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Recreational windsurfing-related acute injuries: a narrative review. Part 2: injury prevention and a proposal for a set of potential prevention strategies with a holistic approach

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Objective: *The purpose of this review was to identify existing prevention strategies for recreational windsurfing-related acute injuries and provide clinicians with a practical overview of current evidence supporting proposed potential prevention strategies.*

Methods: *A literature search was conducted through March 8, 2023, using relevant keywords with Boolean operators, such as "windsurfing" AND "injury prevention" and "windsurfing" AND "exercise interventions," from the PubMed and Google Scholar databases. Only peer-reviewed English-articles were included.*

Results: *Existing prevention strategies, right-of-way rules, a new proposed set of eight potential primary to tertiary prevention strategies for windsurfing-related acute injuries, and proposed definitions of injury*

Blessures aiguës liées à la pratique récréative de la planche à voile: une étude narrative. Partie 2: prévention des blessures et proposition d'un ensemble de stratégies de prévention potentielles avec une approche holistique

Objectif: *Le but de cette étude était d'identifier les stratégies de prévention existantes pour les blessures aiguës liées à la pratique récréative de la planche à voile et de fournir aux cliniciens une vue d'ensemble pratique des preuves actuelles soutenant les stratégies de prévention potentielles proposées.*

Méthodologie: *Une recherche documentaire a été effectuée jusqu'au 8 mars 2023, en utilisant des mots clés pertinents avec des opérateurs booléens, tels que "windsurfing" AND "injury prevention" (planche à voile ET prévention des blessures) et "windsurfing" AND "exercise interventions » (planche à voile ET prescriptions d'exercices) à partir des bases de données PubMed et Google Scholar. Seuls les articles en anglais examinés par des pairs ont été retenus.*

Résultats: *Les stratégies de prévention existantes, les règles de droit de passage, un nouvel ensemble proposé de huit stratégies potentielles de prévention primaire à tertiaire pour les blessures aiguës liées à la pratique*

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prevention levels equivalent to Haddon's matrix were identified and tabled.

Conclusions: *The proposed potential prevention strategies may facilitate clinicians in preventing recreational windsurfing-related acute injuries. Injury prevention for recreational windsurfing is under-researched. Future studies should focus on large prospective clinical trials evaluating the efficacy of prevention strategies for recreational windsurfing-related injuries.*

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KEY WORDS: chiropractic, equipment safety, exercise interventions, exercise prescription, exercise training and conditioning, injury prevention, preparticipation screening, protective gear, rehabilitation, return to play, sports behaviour, sports nutrition, windsurfing.

de la planche à voile, et les définitions proposées des niveaux de prévention des blessures équivalentes à la matrice de Haddon ont été déterminés et présentés.

Conclusions: *Les stratégies de prévention potentielles proposées peuvent aider les cliniciens à prévenir les blessures aiguës liées à la pratique récréative de la planche à voile. La prévention des blessures liées à la pratique récréative de la planche à voile n'est pas suffisamment étudiée. Les études futures devraient se pencher sur de vastes essais cliniques prospectifs évaluant l'efficacité des stratégies de prévention des blessures liées à la pratique récréative de la planche à voile.*

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MOTS CLÉS : chiropratique, sécurité de l'équipement, interventions en matière d'exercices, prescription d'exercices, entraînement et conditionnement à l'exercice, prévention de blessures, dépistage avant la participation, équipement de protection, réadaptation, retour au jeu, comportement sportif, nutrition sportive, planche à voile.

Introduction

Prevention strategies for recreational windsurfing-related acute injuries have not been adequately addressed. When considering preventive measures, injury epidemiologists invoke one or more of the three main strategies: education, engineering, and enforcement.[1] A successful injury prevention program requires a multitude of sports medicine professionals, such as a sports chiropractor, who can play a role in promoting injury prevention and management of recreational windsurfing-related injuries.

Generally, prevention strategies are based on identified risk profiles, such as risk factors, causes, patterns, and mechanisms.[2-4] The data on epidemiological characteristics and the significant serious and catastrophic acute injuries among recreational windsurfers in Part 1 highlight the need for this review (Part 2) to identify existing prevention strategies. The burden of these injuries is potentially significant, but largely in light of the very little available data on hospital interventions. The limited evidence of the hospital burden of severe and devastating windsurfing-related acute injuries can be seen in a study of 22 windsurfers who required transportation to a tertiary hospital, prolonged hospitalization, severe disability, and two deaths.[5]

The purpose of Part 2 of this review was to identify existing prevention strategies for recreational windsurfing-related acute injuries and to provide clinicians with a practical overview of current evidence supporting proposed potential prevention strategies. A research question, "What are the existing prevention strategies for recreational windsurfing-related acute injuries?" was developed.

Methods

A literature search of the PubMed and Google Scholar electronic databases was conducted for existing prevention strategies from the study's inception until March 8, 2023. A manual search of reference lists from selected

articles was used to identify additional articles in the Google Scholar database. The grading systems A, B, and C of the "strength of recommendation taxonomy" (SORT)[6] were used to rate the evidence of prevention strategies for windsurfing-related acute injuries: A = consistent and good-quality patient-oriented evidence; B = inconsistent or limited-quality patient-oriented evidence; C = consensus, usual practice, opinion, disease-oriented evidence, or a case series.

Search strategy

To provide the most articles pertaining to the research question, the search method was broken down into several categories using Boolean operators and keywords such as "windsurfing" AND "injury prevention," "preparticipation screening" AND "windsurfing," "education" OR "technique" AND "windsurfing injuries," "behavior" AND "windsurfing injuries," "protective gear" AND "windsurfing injuries," "equipment safety" AND "windsurfing injuries," "technique modification" AND "windsurfing injuries," "nutrition" AND "windsurfing injuries," and "exercise interventions" AND "windsurfing injuries."

Inclusion and exclusion criteria

Articles were included if they were relevant to injury prevention strategies for recreational windsurfing-related acute injuries. Only peer-reviewed English articles were included. Articles were excluded if their contents were duplicated, ambiguous, or unavailable in English. Boat sailing, stand-up paddle-sailing, and kite-sailing were excluded.

Article selection

A PRISMA-type flow chart was used to provide information through the different phases of the study selection process of *identification*, *screening*, *eligibility*, and *inclusion* of citations. Articles were identified through a preliminary search. Duplications were removed. Articles were screened by title and abstract, assessed by full-text for eligibility, and finally included in the full-text review. Article screening, selection, and reviewing were done by the author exclusively.

Data extraction

Data were extracted, including the titles, authors, year of publications, study designs, number of participants, sample characteristics, interventions, and outcome measures if available. Articles were excluded if interventional data or preventive strategies were not available. To ensure accuracy and confirm that the data extraction of prevention strategies from each article reflected evidence towards the research question, any inconsistencies and limitations of the selected studies were assessed. The relevant data were extracted and compiled.

Results

The preliminary search identified 257 articles. This review included 37 citations in the final review from 82 publications assessed for eligibility (Figure 1). One study of sports chiropractic research collecting data on prevention strategies for nine elite women windsurfers was identified.[7] The existing prevention strategies for recreational windsurfing-related acute injuries were identified and summarized in Table 1. The overall SORT evidence rating of the existing prevention strategies was "C." Based on the identified injury characteristics, such as potential risk factors, causes, patterns, and mechanisms, of the Part 1 review and the relevant findings of selected articles in this Part 2 review, a new set of potential prevention strategies with supporting SORT evidence ratings for a holistic approach to recreational windsurfing-related injuries was identified, proposed, and summarized in Table 2. The overall SORT evidence rating of the proposed set of eight potential prevention strategies for windsurfing-related acute injuries was "C." The SORT evidence rating for prevention strategies for "*sport-specific exercise training and conditioning*" was "B" (Table 2). The proposed definitions of primary, secondary, and tertiary injury prevention and their equivalent relations to the original Haddon's matrix[8] for sports-related acute injuries were identified and compiled in Table 3. The windsurfing right-of-way rules (basic sailing rules, racing rules, and wavesailing rules) of the water to prevent collisions were identified and compiled in Table 4.

