Injuries, ill-health and fatalities in white water rafting and white water paddling

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Injuries, Ill-Health and Fatalities in White Water Rafting and White Water Paddling; a Review.

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Abstract

White Water (WW) activities such as paddling (canoeing and kayaking) and rafting are popular sports for recreational and professional participants. An increase in participation has been seen worldwide. However, these activities come with a risk of injury and even death if not conducted safely. A review was conducted to identify the types of injuries and ill-health which occur as a result of these activities. Injury and fatality rates were assessed to establish the risk attributed to these activities. Web of Science, PubMed, Ergonomics Abstracts and PsycINFO databases were searched and a total of sixteen published articles were identified and reviewed. The shoulders and back were the most vulnerable sites for injury in WW paddling. Injuries to the face and lower limbs were most common in WW rafters. However, injury rates are low and estimates are discussed. Due to different methods used across the studies, the reported injury rates are not comparable. Illnesses have been reported in WW activity participants including gastrointestinal illnesses and surfer’s ear. A relative paucity of studies regarding injuries and fatalities in WW activities was identified. Directions for future research are suggested and discussed.

Key Words: Occupational Health; Work-related Injuries; Injury Rates; Outdoor Industry

Acknowledgements

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1. Introduction

Outdoor activities, mostly land and water based, have been used for recreational, educational, skill development and therapeutic purposes.[1] In the UK, it was estimated that between ten and 15,000,000 people participate in outdoor activities a year.[1] In 2009, between 60,500 and 88,000 employees worked within the outdoor industry sector to facilitate increasing participation rates.[1] Outdoor activities are also popular worldwide. In America, almost half of the population have participated in some form of outdoor activity.[2] Similarly, 64% of New Zealand Adults was estimated to have participated in at least one outdoor activity in 2008.[3] Adventure activities, such as White water canoeing, kayaking and rafting have shown to be especially popular.[2-4] Although popular, outdoor activities do carry a risk of injury or in rare cases death.[5,6]

White water (WW) canoeing and kayaking, known as the umbrella term “WW paddling”, involves the use of a small craft to negotiate WW rivers. Canoes are knelt in and the paddler uses a single ended paddle. Kayakers sit in their craft and use a double ended paddle. WW rafting is an activity where (usually) between four and eight individuals use a single inflatable craft to negotiate a river. Individuals sit side by side and use a single bladed paddle to propel and steer the craft. This is both a commercial, recreational activity, supplied by providers, as well as competitive sport worldwide.[7] WW rivers are defined by water hydraulics formed by water falling over an uneven river bed.[8] Rivers are graded, ranging from I to VI (Table I), depending on the rate of fall of the water, the volume of water and the nature of the river bed.[8] Higher grades indicate more dangerous rivers, which are more technical to negotiate and/or have larger volumes.[8]

[Table I here]

In the UK, in 2010, over 2.75 million adults participated at least once in outdoor water sports[4] (demographics specific to WW are unavailable, as WW activities are just one aspect within the umbrella category of the activity). Canoeing was the most popular water sport with
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over 1 million individuals participating. \cite{4} Almost 148,000 individuals paddle at least once a month in the UK. \cite{9} Similar rates are reported elsewhere. In New Zealand, for example, canoeing was the 16\textsuperscript{th} most popular activity compared to all activities. \cite{3} In America in 2010 over 1.8 million people participated in WW kayaking, an increase of almost half a million from the previous year. \cite{2} America also saw an increase of over 100,000 participants in WW rafting between 2009 and 2010, totalling almost 4.5 million participants. \cite{2}

However, WW paddling and rafting are associated with acute and chronic injuries. \cite{5,6} Acute injuries are incidents of pain which occur rapidly due to a specific event or trauma. Chronic injuries are defined as pain that develops over a period of time, is persisting and long lasting and recurs over time. Injuries can occur at any site of the body, with the upper body being most at risk. \cite{10,11} Overuse injuries that occur for prolonged periods of time can lead to more permanent issues. \cite{12} In addition to injuries and fatalities, acute and chronic illnesses are also associated with WW activities such as surfer’s ear, \cite{13} and gastrointestinal illnesses. \cite{14,15}

With an increase in participants in many countries worldwide, it can be anticipated that there could be a proportional increase in the injuries and potential illnesses occurring. Fiore \cite{6} highlights that research examining injuries within WW activities has been relatively neglected, and there is a specific lack of prospective studies assessing true injury and fatality rates.

This study reviewed the types of injuries experienced and details of fatalities which have occurred as a result from the participating in WW activities worldwide. Specifically, the frequency of such injuries and fatalities are examined and the methods used to report these estimates. Data from articles were synthesised to identify patterns in the literature in order to understand what is currently known. Due to the limited research in this area, this review will establish a foundation of knowledge for research to be built upon.

