Acute injuries in recreational and competitive surfers: Incidence, severity, location, type, and mechanism

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Acute injuries in recreational and competitive surfers; incidence, severity, location, type and mechanism

Running title: Acute injuries in recreational and competitive surfers

Key words: Surfing, injury, water sports, injury prevention, incidence

Abstract

Background: There are an estimated 37 million surfers worldwide with 2.5 million recreational surfers within Australia. The recreational activity and sport of surfing has grown dramatically since the 1960's, however scientific research has been poorly mirrored in comparison to most other mainstream sports.

Purpose: The aim of this study was to identify the incidence, severity, location, type and mechanism of acute injuries in recreational and competitive surfers over a 12 month period.

Study Design: Descriptive epidemiology study.

Methods: An on-line survey using an open-source survey application was utilized. The survey consisted of two primary sections. Section one included demographic information and participation levels (age, height, weight, hours surfed, competitive level). Section two and also incorporated injury type, mechanism, severity and injury management.

Results: A total of 1,348 participants (91.3% males, 43.1% competitive surfers) were included in data analysis. A total of 512 acute injuries were classified as major providing an incidence proportion of 0.38 (CI; 0.35-0.41) acute injuries per year. Incidence rate was calculated to be 1.79 (CI; 1.67-1.92) major injuries per 1000 hours of surfing. The shoulder, ankle and head/face regions had the highest frequencies of acute injury representing 16.4%, 14.6% and 13.3% respectively. Injuries were predominantly of muscular, joint and skin origin representing 30.3%, 27.7% and 18.9% respectively. Skin injuries were primarily a result of direct trauma while joint and muscular injuries were mainly a result of manoeuvres performed and repetitive actions. Key risk factors which increased the incidence of sustaining an acute injury included competitive status, hours surfed (> 6.5 h · wk) and the ability to perform aerial manoeuvres. The incidence proportion for surfers completing aerial manoeuvres was calculated to be 0.48 (CI; 0.39-0.58) major injuries per year, this being the highest IP irrespective of competitive status.

Conclusion: This is the largest surfing specific survey which included both recreational and competitive surfers conducted within Australia to date. We identified the shoulder, ankle, head and face are the key regions where acute injuries occur in surfers. This research may aid in reducing the occurrence of injury through musculoskeletal screening in these key injury prone regions and the use of sports specific strength training and conditioning.

What is known about the subject: Surfing related injuries have commonly been associated with lacerations mainly to the head and leg regions. More recent research has highlighted increasing numbers of musculoskeletal injuries to the extremities.

What this study adds to existing knowledge: This study provides a comprehensive breakdown of injury location, type and mechanism. Mechanism of injury has been neglected in previous studies or been assumed as contact injuries. Surfing technique has drastically changed over the past decade with the introduction of aerial manoeuvres. No study to date has reported on the incidence of injuries associated with these types of manoeuvres until now. This study has revealed a significantly greater number of acute injuries with surfers who complete aerials. This subgroup of surfers also had the highest incidence proportion regardless of competitive status. These results highlight the need to introduce preventative measures to aid in reducing injury incidence.

Keyword: *Surfing, injury, water sports, injury prevention, incidence*

Introduction:

There are an estimated 37 million surfers worldwide [16] with 2.5 million recreational surfers within Australia [24]. The recreational activity and sport of surfing has grown dramatically since the 1960's, however scientific research has been poorly mirrored in comparison to most other mainstream sports.

Currently it is difficult to draw clear conclusions from previous research specific to acute surfing injuries, due to variations in research methodologies. Research conducted in hospital or emergency clinics tends to reveal high frequencies of lacerations mainly to the head and leg regions [1, 2, 21, 25]; however research conducted outside the hospital or emergency setting reveals an increase in soft tissue sprains and strains which are mainly represented in the lower body regions [17].

Incidence definitions along with injury severity, location and type of injury appear to vary between studies [1, 2, 7, 14, 17, 18, 21, 25]. Mechanism of injury has been inconsistently reported and often not linked with injury location and type. These factors highlight the need to capture new acute injury related data that encompasses injury severity, location, type and mechanisms.

World-wide surfing participation has increased from an estimated 13 million in 2002 [18] to 37 million in 2013 [16]. With this significant growth in participation numbers and no clear understanding of injury epidemiology in the sport of surfing, further research is needed. Therefore the aim of this study was to investigate acute injury in recreational and competitive surfers within Australia. The secondary aim was to provide a foundation for injury prevention strategies by initially understanding injury incidence, severity, location, type and mechanism in a surfing population.