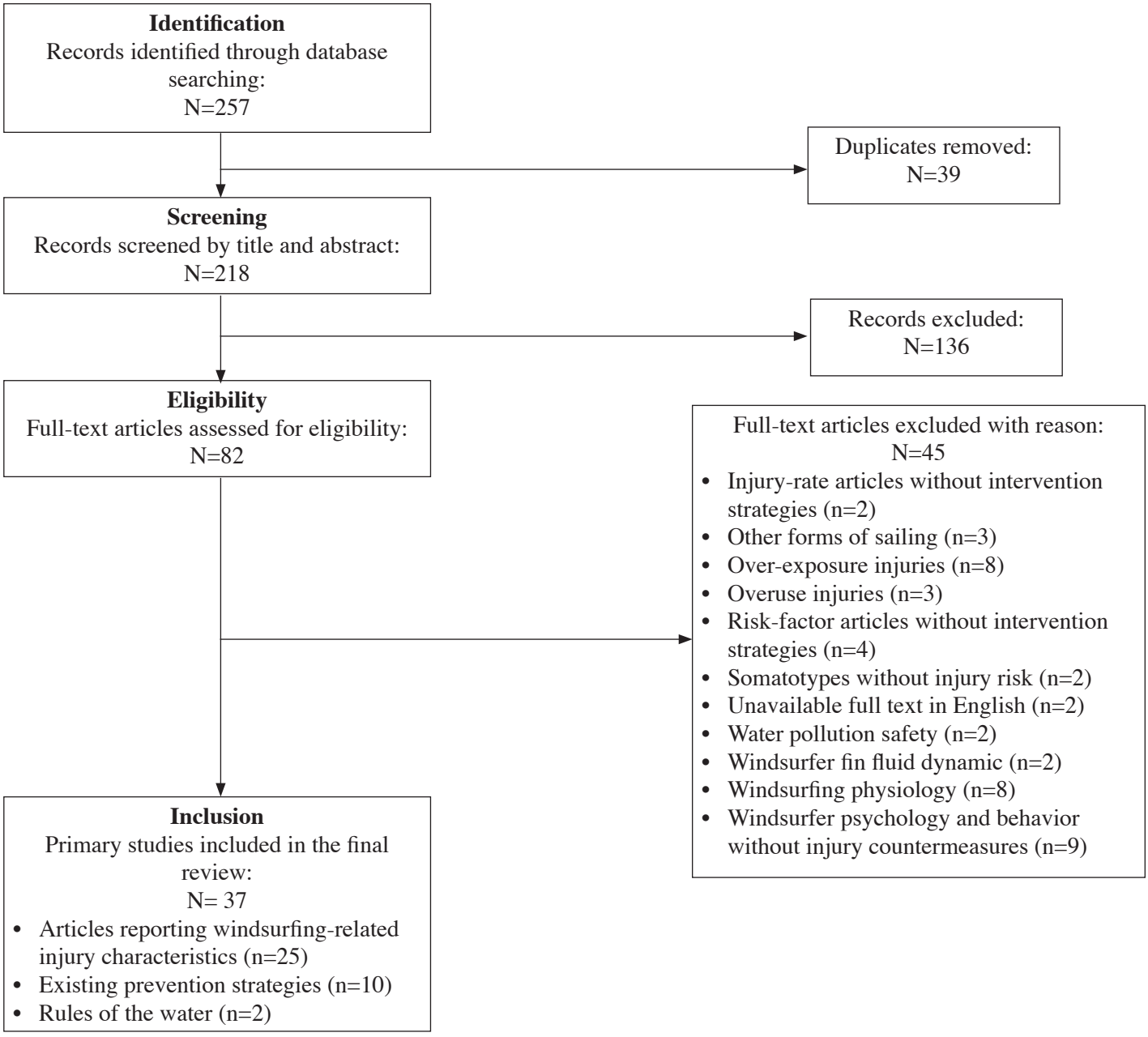

Figure 1.
Summary of a PRISMA-type flow chart of information through the different phases of the study selection process.

Table 1.
Summary of the existing prevention strategies for windsurfing-related acute injuries

Study	Study design	Total number of participants (n)	Existing windsurfing injury prevention strategies
Habal 1986 [22]	Descriptive study		• Obtain proper education (windsurfing) • Never sail alone into the high seas without several buddies • Avoid sailing in areas known to be inhabited by sharks • Protective gear: Wear a lifejacket, a wet or dry suit, a lightweight protective helmet, and a knee brace
Monahan 1986 [68]	Descriptive study		• Prepare for a weight training program, • Prepare for cardiovascular fitness training and conditioning • Warm-up and stretching • Maintain a good hydration • Apply sunscreen • Protective gear: Wear a wet or dry suit, a cap with a visor, a pair of high-protection sunglasses, and a neoprene windsurfing boot • Avoid sailing in offshore wind
McCormick and Davis 1988 [15]	Retrospective study (Survey questionnaire-interview)	n=73 (51 men, 22 women)	• Obtain preparticipation conditioning • Arrange a swimming test • Discourage windsurfing participation for athletes with epilepsy • Protective gear: Wear athletic sunglasses, limit continuous exposure, and wash with "artificial tear", wear a wet suit and protective gloves, and wear booties or shoes • Avoid strong wind and waves • Apply sunscreen at least 30 minutes before windsurfing • Review safety techniques in addition to windsurfing techniques
Nathanson and Reinert 1999 [20]	Retrospective study (Paper- & internet-based survey)	n=294 (90% men including 2 expert professionals)	• Modify fins with duller or softer edges and a shorter length • Modify a harness hook with a load equal to the windsurfer's body weight • Protective gear: Wear puncture-resistant footwear, a face mask, a personal floating device, and a helmet • Choose break-away foot straps
Woo 1997 [7]	Retrospective study (survey questionnaire & face-to-face interview)	n= 9 women (completed questionnaire)	• Sport-specific skills and conditioning (year-round) • Stretching and warm-up • Wear wetsuits, harnesses, and windsurfing athletic sunglasses • Apply sunscreen
Kalogeromitros et al., 2002 [5]	Retrospective study (Survey questionnaire)	n=22 (19 men, 3 women)	• Avoid food, alcohol, and other mind-altering drugs before windsurfing • Select the appropriate board according to the windsurfers' physical condition and abilities • Aware of sea sailing rules • Select a safe sailing area. • Avoid sailing alone at unknown venues • Avoid overpowering winds, busy waterways, and crowds of swimmers • Select foot straps with a releasing mechanism • Wear appropriate clothing (a wet suit) for protection from low-temperature environments
Rosenbaum and Dietz 2002 [24]	Descriptive study		• Apply a waterproof sunscreen • Protective gear: Wear protective gear (a helmet and a personal floating device), shatterproof sunglasses, neoprene booties or slippers, and gloves • Use equipment properly • Select foot straps with a fast-releasing mechanism • Follow the standard sailing rules • Sail with a buddy
Peterson et al., 2003 [33]	Retrospective study (Internet-based survey questionnaire)	n=327	• Protective gear: Wear a helmet • Choose the right board and sail size to prevent overpowering • A longer break after 60 minutes of windsurfing
Dysen et al., 2006 [37]	Retrospective study (Survey questionnaire)	n=107 (88 men, 19 women)	• Train to increase upper and lower body strength and maintain posture • Perform warm-up and stretching • Select a small-diameter boom • Protective gear: Wear a helmet, wet suit, and boots, a lumbar support belt, and an alternative harness • Select foot straps with a fast-releasing mechanism
Van Bergen et al., 2016 [30]	Retrospective study (Hospital records review & survey questionnaire)	n=18 (18 male completed questionnaire)	• Use smaller booms • Select quick-release foot straps • Prepare protective equipment, education, and counselling

The overall SORT evidence rating for the existing prevention strategies is "C." (A = consistent and good-quality patient-oriented evidence; B = inconsistent or limited-quality patient-oriented evidence; C = consensus, usual practice, opinion, disease-oriented evidence, or case series.)