2. Literature Search Methodology
A literature review was conducted to identify published articles from any country, on injuries and fatalities related to the WW paddling and rafting, published since 1990. The inclusion criteria included studies that reported any type of injuries, ranging from minor (e.g. contusions) to severe injuries requiring professional medical attention (e.g. dislocations), and fatalities which were a result of the WW activities stated. All levels of ability were examined, ranging from occasional, novice participants to qualified experts and professional competitors. Patterns in the cause of injuries and fatalities were reviewed as well as the frequencies of occurrence.

The databases searched were Web of Science, PubMed, Ergonomics Abstracts and PsycINFO. These databases were searched using the following terms independently and combined ‘white water canoe*’, ‘white water kayak*’, ‘white water raft*’, ‘white water injury’, ‘white water morbidity’, ‘white water mortality’, ‘white water injury rates’, ‘white water fatality rates’, ‘white water acute’, ‘white water chronic’, ‘white water illness’ and ‘white water disease’. The term ‘white water’ was utilised to eliminate injuries associated with non-WW paddling and rafting. This study focuses on injuries, ill-health and fatalities. In addition to searching these databases, the references of identified journals were utilised to expand the search.

3. Findings

A total of 16 published articles were identified which met the inclusion criteria. Articles were identified from five countries; eight from America, four from New Zealand, two from the UK, one from Ireland and one from Japan. Various methods of data collection were reported. Surveys were used in seven studies,[10,12-14,16-18] provider records were used in three studies,[19-21] hospital discharge data[22,23] were used in a further two studies, observation,[11] telephone interview,[15] tourist compensation claim data[24] and kinematic data[25] were identified in single articles. Samples ranged between 54-473 participants, of which between 53.5 and 89 per cent were male.
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The different types of injuries sustained through WW activities is summarised in Table II.

[Table II here]

It has been reported that the participants' ability is associated with the type of injury sustained. Fiore and Houston,\textsuperscript{[16]} reported that novices, defined as those competent on Grade I and II rivers, sustain more acute, impact related injuries, such as abrasions, lacerations, sprains, strains and fractures. Expert paddlers, on the other hand, defined as individuals who are competent on grade V and VI rivers, sustain more chronic, overuse injuries, such as tendonitis.\textsuperscript{[16]} Acute and chronic injuries and injury rates have been examined in WW paddling and rafting, separately. No gender differences have been observed in any category, therefore all results apply to both males and females.

3.1 Injuries

3.1.1 WW Paddling

A total of five papers were identified which discussed acute injuries associated with WW paddling.\textsuperscript{[10-12,16,18]} The most frequent injuries reported were lacerations, sprains/strains, fractures and dislocations.\textsuperscript{[10-12,16,18]} The majority of injuries were reported to have occurred whilst the paddler was in their boat.\textsuperscript{[16]} Most lower-limb injuries occur when paddlers are ‘swimming’ after capsizing or during the hike to and from river access points.\textsuperscript{[11,16,18]} Novice paddlers reported more lower limb injuries because they capsize more frequently.\textsuperscript{[16]} Acute injuries that occurred tended to require medical attention. However, they were short-term and recovery was usually complete.\textsuperscript{[16]}

Chronic injuries associated with WW paddling were discussed in five identified papers.\textsuperscript{[10,12,16,18,25]} These papers used either a survey\textsuperscript{[10,16,18]} or a physical examination\textsuperscript{[12,25]} to collect data on chronic injuries. The most frequently reported chronic injury was tendonitis which developed through overuse.\textsuperscript{[10,16,18]} This was mostly observed in expert WW paddlers who frequently paddled\textsuperscript{[16,18]} and was more common in professional competitors.\textsuperscript{[10]}
Kameyama et al[12] identified that multiple chronic injuries can result in deformation of the joints if not treated correctly. Deformation is an extreme example of chronic injuries. This specifically occurred in the shoulder joint, a vulnerable area of high stress when paddling. Wassinger et al[25] also highlighted that technique could contribute to chronic injuries in the shoulders. Poor technique could contribute to uneven movement in the scapula, creating a risk of tissue damage in the shoulder due to the unnatural movement.

3.1.2 WW Rafting

A total of three papers were identified which discussed acute injuries associated with WW rafting.[11,20,22] The most common types of injury experienced by commercial WW raft users were abrasions, lacerations, sprains, strains and fractures.[11,20,22] Data collected for these studies were collected from either the WW rafting providers’ records[20] or hospital discharge records.[22]

The face and lower body limbs were reported to be the most common sites of injury.[20,22] Injuries to these parts included lacerations, sprains, strains, fractures, contusions, dislocations and non-fatal submersion. All injuries reported, in the studies reported here, required medical attention. This was because the studies only examined provider[20] or hospital[22] data. In all papers, collision trauma was the most reported cause of injury. Unsurprisingly, this occurred as a result of colliding with obstacles on the riverbed, e.g. rocks, when the participant was ‘swimming’ (i.e. fell out of the raft). Collisions with other raft members’ equipment, e.g. paddle, was the other common form of collision trauma reported.

