurance sports.Furthermore, cold exposure and wind resistance during flight challenge thermoregulation. The body's response to these stressors—such as increased circulation to maintain core temperature—may contribute to improved endurance and metabolic efficiency over time (Wilkes et. al. 2018). These adaptations are particularly relevant for athletes who participate in other high-altitude or endurance sports, as paragliding can serve as an effective training tool for environmental conditioning.

Risk linked to paragliding

Paragliding, as an extreme sport, carries a risk of various injuries, ranging from minor sprains to severe trauma, depending on factors such as flight conditions, pilot experience, and accident circumstances. The most commonly affected areas include the lower limbs, spine, and head, with injuries often occurring during takeoff and landing. Below is a collection of studies that describe the risks and injury patterns associated with paragliding, providing insights into the most common trauma mechanisms and their implications for safety. Several studies have explored the characteristics and outcomes of injuries related to paragliding accidents. Rekand reviewed the epidemiology of hang-gliding and paragliding injuries, though the data were not disaggregated specifically for paragliders. Nevertheless, the review highlighted that paragliding accidents predominantly involve injuries to the thoracolumbar spine and lower extremities, often due to hard landings. Head injuries, while less frequent, can be severe and include intracranial hematomas or skull base fractures. Prognosis largely depends on the fall's height and any spinal cord involvement, with emphasis on early spinal stabilization to prevent secondary damage and the risk of lasting neurological deficits in multisystem trauma (Rekand 2017). Cevik et al. analyzed 41 patients from various aerial sports, including paragliding. Though the paragliding subgroup was not separated, common injuries involved lower extremity fractures (notably tibia and ankle) and lumbar spine compression fractures due to falls from height. No fatalities were reported, and most cases required only short hospital stays or conservative treatment. Recovery was generally favorable, with orthopedic intervention tailored to the complexity of the fractures (Cevik et al. 2017). Feletti et al. provided data from the UK on 1,411 incidents involving foot-launched flying, primarily paragliding and hang-gliding. Injuries mainly affected the spine (thoracic and lumbar), feet, and lower legs—especially the calcaneus and talus bones—typically resulting from poor landings or collisions. Fatal events were rare but involved high-energy trauma. The authors advocated for the use of helmets, back protectors, and better pilot training to reduce the severity of outcomes (Feletti et al. 2017).

Bäcker et al. examined 235 patients in Switzerland injured in aerial sports between 2010 and 2017, with paragliders forming the majority. About 46.5% of injuries involved the spine, particularly the lumbar region, along with chest trauma and lower-limb fractures. Most incidents occurred during takeoff or landing, posing risks for vertebral and multi-limb fractures. There were only two fatalities, while 8.1% of patients required intensive care and 55 underwent urgent surgery (Bäcker et al. 2020). Ströhle et al. analyzed 1,856 accidents (resulting in 2,037 injuries) over 10 years in the Austrian Alps involving various aerial sports, with paragliders comprising a significant subgroup. The most common injuries were multi-trauma involving the spine, pelvis, and thorax. Paragliders frequently sustained thoracolumbar spinal injuries and foot or knee trauma, with some fatalities resulting from high-altitude free falls. The overall mortality rate was approximately 4%. Authors emphasized careful weather assessment and the use of helmets and safe launch practices (Ströhle et al. 2020). Lengwiler et al. described three paragliding-related cases of cranial nerve palsies in Switzerland caused by head trauma. All patients had skull base fractures affecting cranial nerves IV and VI, resulting in diplopia and restricted eye movement. One required neurosurgical-ophthalmic care, while others were treated conservatively. Outcomes were only partially favorable, demonstrating that helmets alone may not fully prevent internal cranial nerve injuries (Lengwiler et al. 2020). In a separate study, Bäcker et al. analyzed 44 patients with sacral fractures from airborne sports, primarily paragliding. Of these, 16 had spinopelvic dissociation—a severe form of injury often accompanied by neurological deficits. These cases had significantly higher injury severity scores (ISS 38.1 vs. 20.4), and 87.5% required surgical stabilization. The study emphasized the need for rapid recognition and surgical management of complex pelvic fractures (Bäcker et al. 2020). Wilkes et al. conducted a large-scale survey involving 1,788 paragliding pilots and 96,000 flights, also analyzing 1,296 incident reports. Approximately 6% of respondents reported injuries requiring medical attention, typically lower-limb fractures and spinal trauma. Fatalities were rare (~1.4 per 100,000 flights), with most injuries linked to landing errors, asymmetric collapses, or rotational forces. The authors recommended continued pilot training, the use of reserve parachutes, and increased risk awareness (Wilkes et al. 2022). Baral et al. studied 76 licensed tandem para-pilots in Nepal, focusing on otolaryngological effects of altitude changes. Thirteen percent experienced middle-ear barotrauma, but no orthopedic or spinal injuries were reported. Most conditions were mild and managed conservatively, with emphasis on pilot education and altitude equalization techniques (Baral et al. 2022). Finally, Bigdon et al. performed a systematic review on injuries in summer mountain sports, including paragliding. Although data specific to paragliding were not isolated, the review found that major injuries typically involved thoracolumbar spine and lower-limb fractures. While the fatality rate was low, the risk of severe trauma was significant. Recommendations included helmets, back protectors, and environmental risk assessments prior to flight (Bigdon et al. 2022). In one of the largest-scale studies, Karakoyun and Golcuk analyzed 241,420 paragliding flights from Mount Babadağ (Turkey) in 2020–2021. There were 44 recorded accidents, including three fatalities. Most incidents occurred during takeoff or landing, but the fatal crashes resulted from mid-air events and altitude loss. Lower-extremity injuries were most common (55.8%), followed by upper-extremity trauma (30.8%). The overall accident rate was low (~0.018%), and improved training and equipment checks were credited with reducing serious outcomes (Karakoyun and Golcuk 2023).

