*Issue Rehabil. Orthop. Neurophysiol. Sport Promot. 2025; 51: 15–27.* ISSN 2300-0767
*DOI: 10.19271/IRONS-000226-2025-51*

REVIEW ARTICLE

# WHAT DO WE KNOW ABOUT WINDSURFING INJURIES? INSIGHTS FROM TRADITIONAL OLYMPIC CLASSES AND FUTURE PERSPECTIVES FOR IQFOIL – SYSTEMATIC REVIEW

# CO WIEMY O USZKODZENIACH NARZĄDU RUCHU W WINDSURFINGU? WNIOSKI Z TRADYCYJNYCH KLAS OLIMPIJSKICH I PERSPEKTYWY DLA IQFOIL – PRZEGLĄD SYSTEMATYCZNY

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ABSTRACT

**Objective**

The purpose of this study was to systematically review the literature regarding injury definitions, localization, incidence in windsurfing and related sailing disciplines, with particular emphasis on implications for the new Olympic iQFOiL class.

**Methods**

Three electronic databases – PubMed, Scopus and Web of Science – were searched for relevant studies up to 15 April 2025. Peer-reviewed articles in English assessing injury epidemiology in windsurfing, sailing, or hydrofoil-based classes were included. Studies were excluded if they were duplicates, inaccessible in full text, not related to sport disciplines, or lacking injury data.

**Results**

From 563 initially retrieved articles, seven studies were included. Injury definitions varied considerably and were applied inconsistently, with most studies relying on retrospective self-reported questionnaires of limited methodological quality. The lower extremities, shoulders, and lumbar spine were the most commonly affected anatomical regions. The incidence of injuries ranged from 1.5 injuries per athlete per year in traditional windsurfing to 7.0 injuries per 1000 hours in kitesurfing.

**Conclusion**

Musculoskeletal injuries are common in windsurfing and related foiling sports, with distinct injury profiles between traditional displacement-based boards and hydrofoil-supported classes. The transition to iQFOiL is likely to shift the injury burden from overuse toward acute trauma, especially in the lower limbs. Given the lack of standardized definitions and prospective surveillance, the current evidence base is insufficient to establish robust risk models or targeted prevention strategies. Future research should implement longitudinal,

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Authors reported no source of funding
Authors declared no conflict of interest

Date received: 21.04.2025
Date revised: 10.09.2025
Date accepted: 12.09.2025
Final review: 12.09.2025

standardized injury surveillance and develop evidence-based, sport-specific prevention programs tailored to the unique biomechanical demands of iQFOiL.

**Keywords:** review, epidemiology, injury, windsurfing, hydrofoiling

STRESZCZENIE

**Cel**

Celem niniejszego badania był systematyczny przegląd literatury dotyczącej definicji uszkodzeń, ich lokalizacji oraz częstości występowania w windsurfingu i pokrewnych dyscyplinach żeglarskich, ze szczególnym uwzględnieniem implikacji dla nowej olimpijskiej klasy iQFOiL.

**Metody**

Trzy elektroniczne bazy danych – PubMed, Scopus i Web of Science – zostały przeszukane pod kątem odpowiednich badań do 15 kwietnia2025 roku. Uwzględniono recenzowane artykuły w języku angielskim dotyczące epidemiologii uszkodzeń narządu ruchu w windsurfingu, żeglarstwie lub klasach opartych na hydrofoilu. Wykluczono badania powtarzające się, niedostępne w pełnym tekście, niezwiązane z dyscyplinami sportowymi lub pozbawione danych o uszkodzeniach.

**Wyniki**

Spośród 563 początkowo zidentyfikowanych artykułów włączono siedem badań. Definicje uszkodzeń różniły się znacząco i były stosowane w sposób niespójny; większość badań opierała się na retrospektywnych, samodzielnie raportowanych kwestionariuszach o ograniczonej jakości metodologicznej. Najczęściej dotkniętymi obszarami anatomicznymi były kończyny dolne, barki oraz odcinek lędźwiowy kręgosłupa. Częstość występowania uszkodzeń wahała się od 1,5 uszkodzenia na zawodnika rocznie w tradycyjnym windsurfingu do 7,0 uszkodzeń na 1000 godzin w kitesurfingu.