Only one paper was identified which discussed chronic injuries associated with WW rafting.[17] Jackson and Verscheure[17] examined the occupational health of WW raft guides, specifically lower back pain. It was reported that chronic back pain was experienced by some WW rafting guides. The working practices associated with this injury were predominantly land based, with the loading and unloading of equipment and lifting rafts to be stored in stacks being the highest predictors of back pain. Jackson and Verscheure[17]
speculated that this could be due to the technique used, lifting and throwing a raft requires a rapid twisting motion of the torso, which can be harmful if it is regularly repeated, which it is as it is part of the daily routine for a raft guide. However, back pain was reported to be short lived and rarely resulted in absenteeism.

3.1.3 Injury Rates

Injury rates are summarised in Table III. A total of four papers were identified reporting injury rates in WW paddling.\textsuperscript{[10,12,18,19]} In-house injury data was used in one study,\textsuperscript{[19]} the remainder utilised survey data to calculate injury rates.\textsuperscript{[10,12,18]} All studies calculated the injury rates by dividing the number of injuries reported by the unit of measurement. However, injury rates were reported using three different units of measurement; injuries per 1,000 participant hours,\textsuperscript{[19]} injuries per participant\textsuperscript{[12,18]} and injuries per year.\textsuperscript{[10]} For example, in New Zealand, an injury rate of 0.014 per 1,000 participant hours was observed.\textsuperscript{[19]} In the USA 677 injuries were observed in 388 participants, creating a rate of 2.1 injuries per participant in recreational paddlers.\textsuperscript{[18]} This was more than triple the 0.69 injuries per participant reported in Japanese paddlers (n=288).\textsuperscript{[12]} The studies which reported injuries per participant did not provide a timescale, therefore an accurate estimate cannot be calculated. However, one study\textsuperscript{[10]} which examined Olympic paddlers reported 0.46 injuries per year (n=57).

A total of four papers were identified as reporting injury rates in WW rafting.\textsuperscript{[17,19,20,22]} WW rafting provider records,\textsuperscript{[19,20]} hospital data\textsuperscript{[22]} and a survey,\textsuperscript{[17]} were the methods of data collection. Commercial WW rafting provider records in the USA indicate an injury rate of 0.26 per 1,000 participants (26.3 per 100,000 participants).\textsuperscript{[20]} Provider records in New Zealand report an injury rate of 0.54 per participant 1,000 hours.\textsuperscript{[19]} Hospital records in New Zealand suggest that 1.04-1.81 injuries occur to every 100,000 participants.\textsuperscript{[22]} The hospital record data suggests that very few injuries require hospital treatment. Although acute injury rates were predominately reported from record data, one study examined the prevalence of chronic back pain.\textsuperscript{[17]} Jackson and Verscheure\textsuperscript{[17]} reported a prevalence of back pain among
American WW raft guides that was similar to the general population. This suggests that raft
guides are at no additional risk of developing back pain compared to the general population.

[Table III here]

3.2 Illness

In addition to injuries, WW users are at risk of contracting illnesses related to water activities
(Table II). A total of three papers were identified directly examining ill-health in WW
paddlers.\(^\text{[13-15]}\) Of these, two papers examined acute illness induced by swallowing
contaminated water.\(^\text{[14,15]}\) The remaining study examined chronic illness as a result of repeat
exposure to cold water.\(^\text{[13]}\)

Lee et al\(^\text{[14]}\) assessed the relationship between water quality and participant health, samples
of water were collected and analysed alongside questionnaire data in the UK.\(^\text{[14]}\) Water
samples were examined on an hourly basis. Questionnaires were available for users
participating on the test days (n=473). Ingesting river water, whilst bacteria levels were high,
were the strongest predictors of ill-health. Frequent users of the WW facility reported fewer
cases of illness than infrequent users. Boland et al\(^\text{[15]}\) explored an outbreak of Leptospirosis,
following a canoeing competition in Ireland. Telephone interviews were conducted with 62
competitors of this competition. A total 18 participants reported symptoms of gastrointestinal
illness following the competition. Of these, there were 6 cases of Leptospirosis identified.
Similar to Lee et al,\(^\text{[14]}\) ingesting contaminated water was the highest reported predictor of
contracting the illness.