Table 2.
Summary of a proposed set of potential strategies for windsurfing-related acute injuries with strength of recommendation taxonomy (SORT) evidence ratings

Proposed potential sports injury prevention strategies and aims (Individualized, holistic, and multidisciplinary approaches for the following potential eight prevention strategies)	**Sports injury prevention levels**	**SORT evidence ratings [6]**
1. Preparticipation screening: • To identify and disqualify conditions that may threaten potential injury or the safety of windsurfing (sports) participation • To identify potential modifiable musculoskeletal conditions such as previous injuries, muscle imbalance, and ligament hypermobility that require training, retraining, conditioning, and rehabilitation • To identify and disqualify non-modifiable medical conditions such as myocardial infarction and epilepsy that may cause a potential risk of drowning from attacks during windsurfing	Primary prevention	C
2. Preparatory education and technique considerations: • To provide appropriate preparatory education, such as the Beaufort scale and the rules of the water, and technique considerations such as windsurfing basic techniques and self-rescue techniques • To learn basic sports injury prevention strategies and potential risk factors • To learn basic windsurfing (sports) techniques • To learn basic sports nutritional strategies • To learn the basic principles of exercise training and conditioning	Primary prevention	C
3. Sports behavior modifications: • To access, address, and modify potential risk-taking sports behaviors • To identify and overcome barriers to behavior change and compliance	Primary prevention	C
4. Enforcement of protective gear: • To emphasize the need for wearing appropriate protective gear • To promote the need for protective gear enforcement	Primary prevention	C
5. Equipment safety and engineering modifications • To identify equipment-related risks • To improve and modify equipment design to reduce injury	Primary prevention	C
6. Technique modifications and skill development • To identify technique and skill incompetence • To optimize sport-specific physical fitness and sailing techniques • To correct and retrain poor technique, modify improper technique posture, and develop skill	Primary prevention	C
7. Sports nutrition considerations • *Sports nutrition screening, counseling, and guidance* ° To identify susceptible athletes with energy deficits and/or electrolyte disturbances ° To identify insufficient fluid consumption and alcohol consumption • *Preventive hydration and fluid replacement* ° To prevent hypohydration and exercise-associated dehydration, ° To prevent overhydration and exercise-associated hyponatremia ° To monitor fluid and electrolyte replacement	Primary prevention Primary and secondary prevention	C C
8. Sport-specific exercise interventions • *Exercise prescription (for athletes with or without sports-related injuries)* ° To prescribe personalized, self-directed, periodized exercise training and conditioning ° To identify training errors and prevent the risk of training-related injuries and overtraining ° To monitor training load and progression for effectiveness and determine any adverse effects • *Preparatory exercise training and conditioning* ° To help athletes increase muscle strength, power, endurance, etc, and reduce the chances of windsurfing-related (sports-related) injuries ° To enhance cardiorespiratory fitness • *Sport-specific exercise training and conditioning* ° To improve cardiorespiratory fitness ° To improve VO_2 max, aerobic, and anaerobic capacity, and lactic threshold. ° To improve muscle buffering capacity and the power of both upper and lower body muscles • *Sport-specific rehabilitation and return-to-sport* ° To identify suboptimal physiological and biomechanical conditions that should be adequately and specifically retrained, reconditioned, rehabilitated, and fully recovered. ° To prevent sports injuries or reinjury ° To ensure a safe return-to-training and a safe return-to-sport	Primary prevention Primary prevention Primary prevention Tertiary prevention	C C B C

The overall SORT evidence rating for the proposed set of potential prevention strategies is "**C.**" The SORT evidence rating for "Sport-specific exercise training and conditioning" is "B." (**A** = consistent and good-quality patient-oriented evidence; **B** = inconsistent or limited-quality patient-oriented evidence; **C** = consensus, usual practice, opinion, disease-oriented evidence, or case series.)

Table 3.
Proposed definitions of primary, secondary, and tertiary injury prevention and equivalent relation to the original Haddon's matrix for sports-related acute injuries

Definitions of sports injury prevention levels 1	Equivalent relation to the original Haddon's matrix 8
1. Primary injury prevention (risk factor prevention) is defined as the *prevention of the pre-event before the sports-related accident*, • using sports-related injury risk factors and sport-specific prevention strategies • by "identifying" risk factors and "removing" or "reducing" risk exposure to prevent the onset of the sports injury.	Pre-event (Before the accident)
2. Secondary injury prevention (preclinical prevention) is defined as the *prevention of the event during the sports-related accident*, • using preclinical prevention strategies by "screening" and "identifying" sports injuries in the earliest stages before the onset of signs and symptoms, and • by "ameliorating" the preclinical injury conditions through appropriate clinical tests, interventions, and/or sports-related modifications.	Event (During the accident)
3. Tertiary injury prevention (clinical prevention) is defined as the *prevention of the post-event after the sports-related accident*, • using clinical prevention strategies for the post-event • by "reducing" or "eliminating" the sequelae of the sports injury conditions through appropriate multidisciplinary sports rehabilitation and medical and/or other interventions to prevent longterm impairment and disabilities from injury, maximize the rehabilitation outcomes, or minimize and delay disabilities, and prevent reinjury.	Post-event (After the accident)

Adopted and modified from Press & Hagel 2005 [1] and Haddon 1972. [8]

Table 4.
The windsurfing right-of-way rules of the water to prevent collisions

Examples of the windsurfing right-of-way rules to prevent collisions
Basic sailing rules • To avoid busy waterways,[5] windsurfers must keep clear of swimmers, surfers, rowers, paddlers, and all other self-powered water users. • The overtaking board must keep clear[23] when overtaking a board, a sailboat, or a powerboat. • A windsurfer with right of way must *maintain his direction and speed*, while a windsurfer without right of way must keep clear and change directions to avoid collisions.[25] • A board riding towards the shore has right of way over one sailing out to sea.[23] Racing rules • *Tacking*: Any board in the process of *tacking* (turning the board through the eye of the wind) or *gybing* (turning the back of the board through the wind) must keep clear of boards not tacking or gybing.[23] • *Tacking*: While *tacking*, after a board passes head to wind, she shall keep clear of other boards until her sail has filled.[25] • *On the opposite tack (starboard tack over port tack)*: If two windsurfers are sailing towards each other from the *opposite* direction, the one on *starboard tack* (right shoulder closest to the mast) has right of way over the one on port *tack* (left shoulder closest to the mast).[23,25] • *On the same tack, overlapped (leeward over windward)*: If two windsurfers are sailing in the *same* direction, the *leeward* (side farther away from the wind) has right of way over the *windward* (side nearest to the wind).[23,25] • *On the same tack, not overlapped (clear ahead over clear astern):* when boards are on the same tack and not overlapped, a board *clear astern* shall keep clear of a board *clear ahead*.[25] • *Acquiring right of way*: when a board acquires the right of way, she shall initially give the other board room to clear, unless she acquires the right of way because of the other board's action.[25] • *Changing course*: when a right-of-way boat changes course, she shall give the other board room to clear.[25] Wavesailing rules • When two boards are riding the same wave, the board nearest the peak (breaking point of the wave) has the right of way.[23] • When two boards are riding different waves, the board furthest from the shore has the right of way.[23]

Adapted and modified from references.[5,23,25]
For details of windsurfing racing rules, please refer to "The racing rules of sailing, windsurfing fleet racing edition for 2021-2024.[25]

Discussion

This review found that the existing prevention strategies of the studies in Table 1 were inadequate, non-specific, and non-holistic. The suggested existing injury prevention measures were not strongly evidence-based but based on subjective data from participants from retrospective survey studies or from descriptive studies based on expert opinion. The identified injury prevention levels in Table 2 were mainly primary prevention (ten); the rest were primary/secondary prevention (one) and tertiary prevention (one). Notably, the eight prevention strategies listed below can be adapted to prevent athletic injuries in other sports. This review will discuss an overview of the proposed set of potential prevention strategies with supporting SORT evidence ratings for windsurfing-related acute injuries (Table 2). The SORT evidence rating for all the following preventative interventions is level C (except for sport-specific exercise training and conditioning, which is rated level B).

