Injury patterns in competitive and recreational surfing: a systematic review

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ABSTRACT

Context Despite the growing evidence regarding surf-related injuries, investigation seems to overlook the differences between professional and recreational surfers' injuries and their specific risk factors.

Objective This review aimed at identifying differences in injuries sustained by recreational and competitive surfers. It also presents research gaps and suggests recommendations for future injury research and prevention.

Methods Study search was conducted on MEDLINE/PubMed, SportDiscus and Web of Science databases. To be included studies needed to report original data, clearly specify if recreational and/or competitive surfers were included, provide information regarding acute surfing injuries and/or analyse data concerning those injuries.

Results 17 studies were included in the analysis. All included studies had at least Oxford Centre for Evidence-Based Medicine level of evidence 3. The percentage of recreational surfers sustaining at least one injury ranged from 31% to 35% in the 12 months prior to data collection and from 88% to 100% in lifetime while 42% to 49% and 81% to 100% of competitors were injured over the same periods. Competitive surfers appear to have a higher injury risk. Both recreational and competitive surfers appear to sustain more frequently skin, joint/ligament and muscle/tendon injuries affecting the lower limbs and caused by contact with their own equipment.

Conclusions Competitive status, less surfing experience, older age and prior surgical injuries are risk factors for sustaining injuries while surfing. The most common types, anatomical locations and mechanisms of injury seem to be similar between recreational and competitive surfers.

INTRODUCTION

There are an estimated 37 million surfers worldwide[1] and the surfing industry attracts an increasingly higher number of new fans every day.[2] The growing popularity of surfing as a sport has turned it into a more mainstream activity, enjoyed by people of all standards[2] and this has contributed to its recent inclusion in the list of Olympic sports.[3]

Surfing is widely regarded as a healthy activity that not only contributes to a higher quality of life but also has both physical and psychological benefits.[4 5] Being a high intensity activity often regarded as very attractive for adrenaline-seeking people, surfing is also considered a mean to achieve personal balance and relieve stress.[6] Nonetheless, like other sports, it is not risk-free. In fact, surfing is a physically and mentally demanding activity[7] involving both aerobic and anaerobic performance[8] and affected by a myriad of meteorological (wind, waves, tides and currents) and geological (sea bottom, surf spot access) factors, all of which can have a significant impact in the rate and type of injuries sustained while surfing.

The first epidemiological surfing studies date from the 70s[9] and 80s.[10] Over the last two decades, the scientific community has amplified its interest in this sport and there has been a surge in studies regarding the physiological, pathological, social and even environmental aspects of surfing. Nevertheless, scientific evidence regarding surfing pathology continues to be scarce, consisting mostly of case reports, case series and cross-sectional retrospective studies based on data from medical records or surveys and relying on limited and convenience samples. Most studies in this field of sports medicine focus on acute and/or chronic injuries or surfing-related illnesses exploring their pathophysiology and mechanisms of injury but there seems to be a shortage of evidence exploring the differences between recreational and competitive surfers' injuries and their specific risk factors and physiopathological mechanisms.

This review aimed at integrating the available evidence to identify possible differences in injury rates, severity, patterns and risk factors, between recreational and competitive surfers. Furthermore, it also identifies research gaps and recommends further topics for consideration that shall help in formulating future injury prevention interventions.

METHODS

A systematic review of peer-reviewed and grey literature was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines[11] and prospectively registered with PROSPERO CRD42020171601. The PI(E)CO (Population, Intervention/Exposure, Comparator, Outcome) framework[12] was used to formulate the review question. The question was: Do surfers (P) who surfboard-ride recreationally (I/E), compared with competitive surfers (C) have higher injury rates and less severe injuries (O)?

Inclusion criteria were literature written in English, Spanish or Portuguese which reported original data regarding acute surfing injuries, their

risk factors, contributors and/or predictors. Studies should clearly specify if recreational and/or competitive surfers were considered in their analysis. For the purpose of this review, surfing included the use of a shortboard, longboard, bodyboard, stand-up paddle and tow-in surfing.

A search of peer-reviewed literature published until 31 March 2020 was conducted using MEDLINE (Ovid), PubMed, SportDiscus and Web of Science databases.