External Auditory Canal Exostoses (EACE) also known as surfer’s ear, is a chronic illness
associated with WW kayaking.\(^\text{[13]}\) The presence of EACE was assessed using a survey and
medical examination.\(^\text{[13]}\) Over two thirds of the kayakers (n=92) in this study displayed
symptoms of EACE, this was compared to 1.7% of the rock climber control group (n=65).\(^\text{[13]}\)
EACE was associated with years paddling, being observed in 90.6% of kayakers who had
paddled for 10 years or more. Severe cases of EACE (canal obstructed >67%) were only observed in individuals who had participated greater than 10 years. It was suggested that ear plugs may benefit paddlers, however at the cost of impaired hearing whilst in use.\footnote{13}

3.3 Fatalities

Table IV summarises the four papers which were identified as reporting fatalities in WW paddling and WW rafting. All data referring to fatality rates in WW activities have been generated from the USA\footnote{21} and New Zealand.\footnote{17,22,23} Two papers reported comprehensive rates (per 100,000 participants per annum) for WW paddling\footnote{21} and WW rafting\footnote{22} and the other two papers only reported the number of deaths that occurred, with no additional, contextual information to allow fatality rates to be calculated.\footnote{17,23}

In WW rafting, drowning and submersion accounted for 94% of fatalities.\footnote{22} Other fatalities occurred as a result of an accident to the watercraft or an unspecified fall in water transport.\footnote{22} Fatalities seem rare, hospital data in New Zealand, reported a rate of 0.16-0.27 per 100,000 participants per annum in WW rafters.\footnote{22} In the USA, managed river access facility data were used to calculate fatality rates for WW paddlers.\footnote{21} A rate of 2.9 fatalities per 100,000 participants per annum was reported.\footnote{21} Details of how the fatalities occurred in WW paddlers were not included. Although it has been reported that more fatalities occurred in WW rafting,\footnote{23,24} differences in participation numbers could also explain the observed differences in the fatality rates.

[Table IV here]

4. Discussion

This review identified a total of 16 published articles. The main results identified through the reviewed papers were that injuries are most likely to be sustained in the upper body. Expert, particularly competitive WW users are more at risk of sustaining chronic injuries than novices who occasionally partake in the activities. The injury rates for recreational participants
appear to be relatively low, around 4.5 per 1,000 participant days for WW paddling\textsuperscript{[18]} and 26.3 per 100,000 participants in WW rafting.\textsuperscript{[20]} It is important to be cautious when considering the accuracy of these rates for two reasons. Firstly, sample sizes and methods utilised to collect data were different, meaning that injury rates, risks to health and fatality rates could not be directly compared. Second, the definitions of the term ‘injury’ vary between studies. Schoen and Stano\textsuperscript{[18]} allowed for self-report of injuries in a survey. This could lead to over-reporting, particularly when comparing these data to injuries that required medical attention and were recorded officially by providers.\textsuperscript{[20]} All WW rafting injuries were defined as requiring medical attention, therefore any injury that was perceived as not requiring medical attention were excluded from these rates. This could have occurred if the injury was not considered severe enough to report. Cultural and/or environment differences may further influence this decision process.

This review suggests that acute injuries are associated often with hospitalisations and medical treatment.\textsuperscript{[18,22]} However, chronic injuries can be just as severe even if they occur less frequently such as joint distortions.\textsuperscript{[12]} The only interventions that were identified in this review to reduce chronic injuries were balanced training to avoid overusing specific muscle and joint areas and adequate rest.\textsuperscript{[12]} However, the extent to which guidelines are adhered to currently remains unknown.

The review also identified that illness among WW users is most likely to occur following a flood where contaminants may be present in the water.\textsuperscript{[14,15]} Improved hygiene awareness may be beneficial in reducing illness contracted in this way. Although Governing Bodies such as the British Canoe Union [BCU] provide information regarding illness and disease associated with WW activities, this information is not always accessed by WW users.\textsuperscript{[26]} However, Philipp’s report is now dated and a more recent examination of the impact of health related information, advice, and guidelines to prevent illness may be beneficial.
Weiss\textsuperscript{11} suggested that appropriate equipment and correct techniques can prevent injuries, particularly among novices. For example, a correct paddling technique can help prevent a capsize incident and thus avoid potential injury or fatality. Most WW rafting injuries arise from a collision. Users can collide with either other users, equipment or obstacles in the water.\textsuperscript{11,20,22} Whisman and Hollenhorst\textsuperscript{20} suggest a number of preventative measures to reduce injury prevention. These include face guards and limited number of users per raft.\textsuperscript{20} Cooper et al\textsuperscript{13} additionally suggests the use of ear plugs to protect against the development of EACE. The extent to which personal protective equipment (PPE) is effective in preventing injuries or ill-health to WW users has not been empirically tested.

Unsurprisingly, in this review, drowning was reported as the most common cause of death in WW activity users. Lower fatality rates were reported for rafting reported as opposed to paddling. One explanation might be that WW rafting is a commercially organised activity lead by a professional guide, whereas WW paddling is a recreational activity which relies on the individual’s ability as opposed to professional guidance. In addition, WW paddlers have lower volume boats compared to rafts, therefore these are more likely to become submerged, particularly on higher grade rivers where the water is more turbulent.