1. Preparticipation screening
2. Preparatory education and technique considerations
3. Sports behaviour modifications
4. Enforcement of protective gear
5. Equipment safety and engineering modifications
6. Technique modifications and skill development
7. Sports nutrition considerations
   - *Sport nutrition screening, counselling, and guidance*
   - *Preventive hydration and fluid replacement*
8. Sport-specific exercise interventions
   - *Exercise prescription*
     - *Monitoring of exercise prescription*
   - *Preparatory exercise training and conditioning*
   - *Sport-specific exercise training and conditioning*
   - *Sport-specific rehabilitation and return-to-sport*

1. Preparticipation screening

The major goal of preparticipation screening is to ensure the health and safety of the athletes.[9] Adopting a standardized process to conduct preparticipation physical examinations using available scientific evidence and best practices will help clinicians identify disqualifying conditions that may threaten the health and safety of participants.[10] Preparticipation screening may help prevent sports injuries[11] by identifying modifiable risk factors of potential neuromusculoskeletal deficits in recreational windsurfers like muscle imbalance[12] or asymmetries in strength and flexibility[13] and previous injuries[7] that require preparticipation sport-specific retraining and reconditioning, sport-specific rehabilitation, and a safe return-to-sport. Preparticipation screening may also identify and reduce the potential risk of drowning during windsurfing, which may be caused by nonmodifiable risk factors of medical conditions, such as heart attacks (myocardial infarctions,[14,15] palpitations,[16] and coronary artery disease[17]) and epilepsy attacks,[15,18,19] that warrant disqualification from windsurfing participation. To prevent sports-related sudden cardiac arrest, the Asian Pacific Society of Cardiology Consensus classifies sports according to the graded intensity of their static and dynamic components, such as windsurfing, as high-cardiovascular-intensity sports and recommends cardiovascular preparticipation screening.[17] Warning the identified epileptic windsurfers[20] about the hazard of a potential submersion injury or death and disqualifying them from windsurfing may help prevent such injuries. As such, preparticipation screening should be considered and implemented to reduce medical complications during recreational windsurfing.

2. Preparatory education and technique considerations

Professional instructional education for beginners in windsurfing is widely recognized as an effective strategy for preventing injuries.[21] Windsurfing injuries may not be easily avoided, and their prevention may not be through protective gear but through proper education.[22] Preparatory education may help novice recreational windsurfers learn the basics of windsurfing and basic injury prevention strategies to be aware of potential risks as well as their physical conditions and limitations. Properly accredited windsurfing education and technique training preparations are progressive; one cannot learn complicated maneuvers and sailing safety until one knows sailing theories, basic windsurfing techniques, the right-of-way rules of the water,[23] rescue techniques, and environmental sailing conditions are fully understood, and relevant techniques are competent.

A windsurfing board is considered a sailing vessel.[24] Windsurfers may be prone to accidents when certain basic rules of the water are violated.[5] A study found that 63% (14 out of 22) of windsurfers associated with severe acci-

dents were inexperienced, and 50% (9 out of 18) of windsurfers involved in severe accidents were unfamiliar with the basic rules of sailing vessels.[5] There are international maritime regulations designed to promote safety on the water, such as the "World Sailing" right-of-way rules to prevent collisions under the rules of windsurfing racing.[25] Windsurfers should be aware of sailing rules[5] and must comply with the right-of-way rules of the water (Table 4).

3. Sports behaviour modifications

Behaviour is the key factor in sports injury prevention.[26] An important step in the modified global model of the prevention sequence is assessing the compliance and risk-taking behaviour of a sports injury prevention strategy.[27] The risk-taking behaviour of windsurfers[5,28] highlights the need for sports behaviour modification. Avoiding habits of ingesting alcohol and other mind-altering drugs before sailing has been advocated.[5] However, barriers to behaviour change in injury prevention (e.g., inconvenience and perceived risk-benefit ratio) do exist.[29] Individual barriers to behavioural change and compliance should be identified and addressed. To overcome barriers, clinicians should consider sports behavioural evaluation and choose active over passive strategies, raising patients' awareness, and informing athletes of their individualized risks of predictable injury-prone circumstances.[29]

4. Enforcement of protective gear

Little is known about the efficacy of protective gear in the prevention of windsurfing-related acute injuries.[30] Studies found that only 20% of recreational windsurfers wear lifejackets,[31] and only 10% of recreational windsurfers[31] and 10% of elite professional windsurfers[32] use helmets to prevent head injuries. Another study found that 28.8% of 548 acute windsurfing injuries were caused by skidding falls;[33] hence, wearing preventive anti-skidding footwear should be considered. Protective gear must be worn when attempting jumps and loops,[31,32] as these maneuvers account for over 20% of all severe windsurfing-related injuries[31]. The burden of serious recreational windsurfing-related acute injuries highlights the need for enforcement of wearing appropriate protective gear, such as helmets [5,31,33] to prevent windsurfing-related head injuries. Enforcement of protective gear for windsurfing should be considered and implemented.

5. Equipment safety and engineering modifications

A recent epidemiological study reported that 28.8%, 5.1%, and 2.7% of 548 windsurfing-related injuries were caused by overpowered material, too strong surf, and material failure, respectively.[28] Windsurfers should therefore ensure that their own or hired equipment is well rigged and in safe, good condition,[23] and that they are knowledgeable about choosing the appropriate board and sail size according to their physical conditions and abilities,[5] as well as weather conditions. An improved design of windsurfing equipment may help prevent injuries.[20] It has been suggested that the development of breakaway foot straps may reduce the incidence of lower extremity injuries.[20,32,34] Fins with duller or softer edges and shorter lengths would likely reduce fin-induced lacerations[35] and fin-penetrating deaths[20]. Also, it has been proposed that a harness hook that disengages from the harness line at a load equal to the sailor's body weight could prevent catapult injuries.[20] Appropriate equipment safety and modification measures should be considered and implemented.

6. Technique modifications and skill development

Windsurfing technique is the ability to perform a correct maneuver, whereas skill is the ability to perform sport-specific maneuvers of different disciplines in the windsurfing competition setting. Technique and skill incompetence should be identified. A recent study found that 34.5% of windsurfing-related acute injuries were caused by the athlete's incompetence.[26] The main cause of freestyle acrobatic maneuver-related acute injuries was poor technique when performing forward and backward loops.[36] In general, windsurfing-related acute injuries may be triggered by fatigue interfering with the proper execution of maneuvers.[37] To prevent injury, a sport-specific skill is being able to choose and perform the right windsurfing techniques at the correct time. Modifying techniques have been considered the most effective way of minimizing or preventing injury.[37] Such modifications include improving lower body strength and body posture to aid optimal sailing technique and developing greater upper body strength to cope with the demands of pumping in the light winds with uphauling particularly in mind.[37] The correct windsurfing technique(s) retraining to maximize competence and/or modifications as well as skill development should be considered and implemented.

7. Sports nutrition considerations

Little is known about sports nutrition for preventing windsurfing-related injuries. However, general sports nutrition principles can be applied to windsurfing. Practical dietary strategies can be found in other non-water sports[38] or in aquatic sports[39-42] to reduce the risk of injury, prevent and treat injuries to muscles, bones, tendons, and ligaments, and improve training adaptations, dietary supplements, and nutrition for recovery.

Recreational windsurfers should have a basic knowledge of sports nutrition and hydration. Sufficient energy, macronutrient, and micronutrient intakes are critical to recreational windsurfing's physical demands and training goals. The results of the windsurfing energy demand study indicate that high demand is needed using both aerobic and anaerobic pathways, whatever the wind conditions.[43] There is limited information regarding dietary strategies for recreational windsurfers to support optimal training adaptations and prevent dehydration-related acute injuries[44] or heat-related illnesses[45].

7.1 Sports nutritional screening, counselling, and guidance

Sports nutritional screening[46] for diet quality[47] or nutrition status[48] and dietary counselling[47] for susceptible recreational windsurfers can be considered for injury prevention to monitor nutrition statuses, such as energy deficits and electrolyte disturbances. A study found that 22% (4 out of 18) of windsurfers ingested at least one unit of alcohol three hours before windsurfing.[5] Because of the association of water-related injuries such as drowning with ethanol consumption before sailing,[16] nutritional screenings should include hydration status and alcohol avoidance[46]. Sports dietitians may help guide and prevent dietary-related injuries in identified windsurfing athletes with glycogen depletion[47] and/or insufficient fluid consumption[48].