**Wnioski**

Uszkodzenia układu mięśniowo-szkieletowego są powszechne w windsurfingu i pokrewnych sportach foilingowych, przy czym profile urazów różnią się między deskami opartymi na wyporności a klasami wspieranymi hydrofoilem. Przejście do iQFOiL prawdopodobnie przesunie obciążenie urazowe z przewlekłych urazów przeciążeniowych w kierunku ostrych uszkodzeń, szczególnie dotyczących kończyn dolnych. Ze względu na brak ustandaryzowanych definicji i prospektywnego monitoringu, obecna baza dowodowa jest niewystarczająca do stworzenia solidnych modeli ryzyka lub ukierunkowanych strategii profilaktycznych. Przyszłe badania powinny obejmować długoterminowe, standaryzowane systemy nadzoru nad uszkodzeniami oraz opracowywać oparte na dowodach, specyficzne dla danej dyscypliny programy profilaktyczne dostosowane do unikalnych wymagań biomechanicznych iQFOiL.

**Słowa kluczowe:** epidemiologia, przegląd, windsurfing, hydrofoiling

## Introduction

Windsurfing has been represented at the Olympic Games since 1984, with several equipment classes used over the years, including Windglider, Lechner, Mistral, and RS:X. Each transition reflected both technological advancements and evolving perspectives on athletic performance in the discipline. The RS:X class, introduced in 2008, remained

the Olympic standard until the Tokyo 2020 Games, where it was raced for the last time. Beginning with the Paris 2024 Olympics, the iQFOiL class replaces RS:X, marking a turning point in Olympic windsurfing by incorporating hydrofoil technology (Sailing Federation, 2022). This change not only modernizes the sport but also fundamentally alters its physiological, technical and biomechanical demands.

Epidemiological evidence from windsurfing classes has documented a range of injury characteristics (Minghelli *et al.*, 2019; Penichet-Tomás *et al.*, 2012; Tan *et al.*, 2016). Overuse injuries were the most frequently reported, particularly affecting the lumbar spine, shoulders, and knees, largely as a consequence of repetitive pumping, prolonged static postures, and asymmetric loading during maneuver execution (Minghelli *et al.*, 2019). Acute injuries were less common but typically related to falls at high speed, collisions with equipment, or environmental factors such as strong wind or waves. Risk factors identified in traditional windsurfing included high training volumes, inadequate recovery, technical errors, and limited experience (van Bergen *et al.*, 2016).

The introduction of hydrofoil technology in iQFOiL represents a paradigm shift for windsurfing. Unlike RS:X, where propulsion and speed were strongly dependent on intensive pumping, hydrofoiling relies on lift generated by the submerged foil, allowing the board to rise above the water surface (Sfakianaki and Tzabiras, 2015). This reduces hydrodynamic drag, increases speed potential, and lowers the physical burden of continuous pumping. However, these benefits are accompanied by new risk factors. Higher velocities in lighter wind conditions, altered postural control above the water, and foil-induced instability create a different biomechanical profile, potentially decreasing the prevalence of some traditional overuse injuries but increasing susceptibility to acute trauma, particularly in the lower limbs. Moreover, the learning process required for mastering new movement patterns may temporarily elevate injury risk, especially among athletes transitioning from RS:X with ingrained motor habits (Webborn, 2012). During this adaptation period – unique for each individual – the body gradually develops mechanical efficiency while learning how to prevent injuries specific to the new discipline. This process typically requires increased energy expenditure and longer recovery times, which, if not properly balanced, may further elevate the risk of injury (Giles, 2011). Additionally, a low skill level and limited experience in the sport represent important risk factors for injuries during this transition phase (Dyson *et al.*, 2006; Feletti *et al.*, 2021).

Given the absence of published studies on injury epidemiology in the iQFOiL class, a substantial knowledge gap remains regarding the health and performance implications of this technological shift. The primary aim of this review is to synthesize the existing literature on windsurfing-related injuries, including those from traditional Olympic classes, in order to analyze their epidemiology and relevance to iQFOiL. By summarizing current evidence and identifying areas where data are lacking, this review seeks to establish a foundation for future research and to inform the development of evidence-based injury prevention strategies in the evolving context of Olympic windsurfing.

**Methods**

The methodology was in according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page *et al.*, 2020).

The objective of this systematic review is to identify, summarize, and critically analyze the available evidence on injury epidemiology in Olympic windsurfing. Specifically, the review addresses the following research questions: what are the reported characteristics and risk factors of injuries (outcome) among competitive windsurfers, including athletes from Olympic classes (patients).

A systematic literature review was conducted to identify publications related to

injuries in professional Olympic-class windsurfing, with a particular focus on the iQFOiL discipline. The search included all records published up to **15 April 2025.** Three major electronic databases were queried: **PubMed, Web of Science, and Scopus.**

*Search strategy*

Initially, the databases were searched using the keywords *"injury AND iQFOiL"*. This search did not yield any records. Consequently, the search strategy was broadened, and the final formula adopted was *"injury AND (iQFOiL OR sailor OR windsurfing)"*, with the results restricted to publications classified as articles.