Case reports relevant to paragliding

Omori et al. described a 64-year-old paraglider pilot who fell from approximately 10 meters and sustained a thoracic aortic injury that required endovascular stent grafting, demonstrating that even a moderate-height crash can produce life-threatening vascular lesions (Omori et al. 2017). Similarly, Niu et al. reported a case in which a patient with a cervical artificial disc at the C4–C5 level experienced implant extrusion following paragliding trauma; the abrupt axial load necessitated explantation and subsequent anterior cervical fusion, thereby illustrating how sudden compressive forces can jeopardize the stability of spinal implants (Niu et al. 2017). Chan et al. presented a case of acute coronary syndrome in a paraglider after blunt chest trauma, where coronary artery damage led to myocardial ischemia and required percutaneous coronary intervention (PCI), underscoring that chest impacts in paragliding can trigger unexpected cardiac complications (Chan et al. 2021). Pereira et al. detailed the case of a 52-year-old man who, after sustaining two separate paragliding crashes, developed sequential cervical fractures at the C4–C5 and subsequently C6–C7 levels; multiple surgeries, including combined anterior and posterior stabilization procedures, were necessary, and although the patient ultimately survived, the case exemplifies the cumulative spinal harm that can result from repeated paragliding accidents (Pereira et al. 2021). Jud et al. reported on a 45-year-old paraglider who, after being caught in a thunderstorm at an altitude of approximately 6000 meters and exposed to temperatures of around –25°C for about 45 minutes, developed second-degree frostbite of the hands characterized by blistering; aggressive warming and vasodilatory therapy enabled complete tissue salvage (Jud et al. 2019). In another case, Bulut et al. described an 18-year-old who sustained a complex foot injury—comprising fractures of the talus, navicular, and calcaneus—following a paragliding accident; surgical reduction and internal fixation resulted in favorable functional recovery at 36 months, representing a rare instance of multi-tarsal injuries from a relatively low-height fall (Bulut et al. 2018). Bakoń et al. reported an atypical exfoliative-type thoracic aortic rupture in a paraglider pilot who, despite exhibiting only minor external trauma, was found on computed tomography to have an aortic tear that required endovascular repair, thereby emphasizing that major vascular injuries can be occult initially (Bakoń et al. 2019). Finally, Sago et al. presented a catastrophic case in which a paramotor paraglider pilot collided with a propeller, resulting in a massive cranial defect and severe head/brain injury; treatment included partial brain resection and omental flap coverage, and although the patient survived, profound neurological deficits persisted (Sago et al. 2023).