Methods

A cross-sectional descriptive survey design was implemented to gather acute injury data. Due to the coastal location of surfers and the accessibility of the internet an online survey was selected as the data collection method. An on-line survey (SurveyMonkey) using an open-source specialized survey application was the tool utilized. Research ethics approval was granted by Bond University Human Research Ethics committee (RO 1540).

Surfing injury data was attained by asking each participant to retrospectively recall any acute injury which occurred while surfing in the past 12 months. A clear description of an acute injury was given at the start of the question to exclude chronic injuries and any acute injuries that were not caused from surfing. A 12 month time frame has been used in previous surf specific research [18, 25]. The ability of a participant to recall whether an injury occurred or not in the previous 12 months has been previously shown to be 100%, however it needs to be noted that as the detail requested increases the ability of recall decreases [5]. Prospective methods are clearly ideal as this does not rely on participant memory. No systems are in place at surf clubs that record injuries making the possibility of prospectively recording injury unattainable.

To take part in the online survey participants had to be active surfers and have at least 12 months of experience [25]. Considering an estimated 2.5 million recreational surfers in Australia [18], to have a 95% chance that our sample proportion would be within ± 3% of this estimated population, we needed to recruit 1067 surfers [25]. Therefore several recruitment strategies were utilized to help ensure adequate participant recruitment.

Recruitment began with sending the study overview and the survey link to local surfing clubs (n=103). Next we sought support from popular Australian surfing websites (Surfing Australia, Surfing Queensland, Swellnet, Tracks, Surfrider Foundation and Surfing Life). Finally the survey was advertised through the local television networks and radio (NBN, Nine news and ABC radio). All media promotion reinforced that surfers did not have to be injured to take part in the survey. This was to ensure a true representation of the surfing population was attempted to be attained.

After initial development of the survey it was pilot tested with a group of relevant experts in the field of sports injuries and the sport of surfing. Relevant experts included exercise scientists and physiotherapists who were on the Surfing Australia sport science and medicine panel. This was to ensure face validity and relevant questions were included. Further pilot testing occurred with 10 surfers.

In an attempt to encourage completion, questions were a range of "yes/no", checklist and drop down options. Text boxes were offered when categorical options could not describe the injury. The survey was active online on the 25th October 2012 and remained active until 25th March 2013.

The survey consisted of three primary sections. Section one contained questions which included demographic information and participation levels (age, height, weight, hours surfed, competitive level). Participants were asked typically, how many hours they surfed per week and how many weeks per year. Competitive level was determined by offering 15 different categories of varying levels of competition. This ranged from local club level competition to the peak international competition (World Championship Tour). Participants were able to select whether they currently or previously were involved in competition. Participants were also asked whether or not they did aerial manoeuvres on a regular basis. An aerial manoeuvre was defined as ‘an ability to propel yourself and the board in the air and land back on the water standing on the board’. This was supplied in the body of the question.

Section two included questions related to acute injury for all the major regions of the body, and also incorporated injury type, mechanism, severity and injury management. In order to determine injury type, five broad types were offered to the participant. These included skin injury, bone injury, joint or ligament injury, muscle or tendon injury or marine injury. These broad injury definitions were based on previous retrospective epidemiological designs [25, 28]. If an injury fell outside these categories a text box labelled ‘other’ was supplied to describe the type of injury. To determine the mechanism of injury the participant was asked to select the movement or event that occurred just before or contributed to the acute injury; these included 15 options and a text box labelled ‘other’ when no option was appropriate for the mechanism of injury. Where the option ‘other’ had been filled out by the participant data was categorised manually. This was applied for injury type and mechanism of injury and was performed by an experienced, credentialed physiotherapist.

To determine the severity, injuries were classified as either minor or major. Major injuries required one day or more off work and/or surfing and/or the participant required treatment from a health professional. Minor injuries did not interfere with work, surfing or involve treatment from a health professional. As it is possible surfers may still participate in the sport with a current acute injury, it was deemed appropriate to classify an injury as major if the surfer received treatment but continued to participate in surfing. Previous epidemiology studies [6, 14] have not combined both variables to determine severity.

In order to determine injury incidence, clear definitions must be implemented. Incidence refers to the number of new occurrences of an injury during a specified time period [22]. Risks and rates are two methods of quantifying incidence however very often these definitions are incorrectly used or authors assume they are the same [9]. Injury risk refers to the number of athletes injured divided by the number of athletes exposed to risk, this is also known as incidence proportion (IP). This answers the question, "what is the probability an athlete will be injured over a 12 month period". Incidence rate (IR) refers to the total number of injuries divided by the total time the athlete is exposed to risk (normally per 1000 hrs). This answers the question, "what is the incidence of injury per unit of exposure".