*Inclusion and exclusion criteria*

Given that the initial database search did not identify any records concerning injuries in the Olympic windsurfing class iQFOiL, the scope of the review was expanded to include two categories of studies: (1) articles addressing injuries in windsurfing, and (2) articles addressing injuries in sailing foiling classes. Only peer-reviewed, English-language articles reporting windsurfing-related injuries were eligible for inclusion. Studies were excluded if they were duplicates, if the full text was inaccessible, or if they were not available in English. Four studies were excluded due to lack of free access to full-text because of no founding and any financial support of this study.

*Article selection*

The article selection process was conducted in four phases – **Identification, Screening, Eligibility, and Inclusion** – in accordance with the PRISMA systematic review strategy (Page *et al.,* 2021). The results of each phase are presented in a PRISMA-style flow diagram. Records were initially identified through database searches and subjected to pre-screening. Duplicate entries were removed prior to screening. The remaining records were screened based on titles and abstracts to determine their relevance before progressing to the eligibility phase, during which full-text articles were assessed against the inclusion and exclusion criteria. Titles, abstracts, and full texts were screened independently by two of the authors (AB and MG). Studies not meeting the predefined eligibility criteria were excluded. In cases of disagreement regarding study inclusion or exclusion, discussions were undertaken to reach consensus.

*Data extraction*

From each included study, the following data were extracted: authors, year of publication, study title, water sport discipline, study design, participant characteristics and inclusion criteria, type of intervention (including follow-up period, injury definition, and severity expressed in time-loss hours), comparator (if applicable), outcomes (results and statistical analyses), and reported study limitations.

**Results**

The search yielded 52 records in PubMed, 186 in Web of Science, and 325 in Scopus, resulting in a total of 563 entries. After removing duplicates, 433 records remained. Abstracts were then screened, and 278 publications were excluded as they were not related to sport. Specifically, studies were removed if abstracts contained keywords referring to military contexts (e.g., *military, navy, seafarers, cadets*), maritime environments unrelated to sport (*marine, maritime, fishermen*), war- or accident-related injuries (*war, post-traumatic, casualties*), illness (*illness*), or technical descriptions of equipment. Conference abstracts were also excluded. At this stage, 155 publications remained. After restricting the time frame to 2005–2025, the number was reduced to 65. The final selection included only studies directly addressing injuries in windsurfing and sailing foil classes, which resulted in 7 articles being incorporated into the review (Figure 1).

*Patient characteristics*

Study populations varied widely in size and composition (Table 1). Samples ranged from 18 elite female windsurfers competing at the 2008 Windsurfing World Cup to 760 elite