The articles reviewed here utilised various methods to assess injury types, including surveys, record data and medical examinations. Surveys are a good technique to collect data from a larger sample, however there can be inconsistencies with interpretations of injury. For example, muscle ache could be interpreted as a strain by some and fatigue by others. In addition, the retrospective nature of data collection may mean some injuries are not recalled or are recalled inadequately. Record data may be more accurate as it is collected at the time of injury or shortly afterwards. There may also be medical assessments which inform these records. However, medical assessments are limited to those whose injuries require treatment. Less serious injuries will not be recorded. However, a number of studies have conducted medical examinations to identify and assess injuries among WW paddlers who do not necessarily report injury.\textsuperscript{12,13} Such studies provide a more objective
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assessment. To date, there is no comprehensive way of recording injuries sustained among WW users. Utilising a mixture of these methods may help build a more comprehensive understanding of injuries experienced. Comparing survey data to record data may provide insight into the types of injuries which are perceived as requiring medical intervention.

None of the articles distinguished between natural rivers and ‘man-made’ river facilities. A comparison examining the injuries sustained on a natural river compared to ‘man-made’ facilities may reveal differences in injury types. To our knowledge, this is an issue that has not been addressed in the literature. There are unlikely to be rocks in a ‘man-made’ facility and this is an important issue that needs to be considered. In addition, personality factors have not been investigated in previous studies and may be a predictor of reporting behaviour and/or risk taking.

Adventure tourism has grown as an industry in New Zealand, the USA, in Europe and elsewhere worldwide. It may be that as participant rates increase,[2-4] injury rates will change in line with this increase. Therefore, much more attention needs to be paid to ensure these activities are as safe as possible for all those who participate.

5. Conclusion

WW adventure activities are developing with increased numbers participating each year.[2] The upper body is the most prone site for injuries, which can be either acute, such as abrasions, or chronic, such as back pain. Novice paddlers and commercial WW rafters appear to obtain more abrasions and impact injuries from falling out of their boat or craft. Chronic injuries are more prevalent in expert paddlers and raft guides. Correct equipment and techniques can aid the prevention of any type of injury. Considering this, injuries are relatively rare in both WW activities, especially those which are fatal. Research examining occupational raft guides and other paddling tourist destinations should be further developed and conducted.
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### Table I Definition of the River Grades. Adapted from the BCU Handbook[8]

<table>
<thead>
<tr>
<th>Grade</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I</td>
<td>Low difficulty river with simple obstructions and regular streams and waves. Hydraulics are small and cannot hold objects.</td>
</tr>
<tr>
<td>Grade II</td>
<td>Moderate difficulty river with simple obstructions and irregular streams and waves. Hydraulics are medium sized, some may hold small objects. Small drops are possible. Route is clear and passage free.</td>
</tr>
<tr>
<td>Grade III</td>
<td>Difficult river with high, irregular waves and larger hydraulics. Hydraulics will hold objects and push boats around. Stream will have drops and numerous obstructions. Route is still recognisable.</td>
</tr>
<tr>
<td>Grade IV</td>
<td>Very difficult river with continuous waves and hydraulics. Hydraulics will hold objects with strong force. Numerous obstructions in the stream, including boulders with undercut currents. Route is not always recognisable, inspection is recommended.</td>
</tr>
<tr>
<td>Grade V</td>
<td>Extremely difficult river with narrow passages, steep gradients and drops. Hydraulics are more extreme than Grade IV rivers. Access to the river is usually difficult due to steep banks. Inspection prior to running is essential.</td>
</tr>
<tr>
<td>Grade VI</td>
<td>High risk rivers which are generally impossible to run; certain water levels are required to negotiate. Highly recommended to portage around these sections of river.</td>
</tr>
</tbody>
</table>
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Table II A summary of injuries and ill-health reported in White Water (WW*) Adventure Activities.