7.2 Preventive hydration and fluid replacement

Water replacement is an essential strategy in high temperatures and high humidity to prevent heat-related illnesses, such as heat cramps, heat exhaustion, and heat stroke.[39] To promote injury prevention, the potential risks of both hypohydration and hyperhydration on health and physical performance have been highlighted in the National Athletic Trainers' Association position statement.[49] Before sailing, windsurfers should consume enough fluids to prevent exercise-associated dehydration. According to the German Nutrition Society, fluid and electrolyte replacement must be considered after sport.[50] A recent review highlights the need for frequent breaks for hydration and careful monitoring.[45] The consensus statement of the Third International Exercise-associated Hyponatremia Conference concluded that fluid replacement (drinking according to thirst) should be educated to avoid hyperhydration due to overconsumption of hypotonic fluids (water or sports drinks) to prevent exercise-associated dehydration and life-threatening exercise-associated hyponatremia.[51,52] Nutritional education[48] for *primary* preventive hydration and *secondary prevention* through fluid replacement should be considered and implemented.

8. Sport-specific exercise interventions

A recent systematic review and meta-analysis found that exercise-based interventions were effective in improving functional movement pattern capability in untrained populations.[53] Exercises such as plyometric and neuromuscular training that help develop neuromuscular control and functional joint stability are critical in conditioning and rehabilitation programs designed for injury prevention in sports.[54] Also, systematic reviews provide convincing evidence that multimodal neuromuscular training can be effective for preventing sports injuries in both young and adult athletes.[55-57] Exercise prescriptions for athletic injuries and rehabilitation should be sport-specific. As such, clinicians should consider personalized and integrative, periodized sport-specific exercise interventions for their patients. For information specific to windsurfing training,[12,58-60] please refer to the following "Sport-specific exercise training and conditioning" section.

8.1 Exercise prescription

Sport-specific exercise prescriptions can be provided in a clinical office setting or via telehealth and/or mobile-health-application (mHealth) settings. Providing exercise instructions using multimedia may improve adherence.[61] A customizable, open-source electronic health record embedded exercise application with digital and printable copies and integrated direct email and/or mHealth options for ease of remote tracking-log sharing with patients and clinicians has been developed to facilitate clinicians' individual standardized exercise prescrip-

tion and to overcome patient adherence and accessibility barriers.[62] Personalized, integrative, self-directed, periodized, home-based prescriptions, including cross-training through the clinical office, telehealth, and mHealth settings, should be consistent with individual sport-specific physical demands, as well as the level of individual physical fitness conditions, cardiorespiratory fitness conditions, and neuromuscular control-balance-coordination conditions. Windsurfing's sport-specific demands can be simulated using easily available, low-cost, low-tech, home-based exercise equipment such as a heavy resistance tube, a suspension trainer, a hurdle ladder, gym rings, a gym ball, a balance board, and a plyometric jump box. Also, patients should be involved in personal goal setting, leading to individualization and goal-specific exercise prescription, which can improve motivation and compliance.[62]

8.1.1 Monitoring of exercise prescription

To assess the effectiveness and determine any adverse effects, athletic training load, progression of exercise prescription, and fatigue should be monitored for pain, perceived fatigue, strength, and ability to perform exercise and function.[63] The association between training loads and training-related injury risk is established.[64] A systematic review concluded that individual characteristics, such as fitness, body composition, injury history, and age, have a significant impact on the intended training load placed on athletes.[63] Monitoring the prescribed training load for injury prevention is to screen for those at increased risk of injury so that the prescribed training load can be adjusted to minimize these risks.[64]

The patient should be advised to monitor his or her progressive exercise responses, including training-associated pain or fatigue, heart rate, perceived exertion ratings, and blood pressure. Importantly, individualized oral and written exercise prescriptions should be given timely feedback on the volume, intensity, and density of the prescribed exercise training and monitored appropriately to identify improper training and prevent the risk of training-related injuries. To prevent the overtraining syndrome, it is important to correct identified training errors with strategies, such as appropriate periodization, adequate sleep, and sports nutrition for training recovery,[65] despite the absence of validated diagnostic tests and preventive measures[66].

8.2 Preparatory exercise training and conditioning

Windsurfing under strong winds requires isometric contraction of the core, upper body, and lower body muscles. Under light and moderate winds, the windsurfer "pumps" the sail rhythmically as a wing by providing the board with additional forward motion.[58] Preparatory exercise training and conditioning programs for the core and bilateral upper body and lower body[12] are essential for windsurfing practices, such as holding the boom, controlling the board, maintaining balance, and performing sail-pumping, and may delay fatigue and thus help prevent injuries. Traditionally, recreational windsurfers lack preparatory exercise training and conditioning,[67] according to most studies in Table 1. As such, recreational windsurfers should prepare a weight-training, cardiovascular fitness, and conditioning program.[16,21,68] Electromyographic pumping studies during simulated windsurfing on-shore[69] and sailing on-water[69] indicated that the main muscles are the trapezius, flexor carpi ulnaris, extensor carpi radialis, biceps brachii, gluteus maximus, and tibialis anterior[69,70]. It is important to include neuromuscular training[54] into traditional exercise training and conditioning. A reasonable amount of physical training should be recommended for musculoskeletal injury prevention.[71]

8.3 Sport-specific exercise training and conditioning

Windsurfing is a high-intensity endurance sport that requires very high aerobic and anaerobic capacities; the intensity of windsurfing is comparable to other endurance sporting activities like cycling, running, or cross-country skiing.[72] Windsurfing-specific strength training may enhance the anaerobic power and capacity of the arm, the leg, or both.[73] Onshore, periodized sport-specific strength training and conditioning, and sport-specific proprioception and neuromuscular training[54,55,57,74] using a similar windsurfing ergometer or windsurfing simulator,[59,75] if available, should be considered. Sport-specific functional training for windsurfers includes core muscles and balance. For example, windsurfing-specific abdominal core training may help with dynamic and static balance[76] and may reduce the risk of injury. Proprioception training, for example, is effective in reducing the risk of ankle sprains.[77] If a windsurfing simulator is not available, sport-specific balance and proprioception training programs such as ankle balancing and proprioception training using an easily available wobble board simulat-

ing the surfing board may help reduce the risk of acute ankle injuries.

Little is known about the relationship between exercise training and the anaerobic lactic acid (glycolysis) and alactic (phosphagen) systems, as well as the aerobic system. High-intensity interval training (HIIT) is characterized by bouts of high-intensity exercise interspersed with active or passive rest periods and can be further sub-categorized into low- and high-volume HIIT and sprint interval training (SIT)[78] above the lactate threshold to improve VO_2max, aerobic and anaerobic capacity, and performance.[79] Windsurfing training regimes should aim at enhancing the athlete's maximal aerobic capacity, the lactic threshold, and the power of both upper and lower body muscles.[80] To prepare for the physical and cardiovascular demands of different sailing techniques, sport-specific strength training programs for improving strength, anaerobic power, endurance, and muscle balance of the lower body and upper body,[12] as well as windsurfing-specific training programs for improving high-intensity cardiovascular demands, such as HIIT[58] or SIT[60] and moderate-intensity continuous training (MICT), should be considered. On-shore, HIIT, SIT, and MICT training can be practiced with improvised windsurfing-specific equipment such as a windsurfing ergometer for pumping[81] or a rowing ergometer that closely mimics explosive sail-pumping and engages both upper and lower body muscles[80] with rest intervals that have been advocated to minimize the risk of acute injuries[58]. On-water, audio real-time feedback coaching with the use of a smartphone in sailing training has the potential to help less experienced windsurfers.[82] Based on the evidence of systematic reviews and meta-analysis of HIIT[78] and SIT[79,83] in other sports, and the evidence of windsurfing training studies,[12,58-60,75,80] including HIIT[58] and SIT,[60] the SORT evidence rating for "*sport-specific exercise training and conditioning*" is "B."