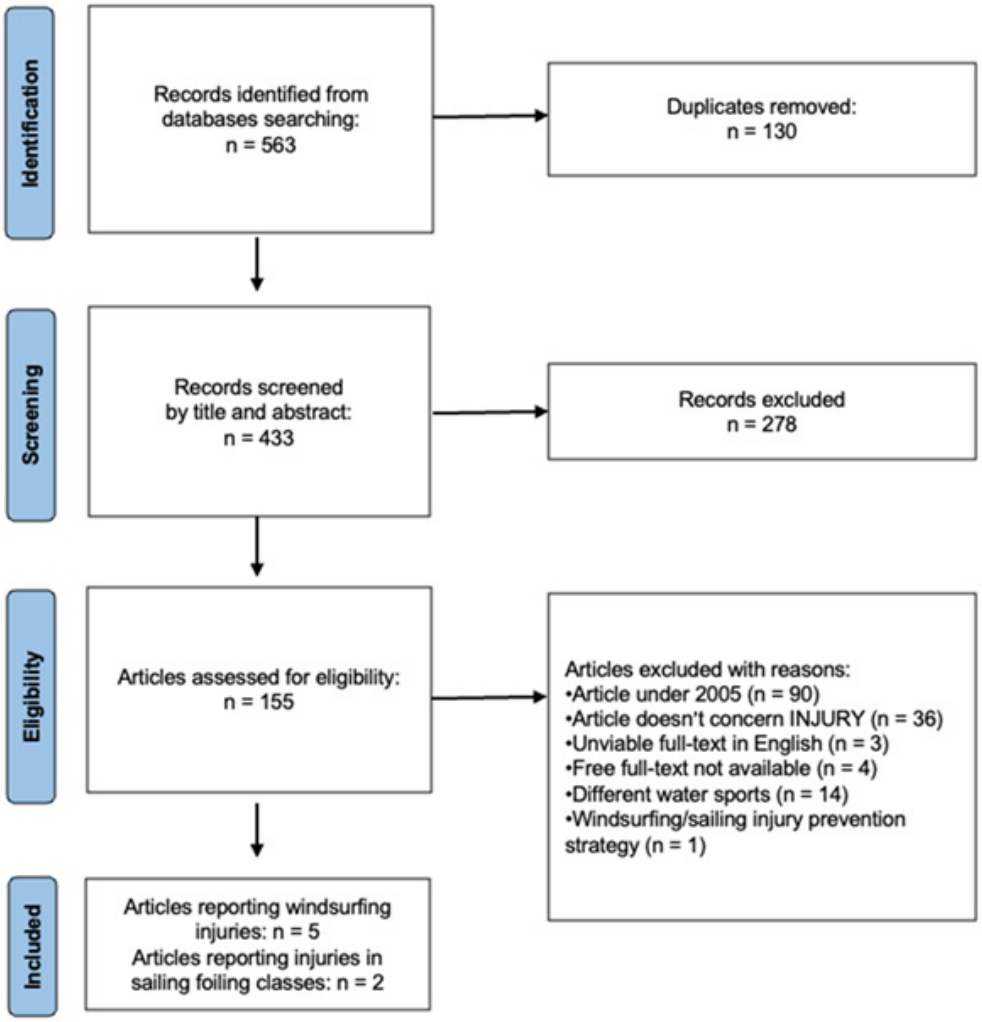


**Figure 1.** PRISMA ow chart of the literature screening. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

sailors across 10 Olympic classes at the 2014 World Championships. Several studies recruited mixed-level athletes, including 107 international windsurfers subdivided into race board, wave slalom, and recreational groups, and 87 championship competitors in race board and windsurfing formula classes (mean age 45 years, range 14–71). A large online survey included 415 wingfoilers (356 men, 59 women; mean age approximately 42 years), of whom 25% were beginners, 55% advanced, and 20% highly experienced. Smaller cohorts included 77 dinghy sailors (91% male), distributed across single-, double-, and three-person boats, and a hospital-based sample of 57 athletes with sailing-related injuries, comprising 25 windsurfers (mean age 31 ± 8 years) and 32 kitesurfers (mean age 29 ± 11 years). Overall, populations spanned elite Olympic-level competitors, club and recreational sailors, and general sport participants, with a broad age range from adolescents to older adults (14–71 years) and varying levels of competitive experience.

*Study design*

The studies were primarily descriptive epidemiological and retrospective in nature, with data collected through questionnaires or medical record reviews. Observation periods varied, including 12-month (Gangl *et al.,* 2023; Minghelli *et al.,* 2019) and 24-month

questionnaire-based surveys (Penichet-Tomás *et al.,* 2012), as well as defined retrospective analyses of hospital records (e.g. windsurfing and kitesurfing injuries between 2009 and 2011, and regatta-related data collected between June and September 2014). One study used researcher-led interviews with questionnaires conducted prospectively over a 12-month period (Minghelli *et al.,* 2019). In another study, data were collected retrospectively from all patients with windsurfing- or kitesurfing-related injuries who presented to the hospital between September 2009 and September 2011 (van Bergen *et al.,* 2016).

*Inclusion criteria*

Inclusion criteria varied across studies. Some investigations applied no explicit criteria, while others required participation in specific regattas (Feletti *et al.,* 2021), provision of written informed consent, and completion of study questionnaires. Online survey studies allowed participation from any individual who had performed wingfoiling within the previous 12 months (Gangl *et al.,* 2023). Additional criteria included being a championship competitor and having formally agreed to participate (Minghelli *et al.,* 2019; Tan *et al.,* 2016). Several studies, however, did not report their inclusion criteria (Dyson *et al.,* 2006; Penichet-Tomás *et al.,* 2012).

*Injury definition*

Injury definitions lacked standardization. Some defined injury broadly as any musculoskeletal complaint causing pain, dysfunction, medical attention, or time-loss (Minghelli *et al.,* 2019; Tan *et al.,* 2016), while others provided no operational definition (Dyson *et al.,* 2006; Feletti *et al.,* 2021; Gangl *et al.,* 2023; Penichet-Tomás *et al.,* 2012; van Bergen *et al.,* 2016). Severity reporting was inconsistent; exposure data were sometimes presented as injuries per 1000 sailing hours (Tan *et al.,* 2016; van Bergen *et al.,* 2016), though not uniformly across studies.