<table>
<thead>
<tr>
<th>Population</th>
<th>N (Male)</th>
<th>Age (Years) (Mean±SD)</th>
<th>Type of Study/Data Source</th>
<th>Site(s)</th>
<th>Injury/Ill-health Type(s)</th>
<th>Possible Cause(s)</th>
<th>Severity</th>
<th>Intervention Suggestions</th>
<th>Comments</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>WW Paddling</td>
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<tr>
<td>Competitive Paddlers in the USA</td>
<td>54 (75%)</td>
<td>34 (+11.8)</td>
<td>Survey (Response Rate 19.6%)</td>
<td>Shoulder most vulnerable. Head, neck, back, arms, elbows, wrists, legs, knees, hands and feet.</td>
<td>Sprain, tendonitis, chronic, bruise, fracture, dislocation and laceration. Cold injury, frostbite, heat, dehydration, insect bite, near drown, drown.</td>
<td>Carelessness. Overuse injuries.</td>
<td>Medical treatment was required for 19.6% of injuries reported.</td>
<td>None.</td>
<td>Generalisations between professional and amateur populations should be taken with caution. No clear definition of ‘injury’. Injuries have been associated with specific sites on the body.</td>
<td>10</td>
</tr>
<tr>
<td>WW Rafters and Paddlers</td>
<td>No info.</td>
<td>No info.</td>
<td>Observation and personal experience</td>
<td>Entire body at risk.</td>
<td>Abrasions, lacerations, strains, sprains, bone fractures and breaks, dislocation of</td>
<td>Inappropriate equipment or none at all. Poor risk assessment. Poor technique</td>
<td>Minor to fatalities.</td>
<td>Use of correct equipment and techniques. Appropriate risk assessment. Seek expert</td>
<td>Based on personal experience. Conclusions were not based on any study based evidence.</td>
<td>11</td>
</tr>
<tr>
<td>Population</td>
<td>N (Male)</td>
<td>Age (Years) (Mean±SD)</td>
<td>Type of Study/Data Source</td>
<td>Site(s)</td>
<td>Injury/Ill-health Type(s)</td>
<td>Possible Cause(s)</td>
<td>Severity</td>
<td>Intervention Suggestions</td>
<td>Comments</td>
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<td>Japanese Canoe Slalom Team</td>
<td>417</td>
<td>26 (+2.9)</td>
<td>Survey. Medical Examinations.</td>
<td>Lower back, shoulder, elbow, knees.</td>
<td>Numbness, limited movement, pain, fractures, dislocations, and osteoarthritis deformity.</td>
<td>Stress from the paddle stroke is focused on the shoulder, elbow and lower back resulting in overuse injuries.</td>
<td>If untreated it can lead to fractures and deformation.</td>
<td>Sufficient rest between training sessions. Strengthening the stability muscles.</td>
<td>Objectively measured injuries through medical examinations.</td>
<td>12</td>
</tr>
<tr>
<td>WW Paddlers</td>
<td>392</td>
<td>34</td>
<td>Survey distributed online, by post and face to face.</td>
<td>Upper body, specifically shoulders.</td>
<td>Abrasions Tendonitis Contusions Dislocations</td>
<td>Striking objects was the most reported cause of injuries. Stress from the force of the water causing injury followed.</td>
<td>51% of the injuries required medical attention. 96% of injuries had either a good or complete</td>
<td>None.</td>
<td>Novices developed more impact injuries from falling out of their boats. Expert paddlers developed chronic injuries mostly from overuse.</td>
<td>16</td>
</tr>
</tbody>
</table>
### Injuries, ill-health and fatalities in white water activities

<table>
<thead>
<tr>
<th>Population</th>
<th>N</th>
<th>Age (Years) (Mean±SD)</th>
<th>Type of Study/Data Source</th>
<th>Site(s)</th>
<th>Injury/Ill-health Type(s)</th>
<th>Possible Cause(s)</th>
<th>Severity</th>
<th>Intervention Suggestions</th>
<th>Comments</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>WW Paddlers</td>
<td>319 (72%)</td>
<td>No info.</td>
<td>Mail out mail back survey</td>
<td>Shoulder/arm, wrist/hand, head/face/neck, knee</td>
<td>Laceration, contusions and abrasions were most common acute injuries. Tendonitis, sprains/strains were most common chronic injuries.</td>
<td>Accidents whilst transporting boats. Rodeo and Slalom disciplines are at more risk of developing injuries.</td>
<td>Non serious to requiring medical treatment.</td>
<td>None.</td>
<td>None.</td>
<td>Subjective definition of ‘injury’, compared to medical assessment.</td>
</tr>
<tr>
<td>Expert WW Paddlers</td>
<td>25 (92%)</td>
<td>34.1 (±9.4)</td>
<td>Three dimensional scapula and humeral kinematic data.</td>
<td>Shoulder</td>
<td>Potential for acute and chronic injuries</td>
<td>Thrust motion of paddle stroke.</td>
<td>Unspecified</td>
<td>Further research.</td>
<td>Association found between shoulder stability and paddle stroke movement. Further research required to explore this association.</td>
<td>25</td>
</tr>
</tbody>
</table>

**WW Rafting**
## Injuries, ill-health and fatalities in white water activities

<table>
<thead>
<tr>
<th>Population</th>
<th>N (Male)</th>
<th>Age (Years) (Mean±SD)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>WW Rafters and Paddlers</td>
<td>No info.</td>
<td>No info.</td>
<td>Personal experience and observation data</td>
<td>Entire body at risk.</td>
<td>Abrasions, lacerations, strains, sprains, bone fractures and breaks, dislocation of joints, drowning.</td>
<td>Inappropriate equipment or none at all. Poor risk assessment. Poor technique and levels of skills.</td>
<td>Minor to fatalities.</td>
<td>Use of correct equipment and techniques. Appropriate risk assessment. Seek expert advice before paddling a river.</td>
<td>Based on personal experience. Conclusions were not based on any study based evidence.</td>
<td>11</td>
</tr>
<tr>
<td>WW Raft Guides</td>
<td>390 (No info.)</td>
<td>No mean. Range 18-60+</td>
<td>Mail-out, Mail-back survey. (Response Rate 15.5%)</td>
<td>Lower Back, Shoulder, Elbow</td>
<td>Chronic back pain</td>
<td>Lifting, loading and uploading equipment.</td>
<td>Short lived. Few needed medical treatment.</td>
<td>Use mechanical lifts. Lift equipment in groups</td>
<td>Did not included individuals who may have retired due to injury. Low response rate. Only study assessing occupational health.</td>
<td>17</td>
</tr>
<tr>
<td>Commercial WW raft users</td>
<td>30 Providers †</td>
<td>No info.</td>
<td>WW Raft provider† records in</td>
<td>Face most common site. Upper and</td>
<td>Lacerations, sprains/strains, fractures, Collisions with rocks, equipment and other rafters.</td>
<td>Majority of injuries were minor. Fewer individuals per raft.</td>
<td>Face guards can restrict vision which can be an additional</td>
<td></td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>
# Injuries, ill-health and fatalities in white water activities