8.4 Sport-specific rehabilitation and return-to-sport

Physical training, conditioning, and rehabilitation[54] and sport-specific functional tests should be considered for sport-specific demands to facilitate a safe return-to-sport. When athletes are injured, physical attributes, such as muscular strength, power, endurance, flexibility, balance, proprioception, speed, agility, and functional movement patterns, are less than optimal; a return to full recreational sports requires a nearly complete return of these physical components.[84] Athletes should be aware of the relevance of adequate treatment and rehabilitation after injury to avoid the recurrence of injuries.[71] Identified suboptimal conditions of these physical components should be adequately and specifically retrained, reconditioned, rehabilitated, and functionally recovered. A multidisciplinary team is often required to better treat and rehab an athlete and permit a prompt return-to-sport.[85] Several physical tests are used in sports rehabilitation to measure strength and power, such as the isometric maximal voluntary contraction tests, the one-repetition maximum tests, and other tests that target the upper and lower limbs.[86] Despite the lack of a "gold standard" in sports testing[87] and the limited evidence of functional movement screening for injury prediction,[88] functional performance tests using a windsurfing simulator[89] can help determine when an athlete can safely return to unrestricted activities[84].

The key goal of sport-specific rehabilitation protocols is *tertiary* injury prevention. When to return to windsurfing safely after injury is a complex and multifactorial decision that should be personalized. The return-to-sport clearance looks throughout the continuum of healing to determine readiness for sport.[87] There are five phases of the return-to-sport clearance continuum: repair, recovery, reconditioning, performance, and return-to-training.[87] According to studies, the average time for windsurfing-related moderate foot and leg injuries to return-to-training was 25.2 days,[90] and the average time for moderate injuries to return-to-sport was five weeks[30]. Importantly, personalized functional progression along the rehabilitation continuum and stages from the acute phase to reconditioning and return-to-sport should be based on functional criteria with sport-specific functional testing(s) and psychological readiness and not on time-based average return-to-training and return-to-sport data in the literature. Until return-to-training and return-to-sport rehabilitation protocols are met and completed to prevent injury or re-injury, only a gradual, personalized, and safe return-to-sport should be considered.

Strengths and limitations

According to my knowledge, this is the first study in which levels and definitions of injury prevention are suggested for windsurfing injuries, and a holistic set of eight potential injury prevention strategies (mainly primary preven-

tion) for recreational windsurfers is proposed with current evidence. The SORT evidence grading systems are used to rate the potential prevention strategies for windsurfing-related acute injuries. Practically, the proposed potential prevention strategies can be modified and adapted to prevent athletic injuries in other sports. However, this study has several limitations. Other electronic databases were not searched. Relevant and important data could be missed. There is a single author and article selection bias; information extraction was also done subjectively. The findings were limited by the inherent methodology of narrative literature reviews, such as the purely descriptive nature of the review and the inability to test any hypotheses about the relative effectiveness or ineffectiveness of the identified existing and proposed preventative measures. Only a brief overview of the current evidence-based prevention strategies is provided.

Conclusions

Injury prevention for recreational windsurfing is under-researched. The existing prevention strategies are inadequate, non-specific, and non-holistic. The proposed new set of eight primary to tertiary potential prevention strategies with supporting SORT evidence ratings and best practices for an individualized, holistic, and multidisciplinary approach may facilitate clinicians in mitigating risks and preventing recreational windsurfing-related acute injuries. Sports chiropractors can play a role in promoting a patient-oriented holistic approach to injury prevention and the management of windsurfing-related injuries. Future studies should focus on high-quality, large prospective randomized clinical trials evaluating the effectiveness of prevention strategies for recreational windsurfing-related injuries.

References

1. Pless IB, Hagel BE. Injury prevention: a glossary of terms. J Epidemiol Community Health. 2005;59: 182-185. https://doi.org/10.1136%2Fjech.2003.017715
2. Meeuwisse WH. Assessing causation in sport injury: a multifactorial model. Clin J Sport Medicine. 1994;4: 166-170. https://doi.org/10.1097/00042752-199407000-00004
3. Bahr R, Krosshaug T. Understanding injury mechanisms: a key component of preventing injuries in sport. Br J Sports Med. 2005;39: 324-329. http://dx.doi.org/10.1136/bjsm.2005.018341
4. Bittencourt NFN, Meeuwisse WH, Mendonca LD, Nettel-Aguirre A, Ocarino JM, Fonseca ST. Complex systems approach for sports injuries: moving from risk factor identification to injury pattern recognition –narrative review and new concept. Br J Sports Med. 2016;50: 1309-1314. http://dx.doi.org/10.1136/bjsports-2015-095850
5. Kalogeromitros A, Tsangaris H, Bilalis D, Karabinis A. Severe accidents due to windsurfing in the Aegean Sea. Eur J Emerg Med. 2002;9: 149-154. http://dx.doi.org/10.1097/00063110-200206000-00009
6. Ebell MH, Siwek J, Weiss BD, Woolf SH, Susman J, Ewigman B, Bowman M. Strength of recommendation taxonomy (SORT): a patient-certified approach to grading evidence in the medical literature. Am Fam Physician. 2004:548-556.
7. Woo CC. World-class female windsurfing champions: a pilot study of physical characteristics and injuries. J Sports Chiro Rehab. 1997;11: 11-17.
8. Haddon W Jr. A logical framework for categorizing highway safety phenomena and activity. J Trauma. 1972;12: 193-207. https://doi.org/10.1097/00005373-197203000-00002
9. Armsey TD, Hosey RG. Medical aspects of sports: epidemiology of injuries, preparticipation physical examination, and drug in sports. Clin Sports Med. 2004;23: 255-279. https://doi.org/10.1016/j.csm.2004.04.007
10. Conley KM, Bolin DJ, Carek PJ, Konin JG, Neal TL, Violette D. National Athletic Trainers' Association position statement: preparticipation physical examinations and disqualifying conditions. J Athl Train. 2014;49: 102-120. https://doi.org/10.4085/1062-6050-48.6.05
11. Kibler WB, Chandler TJ, Uhl T, Maddux RE. A musculoskeletal approach to the preparation physical examination- preventing injury and improving performance. Am J Sports Med. 1989;17: 525-531. https://doi.org/10.1177/036354658901700413
12. Wallace MB, Stephens D. The 1996 Olympic windsurfing trials – training considerations for windsurfing. Strength Condit J. 1998;20: 13-15.
13. Caraballo I, González-Montesinos JL, Alías A. Bilateral and unilateral asymmetries of strength and flexibility in young elite athletes: windsurfing, optimist and laser classes. Symmetry. 2022;12: 184. https://doi.org/10.3390/sym12010184
14. Schmid P, Weybora W, Langsteger W, Maurer E. Myocardial infarction while boardsailing (article in German). MMW Munch Med Wochenschr 1981; 123: 1417-9.
15. McCormick DP, Davis AL. Injuries in sailboard enthusiasts. Br J Sports Med. 1988;22: 95-97. http://dx.doi.org/10.1136/bjsm.22.3.95
16. Ullis KC, Anno K. Injuries of competitive board sailors. Phys Sportsmed. 1984;12: 86-93. https://doi.org/10.1080/00913847.1984.11701874