*Injury characteristics*

Injury characteristics showed variability in incidence and prevalence. Reported values ranged from 1.5 injuries per athlete per year among windsurfers (Dyson *et al.,* 2006) to 7.0 injuries per 1000 hours in kitesurfing (van Bergen *et al.,* 2016), with prevalence up to 64% in Olympic dinghy classes (Tan *et al.,* 2016). Across studies, the most common injury types were muscle/tendon strains, sprains, contusions, and tendinopathies (Dyson *et al.,* 2006; Gangl *et al.,* 2023; Minghelli *et al.,* 2019; Penichet-Tomás *et al.,* 2012; Tan *et al.,* 2016), with frequent locations including the knee, ankle/foot, lower leg, shoulder, and lumbar spine (Dyson *et al.,* 2006; Gangl *et al.,* 2023; Minghelli *et al.,* 2019; Penichet-Tomás *et al.,* 2012; Tan *et al.,* 2016). Mechanisms most often involved maneuvers, contact with equipment (hydrofoil, board, ropes), rapid body movements, or environmental factors (Feletti *et al.,* 2021; Gangl *et al.,* 2023; Minghelli *et al.,* 2019).

*Applied statistics*

Statistical analyses were predominantly descriptive, supplemented by $\chi^2$ tests, Fisher's exact test, t-tests, or Mann–Whitney U-tests depending on data distribution (Dyson *et al.,* 2006; Feletti *et al.,* 2021; Gangl *et al.,* 2023; Minghelli *et al.,* 2019; Penichet-Tomás *et al.,* 2012; Tan *et al.,* 2016; van Bergen *et al.,* 2016). Confidence intervals related to injury rates were assessed using the Wilson score interval method (Feletti *et al.,* 2021).

*Intervention and follow-up*

Most studies used questionnaires as the primary data collection tool. The majority applied them only once, with no follow-up. Only one study incorporated limited follow-up, with assessments conducted before and after each of three sailing events (Feletti *et al.,* 2021).

*Main study limitations*

Study limitations included small sample sizes (Feletti *et al.,* 2021; Penichet-Tomás *et al.,* 2012; van Bergen *et al.,* 2016), recall and self-report

bias (Gangl *et al.,* 2023; Minghelli *et al.,* 2019; Penichet-Tomás *et al.,* 2012), absence of medical verification (Minghelli *et al.,* 2019), and restricted recruitment settings such as single regattas or hospitals (Tan *et al.,* 2016; van Bergen *et al.,* 2016), all of which limited external validity.

**Discussion**

The findings of this review indicate that musculoskeletal injuries are common across windsurfing, sailing, and foiling disciplines, with incidence rates ranging from approximately 1.5 injuries per athlete per year to 7 injuries per 1000 hours of exposure, depending on the discipline and study design (Dyson *et al.,* 2006; van Bergen *et al.,* 2016). Consistent with broader sports injury epidemiology, the lower extremities, shoulders, and lumbar spine emerged as the most frequently affected anatomical regions (Minghelli *et al.,* 2019; Tan *et al.,* 2016; Gangl *et al.,* 2023). This pattern mirrors earlier evidence from other water-based and board sports such as kitesurfing and dinghy sailing, where repetitive loading of the knee, ankle, and trunk stabilizers is a dominant injury mechanism (Feletti *et al.,* 2021; Penichet-Tomás *et al.,* 2012). Similar distributions have also been reported in surfing and rowing, where the lower back and shoulder girdle are disproportionately affected due to high repetitive forces and postural demands (Nathanson *et al.,* 2002; McGregor *et al.,* 2012). Furthermore, epidemiological reviews of Olympic sailing indicate that acute traumatic injuries frequently coexist with overuse injuries, with the knee, ankle, and lumbar spine consistently identified as high-risk regions (Engebretsen *et al.,* 2013). Collectively, these findings suggest that both repetitive strain and acute trauma contribute substantially to the injury burden in windsurfing and related foiling disciplines, reinforcing the importance of surveillance and targeted prevention strategies.

The predominance of acute injuries in foiling disciplines contrasts with the higher prevalence of overuse injuries traditionally observed in windsurfing, suggesting that the introduction of hydrofoil technology fundamentally alters the biomechanical demands of the sport. Similar observations have been documented in foiling dinghy sailing, where increased velocity, reduced hydrodynamic resistance, and equipment instability predisposed athletes to traumatic rather than repetitive strain injuries (Feletti *et al.*, 2021). This is consistent with evidence from competitive sailing and kitesurfing, where high-speed maneuvers and equipment contact were identified as major mechanisms of acute trauma, often involving the lower extremities and upper limbs (van Bergen *et al.*, 2016; Tan *et al.*, 2016). The present findings that contact with hydrofoils, boards, and rigging accounted for a substantial proportion of acute injuries (Gangl *et al.*, 2023; Minghelli *et al.,* 2019) align with reports from surfing and snowboarding, in which rapid transitions, loss of balance, and high-energy impacts similarly elevate the risk of acute musculoskeletal injury compared to non-foiling disciplines (Nathanson *et al.*, 2002; Bladin *et al.*, 2004). Collectively, these results underscore that hydrofoiling introduces novel risk profiles, shifting the injury burden from overuse syndromes toward acute, traumatic events associated with high speed, instability, and direct equipment contact.