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Commercial WW Rafters</td>
<td>215</td>
<td>30.4 (±11.7)</td>
<td>Hospital discharge data</td>
<td>Lower limbs.</td>
<td>Fractures</td>
<td>Unspecified water transport accident.</td>
<td>All injuries resulted in hospitalisation.</td>
<td>None.</td>
<td>Face guards with the helmets.</td>
<td>hazard.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower limbs most common site, specifically the feet. Face and shoulder.</td>
<td>Non-fatal submersion</td>
<td>Submerged after falling out of the raft.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sprains/strains</td>
<td>Accident to watercraft causing injury.</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Contusions</td>
<td>Unspecified fall in water transport.</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dislocations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WW Kayakers</td>
<td>92 (75%)</td>
<td>29.3 (±8.72)</td>
<td>Questionnaire and Physical Examination. Comparison to Ear</td>
<td>External auditory canal exostoses (EACE)</td>
<td>Exposure to sudden cold water. Frequency and years of</td>
<td>69.5% of kayakers showed symptoms</td>
<td>The use of ear plugs reduce symptoms of EACE, however</td>
<td></td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

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**Illness**

- **WW Kayakers**: 92 (75%), 29.3 (±8.72) | Questionnaire and Physical Examination. Comparison to Ear | External auditory canal exostoses (EACE) | Exposure to sudden cold water. Frequency and years of | 69.5% of kayakers showed symptoms | The use of ear plugs reduce symptoms of EACE, however | 13
### Injuries, ill-health and fatalities in white water activities

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<th>Intervention Suggestions</th>
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</tr>
</thead>
<tbody>
<tr>
<td>WW Rafters and Paddlers</td>
<td>473 (No info.)</td>
<td>No info.</td>
<td>Survey.</td>
<td>Gastrointestinal illness</td>
<td>Gastrointestinal illness</td>
<td>River water ingestion. Consume food and drink with contaminated hands.</td>
<td>No info.</td>
<td>Better hygiene after participation.</td>
<td>Regular users experienced illness less frequently than those on daytrips. Possible explanations include: frequent users are more experienced and skilled therefore become submerged less frequently and ingest less water. Also frequent users tended to live local and</td>
<td>14</td>
</tr>
</tbody>
</table>
Injuries, ill-health and fatalities in white water activities

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<tr>
<th>Population</th>
<th>N (Male)</th>
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<th>Severity</th>
<th>Intervention Suggestions</th>
<th>Comments</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>WW Canoeing competitors in Ireland</td>
<td>62 (89%)</td>
<td>No mean. Median = 22 (Range = 11-43)</td>
<td>Telephone questionnaire.</td>
<td>Leptospirosis</td>
<td>Swallowing more than one mouthful of contaminated river water. Increased rainfall and release of hydroelectric water.</td>
<td>18 individuals reported illness. 6 confirmed cases of leptospirosis.</td>
<td>A total of 62 of 69 competitors were interviewed over the telephone. A good sample from this specific event. However, because such a specific event, findings are difficult to generalise.</td>
<td>therefore did not consume food directly after participation.</td>
<td>15</td>
</tr>
</tbody>
</table>

*A Provider is a commercial organisation which sells adventure activities.

*WW = White Water
Table III A summary of injury rates reported in White Water (WW*) Adventure Activities