Databases were searched to identify published studies reporting injury rates, severity and/or anatomical patterns of surfing, longboarding, bodyboarding, stand-up paddle and tow-in surfing. The search strategy combined MeSH terms, subject headings and keywords from the PI(E)CO question, population AND (exposure OR comparator) AND outcome. The complete search strategy is included as online supplemental material. Additional studies found by backward citation searching of captured reviews and included studies were also considered and independently screened for the eligibility criteria.

Titles and abstracts of studies retrieved from databases searching were screened by two reviewers independently (CEMPM & JMP or CEMPM & ACQ) to identify studies that met the eligibility criteria. After checking for agreement, the full text of potentially relevant studies was read and independently screened for the eligibility criteria. Discrepancies in the study selection were discussed with a third reviewer. Inter-rater reliability was assessed with Cohen's Kappa Coefficient using SPSS Statistical Package v26 (IBM).

The methodological quality of included studies was assessed using the 'Strengthening the Reporting of Observational Studies in Epidemiology' (STROBE) statement.[13] Studies were categorised based on the percentage of items of the STROBE checklist they fulfilled.[14 15] Studies were classified as having poor, moderate or good quality if they fulfilled less than 50%, between 50% and 80% or more than 80% of the items, respectively. Studies were also classified by level of evidence in accordance with the guidelines from the Centre for Evidence-Based Medicine.[16]

After the final selection of studies against eligibility criteria, data was extracted. Discrepancies in the extraction process were discussed and resolved by consensus.

Original data was recorded for all studies reporting it. When a study did not provide such data, the percentage of injured surfers and number of injuries per surfer were calculated, as long as the information provided was sufficient. If the studies provided separate data for recreational and/or competitive surfers regarding anatomical location and injury type, the absolute frequencies for each category were collected and then merged. Anatomical location and injury type were compared using categories created based on the information extracted from the included studies. The four 'anatomical location' categories were 'head and neck', 'torso and pelvis', 'upper limbs' and 'lower limbs'. As for the type of injury, the six categories were 'muscle/tendon"' 'joint/ligament', 'skin', 'bone', 'spinal cord and peripheral nerve' and 'other'. 'Muscle/tendon' category includes muscle strain, tear or rupture and tendon injury. 'Joint/ligament' includes ligamentous sprain, cartilage damage, discal injury, dislocation, subluxation and bursitis. 'Skin and subcutaneous tissue' includes lacerations, burns, abrasions, contusion, bruising and haematomas. 'Bone' includes fractures, avulsion and bone bruising. 'Spinal cord and peripheral nerve' includes neural compression, nerve stretch or other nervous injuries. The 'other' category includes pneumothorax, eardrum perforation and other acute ear injuries, eyeball and eye socket injuries, concussions, loss of consciousness and other brain injuries. Considering the observed inconsistency in injury type grouping being reported by each study, the option was to include such injuries in the broader category when in doubt.