The high prevalence of muscle and tendon strains observed across studies is consistent with other endurance-based sports (running, football), where repetitive propulsion, stabilization, and sudden maneuvering contribute to tissue overload (Dempster *et al.* 2021; Mayhew *et al.,* 2021; Dyson *et al.*, 2006; Penichet-Tomás *et al.,* 2012; Tan *et al.,* 2016). However, the relatively high proportion of contusions, lacerations, and fractures in foiling classes reflects the additional risk of direct equipment contact and high-speed crashes, an injury mechanism less prominent in earlier windsurfing classes (Gangl *et al.*, 2023; Minghelli *et al.*, 2019).

Notably, the heterogeneity of injury definitions, study designs, and populations across

the included studies limited direct comparisons. Most investigations relied on retrospective self-reported questionnaires without standardized severity classification or medical confirmation, leading to potential recall bias and under-reporting of minor injuries (Minghelli *et al.*, 2019; Gangl *et al.*, 2023; Penichet-Tomás *et al.*, 2012). This methodological limitation is not unique to windsurfing research; similar challenges have been highlighted in systematic reviews of injury surveillance in Olympic sailing and other emerging sports (Tan *et al.*, 2016; Webborn, 2012). The lack of longitudinal, prospective surveillance systems in iQFOiL and related disciplines underscores a broader gap in water sport epidemiology.

In the context of existing evidence, the present synthesis suggests that the transition from traditional displacement-based windsurfing (RS:X, Race board) to hydrofoil-supported iQFOiL is likely to shift the injury profile from overuse-dominated patterns toward a greater burden of acute traumatic events, particularly involving the lower limbs. Comparable trends have been observed in other high-velocity board sports such as snowboarding and kitesurfing, where increased speed, instability, and equipment contact contribute to a predominance of acute musculoskeletal injuries, especially to the knee, ankle, and head (Dut *et al.*, 2020). These findings highlight the importance of preventive strategies adapted to the biomechanical and technical demands of hydrofoiling, including neuromuscular training, protective equipment design, and structured skill acquisition programs (Giles, 2011; Webborn, 2012).

Existing prevention strategies for windsurfing-related acute injuries remain largely inadequate, non-specific, and lacking a holistic framework (Woo, 2023a). Current recommendations are predominantly based on retrospective surveys and descriptive studies, with limited methodological quality and scarce high-level evidence to support their effectiveness. Consequently, most suggested measures rely on subjective athlete reports or expert opinion rather than prospective surveillance or controlled intervention trials. As a result, injury prevention in windsurfing is still fragmented and poorly standardized, emphasizing the urgent need for systematic, evidence-based approaches adapted to the sport's evolving demands (Woo, 2023b).

Tailored injury prevention programs – characterized by personalized, integrative, and periodized training – are essential for windsurfing and should be adapted specifically to iQFOiL's unique demands. Key elements may involve neuromuscular training to improve balance and proprioceptive control, targeted strength and flexibility protocols for the shoulders, lumbar spine, and lower limbs, and progressive skill-based drills to facilitate safe adaptation to hydrofoil equipment. Empirical evidence supports components such as neuromuscular training, strength and flexibility protocols, and skill-specific drills for effective injury risk reduction. A meta-analytic review demonstrates that neuromuscular training significantly reduces lower limb injuries as well as acute knee and ankle sprain injuries in various sports (Hübscher *et al.*, 2010). Further, an umbrella review confirms that multicomponent injury-prevention programs improve performance metrics – such as balance, agility, jumping, and speed – highlighting their value in both prevention and performance enhancement (Bel *et al.*, 2021).

**Conclusion**

Based on the studies included in this systematic review, the incidence and prevalence of injuries in windsurfing and related sailing disciplines appear comparable to those observed in other water- and board-based non-contact sports. The lower limbs, shoulders, and lumbar spine were the most commonly affected anatomical regions, while the nature of injuries ranged from muscle and tendon strains to contusions, sprains, and acute trauma related to equipment or environmental factors.

However, no study to date has specifically evaluated injury epidemiology in the Olympic windsurfing class – iQFOiL.

Most available evidence derives from retrospective surveys or descriptive designs of limited methodological quality, with heterogeneous definitions of injury and inconsistent reporting of exposure or severity. Consequently, the current body of evidence is insufficient to establish definitive risk factors or to support robust, evidence-based prevention strategies.

Future research should focus on prospective, standardized injury surveillance in iQFOiL and comparable foiling disciplines, with particular emphasis on identifying specific mechanisms and risk factors. Such work is essential to inform the development of tailored, sport-specific, and evidence-based injury prevention programs for this rapidly evolving Olympic discipline.

*Funding*
This research received no external funding.