The use of IP is more user friendly for practitioners and coaches and allows a simple probability calculation (e.g. one in every two athletes will sustain an acute injury over the season). The definition of IR applies a more complex calculation however is used for scientific and research comparisons (i.e. 11.3 injuries per 1000 hours). Both of these definitions will be used within this paper.

A participant could report multiple injuries at several sites of the body; however recurrent acute injuries at the same location could not be captured by the survey. Chronic injuries were analysed in the third section of this survey, however for the purpose of this study this section was not included.

Descriptive statistics and frequencies were used to summarise each variable. Significant differences ($p \leq 0.05$) were determined between groups using independent t-tests for continuous data. For categorical variables a Chi-square test of independence was used to determine differences between variables. All statistical analysis was completed using Statistical Package for the Social Sciences (Ver 20.0).

Results

A total of 1582 participants commenced the survey however 234 participants had a significant amount of data not completed and consequently were excluded from data analysis. Therefore 1,348 participants (91.3% males, 43.1% competitive surfers) were included in the data analysis. It is not possible to provide an estimation of the percentage of respondents to non-respondents due to the extremely broad outreach to participants through the several promotional strategies used to advertise the survey (websites, television, radio and email).

The mean age was 35.8 (s = 13.08; range 11-70) years, with a median of 35.0 years. Males were significantly older ($t = 4.00$, $P < 0.001$) with the mean age being 36.21 years compared to females (31.87 years). Key physiological and surfing demographics are summarized in Table 1.

Of 1,348 surfers, a total of 512 participants reported sustaining an acute major injury. As more than one injury could be reported by a participant a total of 739 injuries were classified as major.

****Table I near here******

Incidence Rate (IR) and Incidence Proportion (IP)

In order to determine IR (injuries per athlete hour of exposure) the total number of injuries was divided by the total number of hours surfed per year. The IR was calculated to be 1.79 major injuries per 1000 hours of surfing. As surfing has high levels of participation, IP (total injured athletes divided by total number of athletes) needed to also be examined as IR is lowered with large hours of participation. Therefore the total number of participants who had sustained an acute major injury (n = 512) was divided by the total number of participants who completed the survey (n = 1348) to determine the IP. An IP of 0.38 (CI; 0.35-0.41) major acute injuries per surfer per year was determined. When considering competitive status there was a significantly higher ($\chi^2 = 6.399$, $P < 0.001$) IP compare to recreational surfers. Out of the 581 competitive surfers 243 surfers had sustained at least one major injury providing an IP of 0.42 (CI; 0.35-0.41) major injuries per surfer per year. Out of the 767 recreational surfers 269 surfers had sustained at least one major injury, thus providing a lower IP of 0.35 (CI; 0.33-0.37) major injuries per surfer per year. Table 2 presents the IP and IR for recreational and competitive.

****Table II near here****

Injury location, type and mechanism

The shoulder, ankle and head/face regions had the highest frequencies of major acute injuries representing 16.4%, 14.6% and 13.3% respectively. Competitive surfers revealed a significantly ($P = 0.001$) higher number of knee injuries compared to recreational surfers (n = 50 vs. 29). Table 3 summarises the site and severity of acute injuries with comparisons between recreational and competitive surfers.

****Table III near here****

Injuries were predominantly of muscular (31.3%), joint (28.7%), skin (17.2%) and nerve (6.9%) origin (Table 4). The remaining 4% encompassed eye, ear, concussion, sacroiliac injury and pneumothorax. Categories at each location of the body were added together to provide the overall percentages above. A complete break-down of injury types at each location can be seen in table 4.

Of the total number of mechanisms of injuries 47.1% were a result of direct trauma with either a surfer's board or contact with the ocean floor. The remaining mechanisms occurred while the surfer was paddling (10.9%), duck diving (4.6%), wave riding (32.7%) and aerial surfing (4.6%). Acute shoulder injuries commonly resulted from paddling (25.6%); meanwhile head and face injuries were predominantly a result of direct trauma/contact injuries (83.7%). Ankle injuries resulted from direct trauma (54.6%), wave riding (30.6%) and aerial manoeuvres (13.9%). The major mechanisms of acute knee injuries occurred during wave riding (73.7%). Each of the categories for mechanism of injury can be seen in table 5. This table also gives a complete breakdown of the different mechanisms of injury at each location.