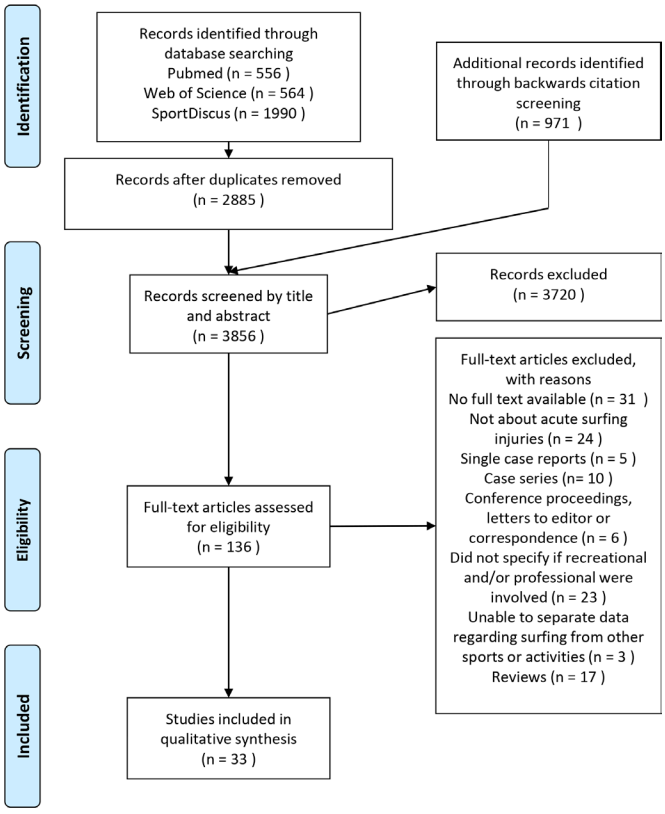

Figure 1 [11]Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

RESULTS

From the 3110 records identified through database searching, plus an additional 971 studies retrieved from backwards citation of captured reviews and the original data studies selected for full-text analysis, a total of 17 studies were included in the analysis. The PRISMA flow diagram (figure 1) summarises the study selection process and presents reasons for excluded articles. The Cohen's Kappa ($k=0.628$, $p<0.01$) rendered 'moderate agreement' between reviewers.

Table 1 illustrates the general characteristics of the included studies, such as study design, data collection method and context, sample size and characteristics, evidence level as well as methodological quality and competitive status. Most of the studies included in the analysis were published after 2010 with only one being published before 2000. Sixteen of the studies deemed eligible were cross-sectional retrospective and one was a cross-sectional prospective cohort study. Ten studies addressed both recreational and competitive surfers' injuries while five reported data exclusively from competitive surfers and two from recreational surfers. Thirteen studies retrieved data from one single country including Australia, Brazil, Portugal and Japan. Four studies included international data from 4 to 48 countries. All except 3 of 17 selected articles comprised data obtained from surveys. The shortage of studies with data from medical records can be explained by the need imposed by the review

Table 1 General characteristics of studies included in the review (N=17)

Author (year)	Title (study design)	Data collection method	Context	Period of data collection	No of participants	Methodological assessment (evidence level)	Recreational and/or competitive
Almeida (2009)[25]	Contribution for the knowledge of surf acute injuries in Portugal (Cross-sectional Retrospective Cohort)	Paper back survey	Surfers attending Portuguese beaches	4 months of 2009	151	Moderate (3)	Recreational and competitive
Base (2007)[17]	Injuries among professional surfers (Cross-sectional Retrospective Cohort)	Questionnaire by interview	Surfers competing in one phase of the Brazilian Professional Surfing Championship, Maresias Beach, Brazil	25 June 2005 to 26 June 2005	32	Moderate (3)	Competitive
Bazanella (2017)[28]	Influence of practice time on surfing injuries (Cross-sectional Retrospective Cohort)	Questionnaire by interview	Surfers from the Paraná Coast, Brazil	Unspecified	66	Moderate (3)	Recreational (65%) and competitive (35%)
Burgess (2019)[4]	An Australian survey on health and injuries in adult competitive surfing (Cross-sectional Retrospective Cohort)	Online survey	2014 Australian Surfing Titles, Coffs Harbour, Australia	1 August 2014 to 31 August 2014	227	Good (3)	Competitive
de Moraes (2013)[18]	Analysis of Injuries' Prevalence in Surfers from Parana Seacoast (Cross-sectional Retrospective Cohort)	Paper back survey	Beaches of the seacoast of Paraná at the cities Guaratuba, Matinhos and Pontal do Paraná, Brasil	Not specified	60	Moderate (3)	Recreational (70%) and competitive (30%)
Foo (2004)[22]	Surfing injuries in recreational surfers (Cross-sectional Retrospective Cohort)	Written survey	Members of Australian surfboard riding clubs and surfers at beaches from Western Australia, Victoria, New South Wales and Queensland	May 2004 to July 2004	146	Good (3)	Recreational
Furness (2015)[1]	Acute Injuries in Recreational and Competitive Surfers Incidence, Severity, Location, Type, and Mechanism (Cross-sectional Retrospective Cohort)	Online survey	Australia	25 October 2012 to 25 March 2013	1348	Good (3)	Recreational (57%) and competitive (43%)
Furness (2017)[19]	Epidemiology of Injuries in Stand-Up Paddle Boarding (Cross-sectional Retrospective Cohort)	Online survey	Australia (67%), United States of America (21.7%), Europe (3.9%).	19 January 2016 to 21 March 2016	230	Good (3)	Recreational (45%) and competitive (55%)
Hohn (2018)[31]	Orthopaedic Injuries in Professional Surfers: A Retrospective Study at a Single Orthopaedic Centre (Cross-sectional Retrospective Cohort)	Medical records	Doctor W. G. K. (Official WSL specialist) Orthopaedics Clinic	1999 to 2016	86	Good (3)	Competitive