17. Wang L, Yeo TJ, Tan B, Destrube B, Tong Kl, Tan SW, et al. Asian Pacific Society of Cardiology Consensus recommendations for pre-participation screening in young competitive athletes. Eur Cardiol Review. 2021; 16: e44. https://doi.org/10.15420/ecr.2021.26
18. Gates JR. Epilepsy and sports participation. Phys Sportsmed. 1991;19: 98-104.
19. Carter JM, McGrew C. Seizure disorders and exercise/ sports participation. Cur Sports Med Reports. 2021;20: 26-30. https://doi.org/10.1249/JSR.0000000000000799
20. Nathanson AT, Reinert SE, Windsurfing injuries: results of a paper- and internet-based survey. Wildness Environ Med. 1999;10: 218-225. https://doi.org/10.1580/1080-6032(1999)010[0218:WIROAP]2.3.CO;2
21. Allen GD, Locke S. Training activities, competitive histories and injuries profiles of elite boardsailing athletes. Aust J Sci Med Sport. 1989;21: 12-14. https://doi.org/10.1175/1520-0434(1998)013%3C0764:MFATCO%3E2.0.CO;2
22. Habal MB. Athletic injuries caused by the new sport of windsurfing and a proposed set of preventive measures. J Fla Med Assoc. 1986;73: 609-612.
23. Cook J, Way P. Windsurfing. London: Usborne Publishing Ltd, 1988.
24. Rosenbaum DA, Dietz TE. Windsurfing injuries: added awareness for diagnosis, treatment, and prevention. Phys Sportsmed. 2002;30: 15-24. https://doi.org/10.3810/psm.2002.05.280
25. World Sailing. The racing rules of sailing, windsurfing fleet racing edition for 2021-2024. World Sailing Limited; 20 Eastbourne Terrace, Paddington, London W26LG, January 2021.
26. Verhagen EALM, van Stralen MM, van Mechelen W. Behaviour, the key factor for sports injury prevention. Sports Med. 2010;40: 899-906. https://doi.org/10.2165/11536890-000000000-00000
27. Van Triggelen D, Wickes S, Stevens V, Roosen P, Witvrouw E. Effective prevention of sports injuries: a model integrating efficacy, efficiency, compliance and risk taking behaviour. Br J Sports Med. 2008;42: 648-652. http://dx.doi.org/10.1136/bjsm.2008.046441
28. Szymski D, Achenbach L, Siebentritt M, et al. Injury epidemiology of 626 athletes in surfing, wind surfing, and kite surfing. Open Access J Sports Med. 2021;12: 99-107. https://doi.org/10.2147/OAJSM.S316642
29. Johnston CA, Vaughan E, Moreno JP. The difficulty of prevention: a behavioural perspective. Am J Lifestyle Med. 2016;10: 14-16. https://doi.org/10.1177/1559827615609532
30. Van Bergen CJA, Commandeur JP, Weber RIK, Haverkamp D, Breederveld RS. Windsurfing vs kitesurfing: injuries at the North Sea over a 2-year period. World J Orthop. 2016;7: 814-820. http://dx.doi.org/10.5312/wjo.v7.i12.814
31. Kucera P, Psalman V. Injuries in windsurfing sports. Page 92-99. In: Proceeding of 10th International Conference on kinanthropology. November 18-20, 2015 Brno Czech Republic.
32. Gosheger G, Jagersberg K, Linnenbecker S, Meissner HJ, Winkelmann W. Injury patterns and prophylaxis in World Cup windsurfing. Sportverletz Sportschaden. 2001;15: 50-54. https://doi.org/10.1055/s-2001-14815
33. Peterson W, Rau J, Hansen U, Zantop T, Stein V. Mechanisms and prevention of windsurfing injuries. Sportverletz Sportschaden. 2003;17: 118-122.
34. Witt J, Paaske BP, Jorgensen U. Injuries in windsurfing due to foot fixation. Scand J Med Sci Sport. 1995;5: 311-312. https://doi.org/10.1111/j.1600-0838.1995.tb00051.x
35. Salvi M, Velluti C, Concu A, Ariu U, Atzori A, Dessy D, Sichel GJ. Retrospective epidemiological evaluation of acute and overuse injuries of muscle and bone in windsurfing. J Sports Traumatol Rel Res. 1997;19: 30-37.
36. Tai YC, Li JL, Lai SL. The aetiology of windsurfing injuries. J Marine Leis Manage. 2009;2: 108-115. https://doi.org/10.29852/JMLM.200912.0008
37. Dyson R, Buchanan M, Hale T. Incidence of sports injuries in elite competitive and recreational windsurfers. Br J Sports Med. 2006;40: 246-350. http://dx.doi.org/10.1136/bjsm.2005.023077
38. Close GL, Sale C, Baar K, Bermon S. Nutrition for the prevention and treatment of injuries in track and field athletes. Int J Sport Nutr Exerc Metab. 2019:29: 189-197. https://doi.org/10.1123/ijsnem.2018-0290
39. Pyne DB, Verhagen EA, Mountjoy M. Nutrition, illness, and injury in aquatic sports. Int J Sport Nutr Exerc Metab. 2014;24: 460-469. https://doi.org/10.1123/ijsnem.2014-0008
40. Mujika I, Stellingwerff T, Tipton K. Nutrition and training adaptions in aquatic sports. Int J Sport Nutr Exerc Metab. 2014:24: 414-424. https://doi.org/10.1123/ijsnem.2014-0033
41. Derave W, Tipton KD. Dietary supplement for aquatic sports. Int J Sport Nutr Exerc Metab. 2014;24: 437-449. https://doi.org/10.1123/ijsnem.2014-0017
42. Burke LM, Mujika I. Nutrition for recovery in aquatic sports. Int J Sport Nutr Exerc Metab. 2014;24: 425-436. https://doi.org/10.1123/ijsnem.2014-0022
43. Castagna O, Pardal CV, Brisswaeter J. The assessment of energy demand in the new Olympic windsurf board: Neilpryde RS:X. Eur J Appl Phyiol. 2007;100: 247-252. https://doi.org/10.1007/s00421-007-0403-1
44. Allen JB, De Jong MR. Sailing and sports medicine: a literature review. Br J Sports Med. 2006;40: 587-593. http://dx.doi.org/10.1136/bjsm.2002.001669
45. Savioli G, Zansa C, Longhitano Y, Nardone A, Varesi A, Ceresa IF, et al. Heat-related illness in emergency and critical care: recommendations for recognition and management with medico-legal considerations.