****Table IV and V near here****

Risk Factors

Competitive status resulted in significantly more acute injuries than the recreational group. There was also a significant difference ($t = 11.0$, $P < 0.001$) between hours surfed for competitive versus recreational surfers (mean values 406.9 vs. 228.7 h · year). As expected those suffering an acute injury (major only) on average spent significantly ($t = 5.5$, $P < 0.001$) more time surfing (360.4 vs. 271.8 h · year) than those who were uninjured.

A total of 194 surfers who completed the survey were able to complete aerial manoeuvres on a regular basis (meaning the surfer can propel themselves into the air and land back onto the wave). Of the 194 surfers who could complete such manoeuvres a total of 94 surfers sustained a major acute injury within a 12 month period. The IP was calculated to be 0.48 (CI; 0.39-0.58) major injuries per year, this being the highest IP irrespective of competitive status. Chi-Square test revealed a significant increase ($\chi^2 = 10.5$, $P < 0.001$) in the group of surfers that were able to perform aerials and sustained a major injury versus the group that sustained a major injury but were unable to complete aerials (94 of 194 vs. 418 of 1154). Of the 94 surfers who could complete aerials and sustained a major injury 76.0% were located to the lower body which was significantly higher ($\chi^2 = 30.5$, $P < 0.001$) than the number of upper body injuries (24.5%) associated with the group of surfers who were able to complete aerial manoeuvres.

Discussion

This study appears to be the largest Australian national survey to date conducted on acute surf specific injuries. The purpose of this study was to explore injury incidence severity, location, type and mechanism for recreational and competitive surfers and provide a foundation for injury prevention strategies. Results have revealed both similarities and differences to previous research.

The demographical data (Table 1) of this survey revealed that surfers on average have BMI's within the normal to high ranges (male's avg. 25.0 ± 3.8 kg · m^2, females 21.9 ± 2.4 kg · m^2). However, BMI does not take into consideration tissue differences (i.e., lean body mass versus adiposity). Given their high degree of participation levels exceeds the World Health Organisation guidelines [27] on physical activity, it is assumed the higher BMI's seen in male surfers may actually be a reflection of increased lean body mass, which we are currently investigating.

This study found an overall IR of 1.79/1000 and an overall IP of 0.38 major injuries per year. It also found that when grouped, both competitive and aerial surfers had the lowest IR (1.51 and 1.35 respectively) however they both had the highest IP rates (0.42 and 0.48 respectively). It appears that the high rate of participation for the competitive and aerial surfers weakens the IR however both groups have the highest risk of being injured. Both measures of incidence are valuable for two types of questions; if an athlete wants to know whether or not he or she has a chance of being injured by competition or performing aerials knowing the IP is more useful than the IR. The IP measure is also more easily understood by coaches and trainers as it provides the probability of injury. It also may motivate both the coach and athlete to engage in exercises to help reduce the potential for injury (proprioception, strength and flexibility). If a researcher wants to know the quantity of injuries per unit and compare between sports, knowing the IR is more appropriate.

The current IR of 1.74 injuries per 1000 hours was similar to previous surf specific research [14, 25] where injury rates were based on hours of exposure. The present study found an overall IP of 0.37 major acute injuries per surfer per year. Therefore one in every three surfers will sustain an acute injury which will either require medical treatment or cause the surfer to take time off work and or surfing.

A study conducted by Meir, Zhou, GilleardCoutts [14] revealed a very similar IP of 0.38 major injuries per surfer per year. This study was also a retrospective design which used an online survey to attain information. However several other surf specific and surf life-saving studies [12, 15, 21] have either not included IP or IR due to lack of participation data or have calculated IR based on days of exposure [1, 12], therefore it is difficult to draw comparisons.

Considering the low IR (1.79 injuries per 1000 hours) surfing appears relatively safe, especially when compared to mainstream sports such as Australian football where the injury rate is 25.7 injuries per 1000 playing hours [19]. It could be hypothesised that the lack of sudden acute injuries and high participation levels may allow the surfer to develop chronic or over-use injuries which may not present as a sudden injury or be even painful until the condition is well established [10]. Chronic injuries often require more extensive treatment impacting the person physically, socially and economically [20]. This validates the need to screen surfers to identify injury prone areas and potentially prevent both acute and chronic injuries.