Continued

Table 1 Continued

Author (year)	Title (study design)	Data collection method	Context	Period of data collection	No of participants	Methodological assessment (evidence level)	Recreational and/or competitive
Inada (2018)[29]	Acute injuries and chronic disorders in competitive surfing: From the survey of professional surfers in Japan. (Cross-sectional Retrospective Cohort)	Medical records	Data retrieved from medical personel in 50 contests of Japan Pro Surfing Tour (2009 to 2016) and one outpatient clinic (2010 to 2016)	2009 to 2016	Unspecified	Moderate (3)	Competitive
Júnior (2013)[20]	Characteristics of training and injuries in amateur surfers (Cross-sectional Retrospective Cohort)	Online survey	Brasil	January to March 2012	33	Moderate (3)	Recreational
Lowdon (1983)[10]	Surfboard-riding injuries (Cross-sectional Retrospective Cohort)	Written questionnaire	Surfers from Victorian Branch of the Australian Surfriders Association	March 1982	346	Moderate (3)	Recreational and competitive
Meir (2012)[23]	An investigation of surf injury prevalence in Australian surfers: A self-reported retrospective analysis (Cross-sectional Retrospective Cohort)	Online survey	Australia	Not specified	685	Good (3)	Recreational (72%) and competitive (28%)
Minghelli (2018)[24]	Injuries in recreational and competitive surfers: a nationwide study in Portugal (Cross-sectional Retrospective Cohort)	Questionnaire by structured interview	Portugal	2016	1016	Good (3)	Recreational (56%) and competitive (44%)
Nathanson (2007)[27]	Competitive surfing injuries - A prospective study of surfing-related injuries among contest surfers (Cross-sectional Retrospective Cohort)	Medical records	Professional (22) and amateur (10) competitions in Hawaii, Australia, California, Tahiti, Argentina and East Coast of USA	March 1999 to September 2005	Unspecified	Good (3)	Competitive
Nathanson (2002)[26]	Surfing injuries (Cross-sectional Retrospective Cohort)	Online survey	Surfers from 48 countries—76% USA, 6% Australia, 5% England, 2% New Zealand, 11% other coutries	May 1998 to August 1999	1348	Good (3)	Recreational and competitive
Santos (2014)[21]	Prevalência e incidência das lesões em surfistas de elite portugueses - Comparação entre competidores e não competidores (Cross-sectional Retrospective Cohort)	Written survey	Top 30 surfers from Portuguese National Surfing Championship and top 30 portuguese free surfers acording to Associação Nacional de Surfistas (Nacional Surfers Association)	March to October 2012	60	Good (3)	Recreational (50%) and competitive (50%)

team for studies to specify whether they gathered information from recreational and/or competitive surfers. Frequently, studies that report data from medical records do not assess competitive status and were thus deemed ineligible. The average overall methodological quality of included studies was 75% (moderate).

Information regarding injury rates, average injuries per athlete, incidence proportions and incidence rates can be found in online supplemental material. While most studies provide percentage of injured surfers or at least enough data to calculate it, only six studies[1 17–21] provided separate data for recreational and/or competitive surfers. Based on these data, recreational surfers sustained less injuries than competitive surfers over a period of 12 months, but no differences were found when considering injuries sustained in their lifetime (online supplemental material). Almost all selected studies provide enough data to calculate the number of injuries per surfer over the analysed period