*Conflicts of interest*
The authors declare no conflict of interest.

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**Table 1.** Study characteristics and results of included articles.

| L.p. | Authors | Sailing type | Study design | Patient | Injury definition | Injury characteristics (main outcome) |
|---|---|---|---|---|---|---|
| 1. | Dyson *et al.*, 2006. | WS | CS | N = 107<br>n = 36 international race boarders (RB),<br>n = 43 international wave slalom surfers (WS)<br>n = 28 recreational surfers (REC). | No information | Injury incidence: **1.5/person/year**.<br>**WS:** 2.0; **RB:** 1.0; **REC:** 1.2.<br>**Muscle strains** = 35% of new injuries; overall **45%** (RB 55%, WS 42%, REC 43%).<br>**Ligament sprains** = 8%.<br>WS: frequent cuts/abrasions; **concussion** (n = 5, REC n = 1).<br>**Lower back strain** = 22% new, 34% recurrent lower-body injuries.<br>~60% of other lower-body soft-tissue injuries = **knee/lower leg** (ankle/foot common).<br>**Upper-body:** 41% shoulder/arm/elbow.<br>**WS:** 250% ↑ recurrent muscle strains vs RB.<br>**WS:** most recurrent ligament (knee) injuries.<br>**RB:** recurrent severe lower-leg bruising. |
| 2 | Feletti *et al.*, 2021 | SF | PR | N = 77<br>(91% Male)<br>n = 58 sailed single-handed boats<br>n = 15 double-handed boats<br>n = 2 three-person boats | No information | Illness prevalence: **6.5%; overuse injuries:** 18.2%.<br>**Acute injuries: 16/1000 sailor-h.**<br>**Injury sites** – upper limbs: 34.6%; lower limbs: 26.9%; lumbar spine: 15.4%.<br>No acute injury reached max severity; **highest score:** 63/100.<br>**Illnesses:** 80% URTI (n = 4); **prevalence:** 5.2%; **incidence:** 0.51/1000 sailor-h.<br>**Environmental factors** involved in **77%** of acute injuries.<br><br>Distribution of injury<br>51.7% lower extremity<br>21.8% upper extremity<br>20.6% trunk<br>5.9% head |
| 3. | Gangl *et al.*, 2023 | WF | CS | N = 415<br>n = 356 Male<br>(average 43.8 years old)<br>n = 59 Female<br>(average 41.7 years old)<br>Experience<br>Beg. 25%<br>Adv. 55%<br>Exp. 20% | Injuries were indicated by the athletes themselves. To estimate the severity of the injuries, questions such as "need to see a doctor or physiotherapist", what kind of therapy was needed and time to return to sports after injury were asked. | Type of injury<br>25.9% bruise<br>21.3% sprain<br>14.5% cut<br>14.0% abrasion<br><br>Localization<br>13.5% foot/toes<br>10.9% lower leg<br>10.7% knee<br>9.6% thorax<br>7.0% ankle<br>6.7% shoulder<br><br>Mechanism of injury<br>25.9% contact with hydrofoil<br>22.0% through rapid body movement<br>20.2% contact with board |

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**Table 1.** (cont.) Study characteristics and results of included articles.