The collective literature on paragliding injuries indicates that the most frequent trauma involves the spine and lower extremities, with the thoracolumbar region being particularly vulnerable to fractures resulting from abrupt, uncontrolled landings. Studies consistently report that spinal injuries, sometimes accounting for nearly half of all trauma cases in certain cohorts, and fractures of the lower limbs (including tibial, ankle, and foot injuries) are predominant in paragliding accidents (Rekand 2012, Ströhle et. al. 2020, Bäcker et al. 2020). Although head injuries occur less frequently, they can be severe—manifesting as intracranial hemorrhage or skull base fractures—with potential for lasting neurological impairment if not promptly managed (Rekand 2012). In large-scale analyses, overall mortality remains low (ranging from under 1% to approximately 4%), yet significant morbidity is observed among those sustaining complex injuries such as spinopelvic dissociation, which is associated with high injury severity scores and considerable rates of neurological deficits (Bäcker et al. 2020). Beyond orthopedic trauma, a spectrum of non-orthopedic complications has been documented. For example, incidents of middle-ear barotrauma, reported in approximately 13.2% of cases in one study, highlight additional risks related to rapid altitude changes (Baral et. al. 2022). Isolated case reports further underscore that even moderate falls can precipitate life-threatening vascular injuries, implant extrusions in patients with pre-existing spinal devices, acute coronary syndromes following blunt chest trauma, and catastrophic cranial injuries (Omori et al. 2017, Niu et al. 2017, Chan et. al. 2021, Bakon et.al. 2019, Sago et. al 2023) A recent forensic analysis in the Canton of Berne further contextualizes these findings by examining fatalities from foot-launched flying sports over an 18-year period. In this study, 39 fatalities were documented in 37 cases, with paragliding accounting for 69% of deaths, followed by speedflying (18%) and hang gliding (13%). The data showed that helmet usage was confirmed in 72% of cases, yet rescue parachutes were deployed in only 22% of incidents, and successful full deployment was even rarer. The deadliest phase was mid-flight, where glider collapse accounted for 24% of accidents (36% among paragliders), highlighting the critical importance of both equipment integrity and pilot decision-making during flight (Soldati et. al. 2022). These findings collectively underscore the importance of comprehensive safety measures in paragliding.

Preventive strategies emphasized across the literature include rigorous pilot training, thorough pre-flight weather assessments, regular equipment inspections, and the consistent use of protective gear such as helmets and back protectors. Additionally, the integration of advanced emergency response protocols has been critical in mitigating the severity of outcomes, despite the inherent risks of the sport (Karakoyun and Golcuk 2023, Feletti et. al. 2017, Wilkes et. al. 2022, Bigdon et. al. 2022).

Summary

Paragliding provides significant cardiovascular and psychological benefits, enhancing heart function through intermittent exertion during takeoff and landing while also promoting stress relief, cognitive function, and mental resilience due to exposure to natural landscapes and controlled risk (Wilkes et. al. 2018, Wilkes et. al. 2017). Additionally, regular exposure to high-altitude conditions contributes to improved oxygen transport and lung function, which may benefit endurance athletes by enhancing environmental stress adaptation (Wilkes et. al 2018). However, despite these benefits, paragliding presents notable injury risks, with the thoracolumbar spine and lower extremities being the most commonly affected areas due to hard landings or mid-flight accidents. Although head injuries occur less frequently, they can be severe and lead to lasting neurological impairment (Rekand 2012, Ströhl et. al. 2020, Bäcker et. al 2020). While the fatality rate remains relatively low (1–4%), the severity of certain injuries, particularly spinal fractures and multi-system trauma, contributes to significant morbidity. Mid-flight accidents, especially those involving glider collapses, account for the most severe outcomes (Soldati et. al. 2022, Wilkes et. al. 2022, Lengwiler et. al. 2020). Consequently, preventive strategies play a crucial role in mitigating risks. Measures such as rigorous pilot training, pre-flight weather assessments, regular equipment inspections, and consistent use of protective gear, including helmets and back protectors, are essential for reducing injury severity. Additionally, emergency response preparedness significantly enhances survival rates and recovery outcomes (Karakoyun and Golcuk 2023, Feletti et. al. 2017, Wilkes et. al. 2022, Bigdon et. al. 2022).

4. **Conclusions**

Paragliding positively impacts human health by enhancing cardiovascular fitness, promoting psychological well-being, and facilitating physiological adaptations to environmental stressors. However, it also presents significant injury risks, particularly to the thoracolumbar spine and lower extremities, with mid-flight accidents being the most dangerous. While overall fatality rates are low, severe injuries can lead to long-term morbidity. Effective risk mitigation requires rigorous pilot training, pre-flight assessments, equipment maintenance, and the use of protective gear. Overall, while paragliding offers substantial health benefits, its inherent risks necessitate ongoing advancements in safety protocols, pilot education, and emergency management to minimize injury rates and improve overall sport safety. Investigating the long-term effects of paragliding-related injuries and evaluating the effectiveness of current safety equipment could lead to more comprehensive risk reduction strategies. A multidisciplinary approach involving sports medicine, biomechanics, and aviation safety experts is essential to ensure continued improvements in both performance and injury prevention.

Disclosure

Author Contribution Statement

Conceptualization: MW, KK; methodology: MW, KK, AW; software: n/a; check: MW, KK, JG, MP, KD, KS, AR; formal analysis: MW, DS; investigation: MW, KK, JG, MP, KD, KS, DS, AR, AW, PZ, KB; resources: MW; data curation: MW, MP, KD, KB, PZ; writing - rough preparation: MW, KK, JG, MP, KD, KS, AR, AW, PZ, KB, DS; writing - review and editing: MW, KK, AR; visualization: MW, AW; supervision: MW, AR, DS; project administration: MW; receiving funding: n/a. All authors have read and agreed with the published version of the manuscript.

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