but only seven[1 17–22] studies provide specific data for recreational and competitive surfers. Of the 10 studies whose samples comprised recreational and competitive surfers' injury data, 6 addressed the possible impact of competitive status on surfing injuries. Furness *et al*[1] provided separate incidence proportion and incidence rates for competitive and recreational surfers (online supplemental material), reporting a significantly higher (χ^2=6.4, p<0.01) incidence proportion of injuries in competitive surfers. When looking at incidence rates in major injuries per 1000 hours of surfing the authors reported a lower incidence rate for competitive surfers (online supplemental material). The authors also found that competitive surfers sustained significantly more acute injuries. Furness *et al* concluded the same.[19] Competitive SUP riders had significantly (χ^2=7.7, p<0.01) more injuries than recreational riders, a significantly higher incidence proportion (χ2=7.12, p<0.01) but lower incidence rate (online supplemental material). Studies by Meir *et al*[23] and Minghelli *et al*[24] also concluded that competitor surfers had higher probability of injury with the later stating that this probability increased with the number of training sessions and decreased with higher surfing experience. Almeida *et al*[25] also reported that surfers with less experience sustained more injuries (r=−0.189, p<0.01) but Nathanson *et al*[26] concluded that surfers who self-rated as advanced or experts/professionals had more probability of being injured when compared with surfers who self-rated as inexperienced or intermediate. Three studies addressed the possible effect of wave size in surfing injuries. Both studies by Nathanson *et al*[26 27] found that surfing larger waves was associated with a higher risk of injury and Almeida *et al*[25] concluded that injuries requiring medical attention occurred more frequently on major height waves. Meir *et al*[23] and Nathanson *et al*[27] explored the role of seafloor composition in injuries and both concluded that surfing over a hard seabed was associated with higher probability of being injured when compared with surfing above a sand seabed. Studies by Furness *et al*[19] and Nathanson *et al*[26] addressed the possible role of age in surfing injuries. Furness *et al*[19] stated that SUP riders older than 46 years had significantly (*t*=3.3, p<0.01) more injuries than younger participants (mean values, 46.7 vs 41.6 years of age) and Nathanson *et al*[26] concluded that surfers aged 40 years or more had 1.9 (OR, 1.1–3.4) more probability of sustaining an injury than those with 19 years or less. The only study[28] that explored the role of prior pathology in the risk of injury showed that surfers who had undergone surgery had significantly more injuries than those who did not (56.9% greater average number of injuries, 95% CI 9.1% to 121.2%).

Online supplemental material also shows severity data retrieved from the selected articles. There is high heterogeneity in the way severity is reported among studies. While some studies described severity in number of days of surfing lost,[10 18] others divided injury severity in terms of the need for medical care or hospitalisation, or described the type of healthcare sought by injured surfers.[4 26] In some studies,[1 10 26 27] the injuries were divided into categories (ie, minor, moderate, severe) based on the need for medical intervention, time spent hospitalised or in a healthcare facility. In other cases,[19 23] injuries were only recorded if severe enough to keep the surfer out of the water while recovering or healing the injury. In one study,[23] injury severity was also assessed by the surfers' perceived outcome of injury, such as 'Significant loss of income due to extended periods of recovery and/or rehabilitation'.

Figure 2 illustrates type and anatomical location of recreational and competitive surfers' injuries. We found great variability in the description of injury type and anatomical location.