The shoulder had the highest number of acute major injuries followed by the ankle and the head and face region. Shoulder injuries have not previously been shown to have the highest frequency of acute injuries. However this is surprising as ~45% of a surfing session involves paddling [4, 13]. Paddling involves predominantly large global muscular strength [23], with the movements of initially abduction followed by adduction and internal rotation. It could be hypothesised that muscle asymmetry occurs between the strength of the internal rotators and the posterior external rotators of the shoulder. Previous research has shown associations between shoulder pathology and muscle tightness and weakness in the posterior rotator cuff in upper body sports such as swimming and tennis [20].

The high number of ankle injuries may reflect the change in surfing styles over the past decade. This may be seen with surfers now attempting aerial manoeuvres; if the landing is not correct it can result in excessive load at the ankle. Surfers attempt to descend from the air back onto the wave where the declining angle of the wave is used to reduce the impact on the lower limb. If the surfer lands in front of the wave on the flat section the ankle may be subject to injury. It could be hypothesised that adequate ankle range of motion and proprioception is a prerequisite before attempting such difficult manoeuvres; screening surfers to detect whether the above is present could possibly reduce such injuries. Previous research has also shown a high incidence of head and lower limb injuries [14, 18, 25], thus supporting our findings.

The most common types of injuries were related to a muscular, joint and skin origin representing 31.3%, 28.7% and 17.2% respectively. The results of this study may be a reflection in the change of current surfing style and board design. Advances in board design have allowed for lighter and smaller boards. This allows for the board and the surfer to more easily manoeuvre on the wave and perform radical torsional movements, it also allows for aerials as described previously.

These movements may place increased stresses on ligamentous and contractile tissues and possibly explain the rise in muscular and joint injuries.

High numbers of muscular and joint injury types differed to the findings of previous research [12, 18, 25] especially if the data was collected within emergency departments [21, 25] where the main type of injury was of skin origin usually a result of direct trauma from a surfer's board. This may again be a reflection in the change of surfing styles over the past decade.

This study has revealed that approximately half of the mechanisms of injuries occur while the surfer is paddling, duck diving or actual wave riding (non-contact); the remaining mechanisms were due to contact injuries (direct trauma). Previous research [14] has either not included specific mechanisms of injury or partially reported and or hypothesised the mechanism of injury [3, 18]. Research conducted by Roger [21] revealed that 100% of all injuries were a result of contact injuries. Several other studies have previously reported the mechanisms of injuries mainly due to contact injuries (direct trauma) [2, 11, 12]. These findings when compared to previous research reveal an increase in non-contact mechanisms. Non-contact injuries involve movements (take off, turning, floater, aerials and tube riding) where the surfer is injured without direct trauma from the surf board or sea floor. It could be hypothesised that conditioning of muscles and joints, which are prone to injury, may prepare these regions during these particular movements.

The rise in non-contact mechanisms could also be attributed to the survey having a wide range of choices of injury mechanism (see Table 5). A study conducted by Roger [21] used only contact mechanisms including; being struck by the surfers own board, being struck by someone else's board and other (e.g. rocks).

The limited mechanism choices can bias the results toward contact injuries (direct trauma).

This research has highlighted a number of risk factors for acute injury including increased participation levels, competitive history and the ability to perform aerial manoeuvres. Identifying these factors may assist clinicians identifying high risk surfers and ensuring injury prehabilitation exercises are implemented.

This research has provided an extensive foundation for further injury prevention research. As with any sport understanding injury incidence, severity, location, type and mechanism are the initial steps to be taken prior to any form of injury prevention program being implemented [26]. The current findings are also extremely useful for the coach, strength and conditioning practitioner and physical therapist dealing with a surfer. Coaches may carefully select waves which aerials will be attempted on or implement land based techniques to ensure correct technique and safe landings on a stable surface prior to entering unstable and unpredictable wave environments. Strength and conditioning practitioners may look to implement strengthening of opposing muscles which aren't utilised during paddling, thus trying to limit muscle imbalance and shoulder impingement. Therapists may wish to screen key joints (ankle and shoulders) for underlying muscle tightness, weakness and passive joint range of motion.

There are several limitations of this survey and mainly due to the data gathered being retrospective. As this relies upon the memory of the participant there is clearly room for error, especially as the rate of recall reduces as the detail of the injury increases [8]. There was no formal evaluation of the reported injuries therefore the reliability of the injury type is questionable and results should be viewed with caution. Ideally future surfing injury epidemiology studies should consider prospective data methods collected from health professionals. In order to do this joint collaboration between surfing organisations is needed. Methods of recording injuries need to be consistent and easily repeatable. However considering the inconsistent surf club competitions/ training sessions and the high participation hours outside of organised club meetings, injuries sustained could easily be missed and not recorded.