| L.p. | Authors | Sailing type | Study design | Patient | Injury definition | Injury characteristics (main outcome) |
|---|---|---|---|---|---|---|
| 4. | Minghelli *et al.*, 2019 | WS | CS | N = 87<br>n = 29 Race board<br>n = 31 Windsurfing Formula<br>n = 37 Foil Formula (excluded from study by Minghelli *et al.*)<br>Average: 45<br>(14–71) years old<br>Experience<br>1–2 years 1.7%<br>3–5 years 10.3%<br>6–7 years 3.4%<br>8–9 years 3.4%<br>>10 years 81% | An injury was defined as any condition or symptom that occurred as result of windsurfing practise and had at least one of the following effects: the athlete had to stop the activity (training, competition) for at least one day, the athlete did not have to stop activity, but had to modified it (to fewer hours of training, lower intensity of effort, or was less able to perform certain gestures or movements/techniques), the athlete sought advice or treatment of health professional to address the conditions or symptoms. | Fracture 5.26% (n = 2)<br>Lumbar spine (n = 1)<br>Fingers and foot (n = 1)<br>Muscle injury (strain, contusion) 13.16% (n = 5)<br>Thorax/chest/ribs (n = 1)<br>Shoulder (n = 2)<br>Thigh (n = 1)<br>Foot and fingers (n = 1)<br>Joint injury (cartilage, meniscus, ligament sprain/luxation) 15.78% (n = 6)<br>Thorax/chest/ribs (n = 1)<br>Forearm (n = 1)<br>Hand and fingers (n = 1)<br>Knee (n = 1)<br>Foot and fingers (n = 2)<br>Cervical pain 2.63% (n = 1)<br>Cervical spine (n = 1)<br>Low back pain 10.54% (n = 4)<br>Lumbar spine (n = 4)<br>Tendinopathy 42.11% (n = 16)<br>Shoulder (n = 7)<br>Elbow (n = 5)<br>Wrist (n = 1)<br>Knee (n = 2)<br>Foot and fingers (n = 1)<br>Laceration 7.89% (n = 3)<br>Hand and fingers (n = 3)<br>Others 2.63% (n = 1)<br>Foot and fingers (n = 1)<br>Any type of injury<br>Cervical spine 2.63% (n = 1)<br>Thorax/chest/ribs 5.26% (n = 2)<br>Lumbar spine 13.16% (n = 5)<br>Shoulder 23.68% (n = 9)<br>Elbow 13.16% (n = 5)<br>Forearm 2.63% (n = 1)<br>Wrist 2.63% (n = 1)<br>Hand-fingers 10.54% (n = 4)<br>Thigh 2.63% (n = 1)<br>Knee 7.89% (n = 3)<br>Foot and fingers 15.79% (n = 6)<br>Cause of injury<br>Impact with the board/material 21.05% (n = 8)<br>Impact on the water 2.63% (n = 1)<br>During the transition 2.63% (n = 1)<br>Foot traction 10.53% (n = 4)<br>Pick up the boom 5.26% (n = 2)<br>Raise the candle 2.63% (n = 1)<br>Transporting material 7.89% (n = 3)<br>During the manoeuvre 26.32% (n = 10)<br>I don't know 21.05% (n = 8) |

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**Table 1.** (cont.) Study characteristics and results of included articles.

| L.p. | Authors | Sailing type | Study design | Patient | Injury definition | Injury characteristics (main outcome) |
|---|---|---|---|---|---|---|
| 5. | Penichet-Tomás *et al.*, 2012 | WS | CS | N = 18 women<br>Age = 20 – 35 years<br>Elite Windsurfing World Cup 2008 | No information | Type of injury<br>Acute 66.7%<br>Overuse 11.1%<br>Other 22.2%<br>Localization of injury<br>Knee = 55.6%<br>Leg = 33.3%<br>Head = 5.6%<br>Spine = 5.6%<br>Windsurfing discipline vs. injury<br>Slalom 50%<br>Free Style 33.3%<br>Speed 16.7% |
| 6. | Tan *et al.*, 2016 | S/WS | CS | N = 760 sailors<br>10 Olympic Classes Elite<br>2014 World Championships | An injury was reported if it fulfilled the following criteria: musculoskeletal symptom or concussion, newly incurred injury or reinjury, incurred in training or competition, and incurred during the ISAF World Sailing Championships (8–21 September 2014).<br>Illness was defined as any physical symptom (not related to injury) during Championships, whether newly acquired or an exacerbation of any chronic pre-existing illness, requiring medical attention. | N = 299 injuries<br>Prevalence in total = 32%<br>49erFX = 64% prevalence<br>RS:X Women = 39% prevalence<br>49er = 37% prevalence<br>Nacra 17 = 36% prevalence<br>Lower back = 29% prevalence<br>Knee = 13% prevalence<br>Shoulder = 12% prevalence<br>Ankle = 10% prevalence<br>Muscle cramp = 20% prevalence<br>Muscle strain = 13% prevalence<br>Sprain = 13% prevalence<br>Tendinopathy = 13% prevalence |
| 7. | van Bergen *et al.*, 2016 | WS/KS | RS | N = 57 sailors<br>25 windsurfers (21 male; aged 31 ± 8 years)<br>32 kitesurfers (23 male; aged 29 ± 11 years) | No information about injury definition<br>Participant hours (number of days a year and mean number of hours a day | Windsurfing = 32 injuries / 6146 windsurfing hours / 2 years<br>5.2 injuries per 1000 h of windsurfing<br>Kitesurfing = 49 injuries / 6978 kitesurfing hours / 2 years<br>7.0 injuries per 1000 h of kitesurfing.<br>Windsurfing<br>Head and cervical spine 9 (36%)<br>Upper extremity 6 (24%)<br>Trunk and thoracolumbar spine 0 (0%)<br>Lower extremity 10 (40%)<br>Kitesurfing<br>Head and cervical spine = 11 (34%)<br>Upper extremity = 5 (16%)<br>Trunk and thoracolumbar spine = 3 (9%)<br>Lower extremity = 13 (41%) |

CS – cross-sectional, RS – retrospective, PR – prospective, KS – kitesurfing, WS – windsurfing, S – sailing, WF – wingfoiling, SF – sailing foil.