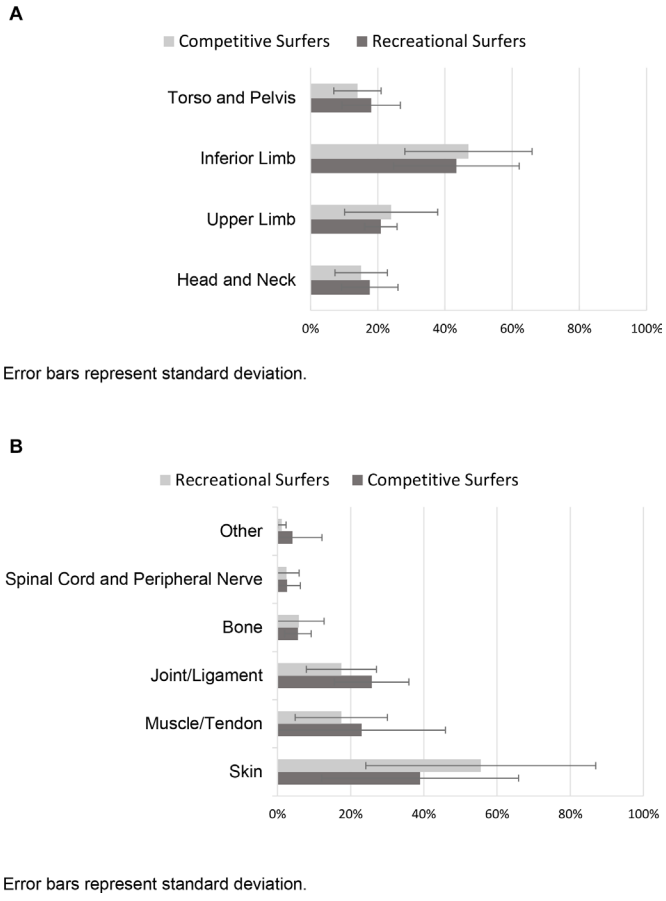

Figure 2 Anatomical location and type of injury sustained by competitive and recreational surfers in studies that included comparable data. Dark grey bars represent data reported for competitive surfers and light grey bars depict data for recreational surfers. **A** - Anatomical location of injury. Data for anatomical location of injury is reported here based on data retrieved from four studies[1 18 19 22] of recreational surfers and six studies[1 17–19 26 29] of competitive surfers. **B** - Injury type. Here is depicted the proportion of injury types reported in five studies[1 18–20 22] of recreational surfers and five studies[1 17–19 29] of competitive surfing.

Seven studies[1 17–20 22 29] provided separate data for the type of injury suffered by recreational and competitive surfers. The three most common types of injury for both competitive and recreational surfers are skin, joint/ligament and muscle/tendon injuries. Competitive surfers seem to sustain more skin (39%), joint/ligament (26%) and muscle/tendon (23%) injuries whereas recreational seem to sustain more of skin (56%), muscle/tendon (17%) and joint/ligament (17%) injuries. Seven studies[1 17–19 22 26 29] provided separate data for the anatomical location of recreational and competitive surfers' injuries. We found that most competitive and recreational surfers injuries affect the lower limbs (47% and 43%, respectively). The second most commonly injured anatomical location for both groups were the upper limbs (24% and 21%, respectively). After excluding data from stand-up paddle injuries[19] from this analysis, the most common types and anatomical locations of injury remained unchanged. The study from Lowdon *et al*[10] was the oldest in our dataset and since in the last decades both surfing equipment and style changed considerably this could have had an impact in this analysis. However, since it did not provide specific data for competitive and recreational surfing injuries it was not included in the analysis of injury type and anatomical location.

Only four studies provided separate data regarding the mechanisms of injury of recreational or competitive surfers. Three studies[4 17 26] regarding competitive surfers' injuries showed that the most prevalent mechanism of injury was contact with the surfers' own board, followed by performing manoeuvres, and contact with sea bottom. Júnior *et al*[20] showed that contact with the surfboard was also the most prevalent mechanism of recreational surfers' injuries (26.2%) with performing manoeuvres (22.1%), wave turbulence (18.9%) and contact with sea bottom (17.2%) also being common.

A total of nine cases of non-fatal drowning were reported in three studies.[23 26 27] Nathanson *et al* reported that six concussions (8%)[26] and two head injuries[27] resulted in non-fatal drownings but no further information was provided in the included studies.

DISCUSSION

The findings of this review support the idea that competitive surfing is associated with a greater risk of injury and may help understand why competitive surfers seem more prone to injury when compared with their recreative counterparts. Incidence proportion and incidence rate retrieved from the studies of Furness *et al*[1 19] support the idea that even though recreational surfers have a higher tendency to injure themselves while surfing, they tend to injure less on a yearly basis because of spending less time surfing. Conversely, competitive surfers have more time of surfing practice, and this translates into higher injury rates.[22 29] Given these differences in injury rates in different time periods it seems that, more than comparing injury rates solely based on the number of injuries suffered in a particular time period, it is important to try to understand which factors might have an impact in recreational and competitive surfers' risk exposure. During competition it is expected that surfers expose themselves to more hazardous geographical and meteorological conditions since surfing competition scores are partly based in the degree of commitment of athletes.[21] The evidence retrieved in this review[23 25–27] highlights the higher probability of injury associated with surfing large waves and over a hard seabed, and therefore, the higher injury rate of competitive surfers might be partially explained by the more challenging geographical and environmental conditions in which they perform.