Another limitation of the study is that surfers who were already injured were possibly more likely to participate in the survey. To limit bias towards injured surfers the advertisements clarified that all surfers were able to participate injured or not. This survey was also not tested for reliability; therefore, the repeatability of this survey cannot be determined. It also needs to be noted that using an online data collection tool limits use to surfers who can access the internet and use a computer. This is a limitation however it provided the opportunity of widespread participation throughout Australia.

Conclusion

This appears to be the largest surfing specific survey which has included both recreational and competitive surfers conducted within Australia to date. Our findings will provide clinicians with fundamental information regarding injury prone regions specific to surfing. We were able to identify that the shoulder, ankle, head and face are the key regions where acute injuries occur in surfers.   The results of our research have identified an increase in muscular and joint injuries along with providing insight into the mechanisms of injury related to specific body regions. Further, this research may aid in reducing the occurrence of injury through screening awareness and the use of sports specific strength training and conditioning. Future studies which evaluate screening of the aforementioned injury regions in surfers may provide further information for more robust prevention measures to be developed.

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Table I. Participants physiological and surfing demographics

Physiological Demographics	Total (n=1348)	Male (n=1231)	Female (n=117)
Age (years.)	35.8 ± 13.1	36.2 ± 13.2	31.9 ± 11.1
Weight (kg)	78.6 ± 12.8	80.2 ± 11.9	61.4 ± 8.2
Height (cm)	178.2 ± 9.0	179.2 ± 8.5	167.3 ± 7.6
BMI (kg/m^2)	24.7 ± 3.8	25.0 ± 3.8	21.9 ± 2.4
Surfing Demographics			
Hours per year[a]	305.5 ± 291.2 (IQR = 312)[b]	302.9 ± 282.6 (IQR = 301)	332.9 ± 369.2 (IQR = 423)
Competitive involvement[c]	581	526	55

[a]Hours per year was calculated by adding the total hours per week and weeks per year together
[b]Interquartile range was used for hours surfed per year due to large standard deviations (low values and some large outliers)
[c]Competitive involvement refers to any surfer who currently or has previously been involved in competitive surfing

Table II. Incidence Proportion (IP) and Incidence Rate (IR) for recreational, competitive and aerialists surfers (major injuries only)

	Major injuries*		Total	IP (total injured surfers/total surfers)	IR (total number of injuries/total hours surfed)
	No	Yes			
Recreational	498	269	767	0.35 (0.33-0.37)	2.18/1000 (1.98-2.42)
Competitive	338	243	581	0.42 (0.39-0.45)	1.51/1000 (1.35-1.67)
Aerialist	100	94	194	0.48 (0.39-0.58)	1.35/1000 (1.14-1.56)
Total	836	512	1348	0.38 (0.35-0.41)	1.79/1000 (1.67-1.92)

*A major injury included any injury that required the surfer to seek medical treatment and or was unable to work or surf for at least one day.
Data in brackets are confidence intervals.

Table III. Location of acute injuries and comparisons between recreational and competitive surfers

Site	Total n (%)	Total Minor n (%)	Total Major n (%)	Recreational Major n (%)	Competitive Major n (%)	Recreational vs. Competitive Chi Square Value (*P* value)
Shoulder	154 (14.7)	33 (10.7)	121 (16.4)	60 (15.7)	61 (17.1)	2.898 (0.089)
Ankle	162 (15.5)	54 (17.5)	108 (14.6)	56 (14.7)	52 (14.6)	1.220 (0.269)
Head/Face	152 (14.5)	54 (17.5)	98 (13.3)	61 (16.0)	37 (10.4)	1.232 (0.267)
Knee	101 (9.6)	22 (7.1)	79 (10.7)	29 (7.6)	50 (14.0)	13.949 (0.001)*
Lower Back	94 (9.0)	24 (7.8)	70 (9.5)	32 (8.4)	38 (10.6)	3.766 (0.052)
Neck	85 (8.1)	17 (5.5)	68 (9.2)	37 (9.7)	31 (8.7)	0.181 (0.671)
Hip/Groin	82 (7.8)	20 (6.5)	62 (8.4)	29 (8.1)	33 (8.6)	0.358 (0.550)
Rib/Sternum	49 (4.7)	10 (3.2)	39 (5.3)	27 (7.1)	12 (3.4)	2.490 (0.115)
Upper Back	42 (4.0)	13 (4.2)	29 (3.9)	15 (3.9)	14 (3.9)	0.324 (0.569)
Shin/Calf	56 (5.3)	28 (9.1)	28 (3.8)	14 (3.7)	14 (3.9)	0.555 (0.456)
Wrist/Hand	43 (4.1)	24 (7.8)	19 (2.6)	11 (2.9)	8 (2.2)	0.008 (0.930)
Elbow	27 (2.6)	9 (2.9)	18 (2.4)	7 (1.8)	11 (3.1)	2.413 (0.120)
Totals	1047 (100)	308 (100)	739 (100)	382 (100)	357 (100)	