Biomedicines. 2022;10, 3542. https://doi.org/10.3390/biomedicines10102542
46. Medina D, Lizarraga A, Drobnic F. Injury prevention and nutrition in football. Sports Sc Exchange. 2014; 27: 1-5.
47. Doumtsios I, Grammatikopoulou MG, Tsigga M. Diet quality and anthropometry between different sailboarding styles. Nutrition Dietetics. 2010;67: 31-36. https://doi.org/10.1111/j.1747-0080.2010.01403.x
48. Gogojewiez A, Pospieszna B, Bartkowiak J. Assessment of nutrition status in amateur windsurfers during regatta in the competitive period—a field study. Int J Environ Res Public Health. 2021;18, 6451. https://doi.org/10.3390/ijerph18126451
49. McDermott BP, Anderson SA, Armstrong LE, Casa DJ, Cheuvront SN, Cooper L, et al. National Athletic Trainers' Association position statement: fluid replacement for the physically active. J Athl Train. 2017;52: 877-895. https://doi.org/10.4085/1062-6050-52.9.02
50. Mosler S, Braun H, Carlsohn A, Großhauser M, König D, Lampen A, et al. Fluid replacement in sports. Position of the working group sports nutrition of the German Nutrition Society (DGE). Ernährungs-Umschau Int. 2019;66: 52-59. http://hdl.handle.net/20.500.12738/5007
51. Hew-Butler T, Rosner MH, Fowkes-Godek S, Dugas JP, et Hoffman MD, Lewis DP, et al. Statement of the 3rd International exercise-associated hyponatremia consensus development conference, Carlsbad, California, 2015. Br J Sports Med. 2015;49: 1432-1446. http://dx.doi.org/10.1136/bjsports-2015-095004
52. Hew-Butler T. Exercise-associated hyponatremia. Front Horm Res. 2019;52: 178-189. https://doi.org/10.1159/000493247
53. Huang J, Zhong M, Wang J. Effects of exercise-based interventions on functional movement capacity in untrained populations: a systematic review and meta-analysis. Int J Eviron Res Public Health. 2022;19: 9353. https://doi.org/10.3390/ijerph19159353
54. Griffin LYE. Neuromuscular training and injury prevention in sports. Clin Orthop. 2003;409: 53-60. https://doi.org/10.1097/01.blo.0000057788.10364.aa
55. Zech A, Hübscher M, Vogt L, Banzer W, Hänsel F, Pfeifer K. Neuromuscular training for rehabilitation of sports injuries: a systematic review. Med Sci Sports Exer. 2009;41: 1831-1841. https://doi.org/10.1249/MSS.0b013e3181a3cf0d
56. Emery CA, Roy TO, Whittaker JL, Nettel-Aguirre A, van Mechelen W. Neuromuscular training injury prevention strategies in youth: a systematic review and meta-analysis. Br J Sports Med. 2015;49: 865-870. http://dx.doi.org/10.1136/bjsports-2015-094639
57. Sañudo B, Sánchez-Hernández J, Bernardo-Filho M, Abdi E, Taiar R, Núñez J. Integrative neuromuscular training in young athletes, injury prevention, and performance optimization: a systematic review. Appl Sci. 2019;9: 3839. https://doi.org/10.3390/app9183839
58. Vogiatzis I, de Vito G. Physiological assessment of Olympic windsurfers. Eur J Sport Sci. 2015;15: 228-234. https://doi.org/10.1080/17461391.2014.920925
59. Quadahi N, Chadli S, Ababou A, Ababou N. A simulator dedicated to strengthening exercise for windsurfers. Procedia Engineering. 2016;147: 532537. https://doi.org/10.1016/j.proeng.2016.06.233
60. Hagiwara M, Ohya T, Yamanaka R, Onuma H, Suzuki Y. The effects of sprint interval training on sail pumping performance in a male windsurfing Olympian. Sports Sci Elite Athlete Support. 2017;2: 31-41. https://doi.org/10.32155/jiss.2.0_31
61. Emmerson KB, Harding KE, Taylor NF. Providing exercise instructions using multimedia may improve adherence but not patient outcomes: a systematic review and meta-analysis. Clin Rehabil. 2019;33: 607-618. https://doi.org/10.1177/0269215518819706
62. Edgar MC, Lambert C, Abbas A, Young JJ, Mclsaac W, Monteiro R, et al. Development of a low resource exercise rehabilitation application for musculoskeletal disorders to help underserved patients in a primary care setting. J Can Chiropr Assoc. 2022;66: 130-137.
63. Jones CM, Griffins PC, Mellalieu SD. Training load and fatigue marker association with injury and illness. A systematic review of longitudinal studies. Sports Med. 2017;47: 943-974.
64. Dew MK, Finch CF. The relationship between training load and injury, illness and soreness: a systematic and literature review. Sports Med. 2016;46: 861-863. https://doi.org/10.1007/s40279-015-0459-8
65. Carter JG, Potter AW, Brooks KA. Overtraining syndrome: causes consequences, and methods for prevention. J Sport Human Perf. 2014;2: 1-14. https://doi.org/10.12922/jshp.0031.2014
66. Kreher JB. Diagnosis and prevention of overtraining syndrome: an opinion on education strategies. Open Access J Sports Med. 2016;7: 115-122. https://doi.org/10.2147%2FOAJSM.S91657
67. Fari G, Notarnicola A, Paoao SDI, Covelli I, Moretti B. Epidemiology of injuries in water board sports: trauma versus overuse injury. J Sports Med Phy Fitness. 2021;61: 707-711. https://doi.org./10.23736/S0022-4707.20.11379-3.
68. Monahan T. Boardsailing: The spills don't dampen the thrills. Phys Sportsmed. 1986;14: 150-161. https://doi.org/10.1080/00913847.1986.11709156
69. Buchanan M, Cunningham P, Dyson RJ, Hurrion PD. Electromyographic activity of beating and reaching during simulated sailing. J Sports Sci. 1996;14: 131-137. https://doi.org/10.1080/02640419608727695
70. Dyson RJ, Buchanan M, Farrington TA, Hurrion PD. Electromyographic activity during windsurfing

on water. J Sports Sci. 1996;14: 125-30. https://doi.org/10.1080/02640419608727694
71. Taimela S, Kujala UM, Osterman K. Intrinsic risk factors and athletic injuries. Sports Med. 1990;9: 205-215. https://doi.org/10.2165/00007256-199009040-00002
72. Bojsen-MØller J, Larrson B, Aagaard P. Physical requirements in Olympic sailing. Eur J Sports Med. 2015;15: 220-227. https://doi.org/10.1080/17461391.2014.955130
73. Allen GD, Locke S. Physiological profile of elite Australian boradsailors. NZ Sports Med. 1992;Winter: 2-4.
74. Hübscher M, Zech A, Pfeifer K, Hänsel F, Vogt L, Banzer W. Neuromuscular training for sports injury prevention: a systematic review. Med Sci Sports Exerc. 2010;42: 413-421. https://doi.org/10.1249/mss.0b013e3181b88d37
75. Bornhauser M, Ricckert H. Volume changes in forearm-muscles during static work: a study on training effects with windsurfers of the German Olympic team. Med Sci Res. 1993;21: 881-883.
76. Zhang L. Abdominal core training in windsurfing. Rev Bras Med Esporte. 2023;29: e2022_0639
77. Rivera MJ, Winkelmann ZK, Powden CJ, Games KE. Proprioceptive training for the prevention of ankle sprain: an evidence-based review. J Athl Train. 2017;52: 1065-1067. https://doi.org/10.4085/1062-6050-52.11.16
78. Sabag A, Little JP, Johnson NA. Low-volume high-intensity interval training for cardiometabolic health. J Physiol. 2022;600: 1013-26. https://doi.org/10.1113/jp281210
79. Boullosa D, Dragutinovic B, Feuerbacher JF, Benitez-Flores S, Coyle EF, Schumann M. Effects of short sprint interval training on aerobic and anaerobic indices: a systematic review and meta-analysis. Scand J Med Sci Sports. 2022;32: 810-20. https://doi.org/10.1111/sms.14133
80. Castagna O, Brisswater J, Lacour, Vogiatzis I. Physiological demands of different techniques of the new Olympic windsurfing class. Eur J Appl Physiol. 2008;104: 1061-1067. https://doi.org/10.1007/s00421-008-0863-y
81. Quadahi N, Ababou A, Ababou N, Larbi MA. Windsurf ergometer for sail pumping analysis and mechanical power measurement. Procedia Engineer. 2014;72: 249-254. https://doi.org/10.1016/j.proeng.2014.06.045
82. Tarnas J, Cyma-Weichenig M, Schaffert N, Stemplewski R. Audio feedback with the use of a smartphone in sailing training among windsurfers. Appl Sci. 2023;13: 3357. https://doi.org/10.3390/app13053357
83. Gist NH, Fedewa MV, Dishman RK, Cureton KJ. Sprint interval training effects on aerobic capacity: a systematic review and meta-analysis. Sports Med. 2014;44: 269-279. https://doi.org/10.1007/s40279-013-0115-0
84. Manske R, Reiman M. Functional performance testing for power and return to sports. Sports Health. 2013;5: 244-250. https://doi.org/10.1177/1941738113479925
85. Fournier M. Principles of rehabilitation and return to sports following injury. Clin Podiatr Med Surg. 2015;32: 261-268. https://doi.org/10.1016/j.cpm.2014.11.009
86. Fares MY, Khachfe HH, Salhab HA, Bdeir A, Fares J, Baydoun H. Physical testing in sports rehabilitation: implications on a potential return to sport. Arthroscopy Sports Med Rehab. 2022;4: e189-e198. https://doi.org/10.1016/j.asmr.2021.09.034
87. Draovitch P, Patel S, Marrone W, Grundstein MJ, Grant R, Virgile A, et al. The return-to-sport clearance continuum is a novel approach toward return to sport and performance for the professional athlete. Arthro Sports Med Rehab. 2022;4: e93-e101. https://doi.org/10.1016/j.asmr.2021.10.026
88. Warren M, Lininger MR, Chimera NJ, Smith CA. Utility of FMS to understand injury incidence in sports: current perspectives. Open Access J Sports Med. 2018;9: 171-182. https://doi.org/10.2147%2FOAJSM.S149139
89. Jaszczur-Nowicki J. The cardiorespiratory responses & energy expenditure of windsurfers during cycle ergometer and windsurfing simulator exercise tests. J Human Kinetics. 2004;12: 147-154. http://www.johk.pl/files/12jaszc.pdf
90. Mettler R, Biener K. Athletic injuries in wind surfing. Schweiz Z Sportsmed. 1991;39: 161-166.