Paradoxically, Santos[21] found that most injuries of elite surfers were sustained in waves of 1.5 m or less and proposed that this might be due to surfers performing more difficult manoeuvres in these conditions. Competitive surfing rewards innovative surfing techniques and,[30] in the past two decades this has translated in a shift towards aerial surfing. Nowadays, aerial surfing is arguably regarded as the cutting edge of surfing technique and given the degree of difficulty of these manoeuvres they are less commonly performed by the everyday recreational surfer. Furness *et al*[1] reported that aerialists had a higher incidence proportion than overall surfers and that there was a significant increase in injuries of surfers performing aerials. Inada *et al*[29] also report a high proportion of knee and ankle injuries due to this kind of manoeuvres. Hence, there is evidence to support the role of high-performance surfing techniques in competitive surfer's injuries.

In fact, aerial manoeuvres seem to play a role not only in the rates of injury of competitive surfers but also in their type and location. Hohn *et al*[31] noted that before the popularisation of aerials the most common injuries were to the shoulder which then significantly decreased ($p=0.05$) accompanied by a significant increase ($p<0.01$) in ankle injuries after aerials became popular in competitive surfing. Furthermore, Inada *et al*[29] not only defined midfoot joint injuries as distinguishing of competitive surfing, but also reported the influence of aerial manoeuvres in knee medial collateral ligament injuries. These findings could help understand why competitive surfers seem to sustain more muscle/tendon and joint/ligament injuries affecting the lower limbs then recreational surfers.

Even though both recreational and competitive surfers seem to suffer more lower limb skin, joint/ligament and muscle/tendon injuries, our review also found that recreational surfers have a higher rate of skin injuries than competitive surfers. The overall higher incidence of lower limb injuries could be explained by the fact that all studies included in the analysis were from warm-water countries where wetsuits are less commonly used. Surfing with boardshorts might expose surfers to a higher number of lower limb skin injuries. On the other hand, since contact with a surfer's own equipment has been regarded as the most common mechanism of injury in the reviewed studies, recreational surfer's higher rate of falls and contact with a surfer's own equipment could also be an explanation for these surfer's higher rate of skin injuries.

Furness *et al*[19] and Nathanson *et al*[26] point to higher rates of injury in older surfers while Bazanella *et al*[28] showed that surgery history was associated with a higher rate of injury. These factors may increase the risk of injury, especially in recreational surfers, in whom we might expect a wider age span and possibly more comorbidities. From the findings of Almeida *et al*[25] and Minghelli *et al*,[24] it seems that less surfing experience is also a risk factor to injury, so we could speculate if older surfers which start surfing later in life might be at higher risk of injury.

Severity of injury appears to be poorly represented in the included studies and there is high heterogeneity in provided data. This prevented us to draw conclusions regarding recreational and competitive surfers' injury severity.

The results from this review should be interpreted with caution given the limitations of data provided by the included studies. Not only sample size varied greatly among studies and was mostly selected by convenience, but data collection was almost always conducted by means of surveys which are known to introduce recall bias. Furthermore, there was high methodological variability among studies, with different injury definitions and descriptions. Our decision of including only studies that clearly defined the competitive status of individuals being studied also excluded most of the studies that retrieved data from medical records which can lead to further bias since most of the diagnostics and injury descriptions are provided by the surfer himself and not validated by healthcare professionals. Nevertheless, the findings in this review cast light into which factors might not only play a role in the differences in injury risk between recreational and competitive surfers but may also lead to differences in anatomical location and type of injury of these two groups of surfers.

The overall injury rate of surfing is not negligible. The studies in this review showed an overall incidence rate that varied between 0.88 and 3.5 injuries per 1000 hours of surfing with a minimum of 30%[24] of surfers sustaining an injury over a period of 12 months. These numbers should encourage future risk reducing interventions. Some of these interventions may include training surfers, lifeguards, surf instructors and surf coaches on the most common surfing injuries and their primary management as well as preventive strategies. Novice surfers should also be taught protective measures in case of fall or imminent contact with their own or other surfer's equipment. We also propose that all surf schools and clubs have a first aid kit and that all surf coaches and surf instructors have basic life

support training or at least a first aid qualification. Unexperienced surfers should be encouraged to use protective equipment and user-friendly material (ie, softboards with rubber fins) given that the main mechanism of injury seems to be contact with surfer's own equipment.