Note; the total major injuries are listed in descending order
n= frequencies
*Significant differences ($P \leq 0.05$)

Table IV. Injury type and location for major injuries and comparisons between recreational and competitive surfers

Site (n, %)	Type of Injury	Total No. of major injuries n, (%)	Recreational n, (%)	Competitive n, (%)
Head/Face 98, (13.3)	Skin Injury[1]	76 (64.4)	46 (65.7)	30 (62.5)
	Bone Injury[2]	15 (12.7)	11 (15.7)	4 (8.3)
	Marine Injury[3]	7 (5.9)	2 (2.9)	5 (10.4)
	Ear Injury[4]	12 (10.2)	7 (10.0)	5 (10.4)
	Eye Injury[5]	5 (4.2)	2 (2.9)	3 (6.25)
	Concussion[6]	3 (2.5)	2 (2.9)	1 (2.1)
Neck 68, (9.2)	Skin Injury	1 (1.0)	1 (1.8)	-
	Bone Injury	7 (7.2)	4 (7.3)	3 (7.1)
	Joint Injury[7]	24 (24.7)	16 (29.0)	8 (19.0)
	Muscular Injury[8]	40 (41.2)	21 (38.2)	19 (45.2)
	Nerve Injury[9]	24 (24.7)	12 (21.8)	12 (28.6)
	Marine Injury	1 (1.0)	1 (1.8)	-
Shoulder 121, (16.4)	Skin Injury	4 (2.5)	3 (4.1)	1 (1.2)
	Joint Injury	70 (44.6)	38 (52.1)	32 (38.1)
	Bone	7 (4.5)	3 (4.1)	4 (4.8)
	Muscular Injury	62 (39.5)	27 (37.0)	35 (41.7)
	Nerve Injury	10 (6.4)	1 (1.4)	9 (10.7)
	Marine Injury	4 (2.5)	1 (1.4)	3 (3.6)
Elbow 18, (2.4)	Skin Injury	3 (15.0)	1 (11.1)	2 (18.2)
	Joint Injury	6 (30.0)	3 (33.3)	3 (27.3)
	Bone	3 (15.0)	2 (22.2)	1 (9.1)
	Muscular Injury	7 (35.0)	3 (33.3)	4 (36.4)
	Nerve Injury	1 (5.0)	-	1 (9.1)
Wrist/Hand 19, (2.6)	Skin Injury	7 (30.4)	6 (42.9)	1 (11.1)
	Joint Injury	9 (39.1)	5 (35.7)	4 (44.4)
	Bone	3 (13.0)	1 (7.1)	2 (22.2)
	Muscular Injury	2 (8.7)	1 (7.1)	1 (11.1)
	Nerve Injury	2 (8.7)	1 (7.1)	1 (11.1)
Upper-back 29, (3.9)	Skin Injury	2 (6.1)	2 (11.1)	-
	Joint Injury	7 (21.2)	4 (22.2)	3 (20.0)
	Bone	4 (12.1)	2 (11.1)	2 (13.3)
	Muscular Injury	18 (54.5)	8 (44.4)	10 (66.7)
	Nerve Injury	2 (6.1)	2 (11.1)	-
Ribs/Sternum 39, (5.3)	Skin Injury	6 (12.2)	4 (11.1)	2 (15.4)
	Joint Injury	7 (14.3)	3 (8.3)	4 (30.8)
	Bone	23 (46.9)	19 (52.8)	4 (30.8)
	Muscular Injury	10 (20.4)	7 (19.4)	3 (23.1)
	Nerve Injury	1 (2.0)	1 (2.8)	-
	Marine Injury	1 (2.0)	1 (2.8)	-
	Pneumothorax	1 (2.0)	1 (2.8)	-
Lower-back 70, (9.5)	Skin Injury	10 (10.0)	5 (11.1)	5 (9.1)
	Bone Injury	4 (4.0)	2 (4.4)	2 (3.6)
	Joint Injury	31 (31.0)	13 (28.9)	18 (32.7)
	Muscle Injury	32 (32.0)	15 (33.3)	17 (30.9)
	Nerve Injury	18 (18.0)	9 (20.0)	9 (16.4)
	Marine Injury	5 (5.0)	1 (2.2)	4 (7.3)
Hip 62, (8.4)	Skin Injury	6 (7.4)	3 (7.0)	3 (7.9)
	Bone Injury	4 (4.9)	2 (4.7)	2 (5.3)
	Joint Injury	20 (24.7)	11 (25.6)	9 (23.7)
	Muscular Injury	45 (55.6)	26 (60.5)	19 (50.0)
	Nerve Injury	5 (6.2)	1 (2.3)	4 (10.5)
	SIJ[10]	1 (1.2)	-	1 (2.6)
Knee 79, (10.7)	Skin Injury	5 (5.0)	3 (8.8)	2 (3.0)
	Joint Injury	52 (52.0)	17 (50.0)	35 (53.0)
	Bone	7 (7.0)	4 (11.8)	3 (4.5)
	Muscular Injury	36 (36.0)	10 (29.4)	26 (39.4)
Shin/Calf 28, (3.8)	Skin Injury	16 (47.1)	8 (47.1)	8 (47.1)
	Bone	4 (11.8)	2 (11.8)	2 (11.8)
	Muscular Injury	12 (35.3)	6 (35.3)	6 (35.3)
	Marine Injury	2 (5.9)	1 (5.9)	1 (5.9)
Ankle 108, (14.6)	Skin Injury	44 (31.4)	25 (34.7)	19 (27.9)
	Joint Injury	38 (27.1)	18 (25.0)	20 (29.4)
	Bone	32 (22.9)	16 (22.2)	16 (23.5)
	Muscular Injury	24 (17.1)	12 (16.7)	12 (17.6)
	Marine Injury	2 (1.4)	1 (1.4)	1 (1.5)