<table>
<thead>
<tr>
<th>Population</th>
<th>N (Male)</th>
<th>Type of Study/Data Source</th>
<th>Injury Rates</th>
<th>Injury Severity</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>WW Paddling</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Competitive Paddlers in the USA</td>
<td>54 (75%)</td>
<td>Survey</td>
<td>A total of 271 injuries were reported.</td>
<td>Medical treatment was required for 19.6% of all injuries reported.</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>An overall rate of 0.08 per participant per year.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japanese Professional Canoe Slalom Team</td>
<td>417 (73.4%)</td>
<td>Survey and Medical Examinations.</td>
<td>229 of the 417 reported 288 problems.</td>
<td>Numbness, limited movement, pain and dislocations. The medical examination identified fractures and osteoarthritis deformity from overuse.</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22.5% experienced back pain.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>21% experienced shoulder pain.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>An overall rate of 0.69 per participant.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreational paddlers.</td>
<td>319 (72%)</td>
<td>Mail out, mail back survey.</td>
<td>388 acute injuries reported (1.2 per person).</td>
<td>Medical attention was required for 47% of acute and 36% of chronic injuries.</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>286 chronic injuries reported.</td>
<td>Shoulder and arm were the most acute injuries requiring medical attention.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A rate of 4.5 per 1,000 participant days.</td>
<td>Back, chest and hip injuries had the longest duration.</td>
<td></td>
</tr>
<tr>
<td>WW Raft Guides in America</td>
<td>390</td>
<td>Mail-out, Mail-back survey.</td>
<td>77.4% experienced back pain.</td>
<td>7.4% missed work.</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20.8% experienced back pain &gt;1 week.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lifting and (un)loading of equipment were the best predictors of back pain.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Injuries, ill-health and fatalities in white water activities

<table>
<thead>
<tr>
<th>Population</th>
<th>N (Male)</th>
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<th>Injury Rates</th>
<th>Injury Severity</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>WW Kayakers and Rafters in New Zealand</td>
<td>142 Providers†</td>
<td>Survey to access Provider records of injuries.</td>
<td>Kayakers 0.01 and Rafters 0.54 per 1,000 participant hours.</td>
<td>Injuries resulting in hospitalisation for greater than 48 hours were defined as severe.</td>
<td>19</td>
</tr>
<tr>
<td>Commercial WW raft users in America</td>
<td>30 Providers†</td>
<td>WW Raft providers in America</td>
<td>0.26 per 1,000 participants.</td>
<td>Sprains/strains (20%)&lt;br&gt;Lacerations (20%)&lt;br&gt;Contusions/bruises (18%)&lt;br&gt;Abrasions (11%)&lt;br&gt;Fractures (11%)&lt;br&gt;Dislocations (4%)&lt;br&gt;Unspecified (8%)&lt;br&gt;Unreported (9%)</td>
<td>20</td>
</tr>
<tr>
<td>Commercial WW rafters in New Zealand</td>
<td>215 hospitalisations identified (53.5%)</td>
<td>Hospital discharge records over a 14 year period from the New Zealand Health Information Service (NZHIS)</td>
<td>Overall rate of 1.04-1.81 per 100,000 participants.</td>
<td>All injuries reported were injuries which resulted in hospitalisation. Mean hospitalisation per annum 15.4 (SD=6.0), Range 7-25.</td>
<td>22</td>
</tr>
</tbody>
</table>

† A Provider is a commercial organisation which sells adventure activities.

*WW = White Water
### Table IV A summary of fatality rates reported in White Water (WW*) Adventure Activities

<table>
<thead>
<tr>
<th>Population</th>
<th>Type of Study/Data Source</th>
<th>Fatality Rates</th>
<th>Common Causes</th>
<th>Comment</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>WW Paddling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreational WW paddlers</td>
<td>Data collected from managed river facilities.</td>
<td>2.9 per 100,000 participants per annum.</td>
<td>Not specified.</td>
<td>This is an estimate as the actual number of participants was unknown. Does not account for paddlers who use unmanaged rivers.</td>
<td>21</td>
</tr>
<tr>
<td>WW Rafting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial WW rafters in New Zealand</td>
<td>Hospital records over a 14 year period from the New Zealand Health Information Service (NZHIS)</td>
<td>33 fatalities reported in 14 years (81.8% males). 0.16-0.27 per 100,000 participants per annum.</td>
<td>Drowning and submersion were the most common cause of death (94%). Accident to watercraft causing injury (3%) and unspecified fall in water transport (3%) were the other causes of death.</td>
<td>Hospital records are an accurate measure of fatality rates, especially when compared against commercial usage.</td>
<td>22</td>
</tr>
<tr>
<td>International Tourist WW Rafters and Paddlers</td>
<td>Hospital records over a 14 year period from the New Zealand</td>
<td>6 WW Rafting fatalities 4 WW Kayaking fatalities</td>
<td>Not specified</td>
<td>No information on participant numbers meant a fatality rate could not be calculated. Tourist data, therefore natives not included in</td>
<td>23</td>
</tr>
</tbody>
</table>
Injuries, ill-health and fatalities in white water activities

<table>
<thead>
<tr>
<th>Population</th>
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<th>Comment</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Information Service (NZHIS)</td>
<td></td>
<td></td>
<td></td>
<td>these figures.</td>
<td></td>
</tr>
<tr>
<td>WW Rafters and Paddlers</td>
<td>Tourist Compensation</td>
<td>0 WW kayak/canoeists</td>
<td>Not specified</td>
<td>Only accounts for those individuals who claimed on their insurance.</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Claim Data in New Zealand</td>
<td>2 WW rafters</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*WW = White Water*