Even though there is still no clear evidence to support the effect of protective head gear, existent research supports the idea that water sport helmets do not increase the likelihood of traumatic brain injury.[32] In fact, using helmets has the potential to protect from mild brain injuries that can accumulate morbidity with time, from skin cancer and from other head injuries such as head lacerations and perforated tympanic membranes.[26 33 34] This review showed that head injuries add up to 15%–18% of all surfer's injuries and one study[26] mentioned that 8% of head concussions resulted in non-fatal drownings. So, the use of helmets might be a beneficial strategy to prevent further injuries and mitigate the long-term impact of previously sustained head injuries.

In studies providing information on type of healthcare professional sought by injured surfers,[4 21 22] the most reported professionals were the physician and physiotherapist. Therefore, in locations where surfing is practised, these professionals should be familiar with the risks associated with this activity not only to better inform their patients on surfing mechanisms of injury and injury prevention but also to provide the most adequate care. In the same way, emergency medicine clinicians practising in these locations should also be familiar in the recognition and management of surfer's injuries.

To better understand the pathology of surfing injuries and the differences between recreational and competitive surfing injuries, there is a need for greater uniformity of the methodological aspects of surfing investigation. Most studies included in our review did not provide a definition of surfing injury.[1 4 10 17 18 20 22 25 28 31] The seven studies that provided this information were very heterogeneous in their definitions.[19 21 23 24 26 27 29] These varied from any condition that kept the surfer out of the water, that changed the type of activity, that lead the surfer to seek medical attention or care or a combination of these. Furthermore, some graded the injuries in categories of severity based on the type of outcome. This certainly introduces a bias in injury description and overall epidemiological data and can also introduce noise when considering and analysing injury severity. In our opinion, surfing injury definitions should not be based on the need for medical care or time spent without surfing. These should instead be used as descriptors of severity, as a mean to better define the outcomes of surfing injuries. In the same way, the use of uniform indicators of severe injury prevalence will be of great value not only in terms of investigation but also to inform prevention efforts. As stated by Burgess *et al*,[4] this has been accomplished in other sports and activities like soccer, tennis, athletics, rugby and horse racing by the means of specialist consensus statements that define the concepts of injury and illness and provide methodological guidance for epidemiological studies. We think that providing uniform guidelines for surfing injury investigation would be a great improvement in this field of research.

Finally, more prospective studies are needed in the field of surfing medicine as data gattered from retrospective survey-based studies is more prone to recall bias and studies from medical records are necessarily more inclined to retrieve data from more severe injuries. Research focusing on the influence of surfing on the health status of specific populations like older surfers or individuals with prior comorbidities would also be relevant.

What is already known on the subject

- Surfing is growing in popularity and gaining new fans of all ages and standards. Being a physically and mentally demanding activity, involving both aerobic and anaerobic performance and affected by a myriad of meteorological and geological factors, it is necessarily associated to injury. Most surfing injuries seem to be minor in severity, consisting of skin, muscle and articular injuries that affect the limbs.

What this study adds

- This study explores the differences between recreational and competitive surfing injuries in terms of their anatomical location and type, highlighting possible risk factors and trying to gain a new understanding of what might explain these differences.
- This review presents research gaps and highlights methodological incongruences that influence injury description and overall epidemiological data and makes suggestions that might improve investigation and subsequently help to inform prevention efforts.

CONCLUSION

Competitive surfers appear to have a higher injury risk than recreational surfers. This might be explained by competitive surfer's higher number of hours of surf practice, their exposure to more dangerous meteorological and geographical conditions and by performing high-performance surfing techniques like aerials. Being older, having less surfing experience and/or having prior surgical history could also raise the risk of sustaining a surfing injury.

The most common types of injury for both competitive and recreational surfers are skin, joint/ligament and muscle/tendon injuries. There is a higher percentage of muscle/tendon and joint/ligament injuries in competitive surfers and a higher percentage of skin injuries in recreational surfers. Most injuries sustained by both recreational and competitive surfers affect the lower limbs and are caused by contact with the surfer's own equipment.

To avoid recall bias, prospective studies or retrospective studies of confirmed injuries are needed in this field of sports medicine.

Developing uniform guidelines or consensus statements would be a great improvement in this field of research.

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