[1] Skin injuries includes lacerations, abrasions, bruising and haematomas. [2] Bone injuries includes fractures and other bony pathologies (avulsions, bone bruising). [3] Marine injuries include stings and bites (the type of sea creature is not defined). [4] Ear injury includes ear drum perforations and any other acute ear pathologies. [5] Eye injury includes, eye ball and eye socket pathologies. [6] Concussion includes loss of consciousness and other brain injuries. [7] Joint injury includes ligamentous sprain, cartilage damage, discal injury, dislocation, subluxation, bursitis. [8] Muscular injury includes, strain, tear and rupture. [9] Nerve injury includes neural compression, stretch or other nervous injury. [10] SIJ includes sacro-iliac joint injuries or dysfunction.

Table V. Site and mechanisms of major acute injuries

	Mechanism of Injury	**Head/Face**	**Neck**	**Shoulder**	**Elbow**	**Wrist/Hand**	**Upper-back**	**Sternum/ribs**	**Lower-back**	**Hip/Groin**	**Knee**	**Shin/Calf**	**Ankle/Foot**	**Totals**
Direct trauma/contact injuries	*Struck by own board*	51	1	4	1	4	-	14	2	3	7	9	25	121
	Struck by other surfers board	11	-	2	2	1	2	2	2	1	-	5	2	30
	Striking sea floor/ bottom	11	20	18	4	6	4	4	11	3	8	4	31	124
	Striking surface of sea	9	14	26	-	-	3	7	12	6	2	1	1	80
Actual wave riding	*Paddling*	-	13	31	4	-	9	7	10	3	4	-	1	82
	Duck diving	2	5	9	3	3	3	1	1	3	4	1	-	35
	Take off	2	3	6	2	3	2	1	10	7	9	1	9	55
	Bottom turn	-	1	1	-	-	2	-	1	5	7	1	1	19
	Top turn	-	-	1	-	-	1	1	7	3	9	1	3	26
	Cut back	-	-	2	-	-	-	-	5	3	7	-	1	18
	Re-entry	1	-	1	-	-	-	1	2	6	9	3	5	28
	Floater	-	-	1	-	-	-	-	2	2	3	-	4	12
	Riding the face of the wave	2	-	2	-	-	1	-	1	7	6	-	2	21
	Tube riding	7	11	17	2	2	2	-	1	7	10	-	8	67
	Aerial	2	-	-	-	-	-	1	3	2	10	2	15	35
	Totals	98	68	121	18	19	29	39	70	61	95	27	108	753