



# **Evidence Summary: Canoeing & Kayaking**

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**Evidence synthesis tool**

<b>SPORT:</b>	Canoeing	<b>Target Group:</b>	Recreational and professional canoeists (paddlers) wide range of age between 20-50 years	
<b>Injury Mechanisms:</b>	<p><b>Common Injuries:</b> Common injuries in canoeing are reported to be tendonitis, external auditory canal exostoses, gastrointestinal illnesses, lacerations, sprains/strains, fractures, dislocations, deformation of the shoulder joint, and very rarely, fatalities.</p> <p><b>Common Mechanisms:</b> Common mechanisms of injury in canoeing are reported as: capsizing, immersion in cold water, striking an object, drowning, weather changes causing extreme conditions, falling and/or rolling rocks, flash floods, and fast moving rapids.</p>			
<b>Incidence/Prevalence</b>	<b>Risk/Protective Factors</b>	<b>Interventions</b>	<b>Implementation/Evaluation</b>	<b>Resources</b>
<p><b>Overall Injury</b></p> <p>In 1999, Toit et al. investigated the incidence and causes of acute tenosynovitis in the forearms of long distance canoeists. An average of 23% developed the condition, and the incidence was significantly higher in the dominant, compared to non-dominant hand; unrelated to the type of canoe and the angle of the paddle blades.</p> <p>In 2010, Diafas et al. studied acute and chronic injuries in white water (WW) canoeists; specifically, the paddling style and equipment used. A survey was distributed at riverside through paddle club bulletins in the summer and fall of 2008, in which 319 useable surveys were returned reporting 388 (1.2 per respondent) acute and 286 (0.9 per respondent) chronic injuries. 72% of the respondents were men, 28% female, with an average paddling experience of 7.3 years and ~50 days paddled per year. The incidence of any injury was estimated at 4.5 injuries per 1000 days paddling. The incidence of significant injuries was estimated at 1.9 injuries per 1000 days paddled. If the average paddle day is estimated to be 4 hours on river, the incidence of significant injury with</p>	<p>No studies were found that examined specific factors associated with canoeing and injury risk.</p>	<p>There are currently no specific evidence-based injury prevention strategies to reduce the burden of injury in canoeing.</p>	<p>No studies were found that have evaluated implementation or evaluation strategies in this sport.</p>	<p><b>Websites</b></p> <p><a href="https://www.betterhealth.vic.gov.au/health/healthyliving/canoeing-and-kayaking-preventing-injury">https://www.betterhealth.vic.gov.au/health/healthyliving/canoeing-and-kayaking-preventing-injury</a></p>

WW paddling is 0.48 significant injuries per 1000 hours paddled.

**Recreational Injury**

In 2012, Wilson et al. reviewed the literature and reported 319 recreational paddlers with 388 acute injuries (1.2 per person) and 286 chronic injuries. There was a reported rate of 4.5 injuries per 1,000 participant days; 73.4% of these injuries were in males. Additionally, fatality rates for paddlers were identified as 2.9 fatalities per 100,000 participants per annum.

**Competitive Injury**

In 2012, Wilson et al. reported 271 injuries in competitive canoers representing an overall rate of 0.08 injuries per participant, per year.

**Common Types of Injuries**

In 2010, Diafas et al. noted sprains/strain to be the most common (26%) known acute injury, followed by laceration and contusion (17% each). Tendinitis was the most common (44%) known chronic injury diagnosis, followed by sprain/strain (27%). Giardia infection was reported in 14% of paddlers. In addition, injuries due to portaging were also common.

In a review by Wilson et al. (2012), it was noted that WW canoeing is associated with various acute and chronic injuries as well as external auditory canal exostoses (EACE) and gastrointestinal illnesses. The most frequently reported acute injuries associated with canoeing were lacerations, sprains/strains, fractures, and dislocations; and most these occurred whilst the paddlers were in their

<p>boats. It was noted that most lower limb injuries occurred when paddlers were 'swimming; after capsizing or during the hike to and from river access points. Using either a survey or a physical examination, the review identified the most frequently identified chronic injuries associated with canoeists: tendonitis in paddlers or professional competitors and deformation of the shoulder joint. It was identified that the novice paddler experiences more acute injuries whereas chronic injuries as associated more with the experienced canoer.</p> <p><b>Common Injury Regions</b></p> <p>In 2010, Diafas et al. noted the shoulder, wrist/hand, and elbow/forearm to be the most common sites of injury.</p> <p>In 2012, Wilson et al. identified the shoulder and arm as the most acute injuries requiring attention while the back, chest and hip injuries were identified as more chronic injuries. Overall the injuries sustained were most likely in the upper body.</p>				
<p><b>Works Cited:</b></p> <p>Diafas, V., Chrysikopoulos, K., Diamanti, V., Koustouraki, P., Prionas, G., Baltopoulos, P. (2010). Year 2008 whitewater injury survey. <i>Biology of Exercise</i>, 6 (1), 49-60.</p> <p>Toit, P., Bowerbank, P., Noakes, T.D. (1999). Incidence and causes of tenosynovitis of the wrist extensors in long distance paddle canoeists. <i>British Journal of Sports Medicine</i>, 33, 105-109.</p> <p>Wilson, I., McDermott, H., Munir, F. (2012).</p>				

Injuries, Ill-health and fatalities in white water rafting and white water paddling. <i>Sports Medicine</i> , 43, 65-75.				
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## Review of Sport Injury Burden, Risk Factors and Prevention

### Canoeing (Whitewater)

Whitewater activities such as paddling, particularly canoeing, are popular sports for recreational and professional participants (Wilson et al., 2012). An increase in paddling sports has been seen worldwide; thus, it can be anticipated that there could be a proportional increase in the occurrence of injuries and potential illnesses (Wilson et al., 2012). Whitewater canoeing requires the canoer to kneel while the paddler uses a single-ended paddle to negotiate down white water (WW) rivers (Wilson et al., 2012). Despite the increase in popularity of the sport, there is a lack of information on the incidence, risk factors and interventions to reduce the impact of injury while canoeing.

### Incidence and Prevalence

To date, there is a paucity of literature examining incidence rates in canoeing. The studies that have examined injury rates in canoeing use varying methodologies. In 1999, Toit et al., investigated the incidence and causes of acute tenosynovitis of the forearm of long distance canoeists. An average of 23% of canoeists developed the condition, and the incidence was significantly higher in the dominant, compared to the non-dominant hand. This was unrelated to the type of canoe and the angle of the paddle blades. However, this study only looks at one type of possible injury experienced by a canoeist.

In 2010, Diafas et al. studied acute and chronic injuries in white water (WW) canoeists; specifically, the paddling style and equipment used. A survey was distributed at riverside through paddle club bulletins in the summer and fall of 2008, in which 319 useable surveys were returned reporting 388 (1.2 per respondent) acute and 286 (0.9 per respondent) chronic injuries. 72% of the respondents were men, 28% female, with an average paddling experience of 7.3 years and ~50 days paddled per year. The incidence of any injury was estimated at 4.5 injuries per 1000 days paddling. The incidence of significant injuries was estimated at 1.9 injuries per 1000 days paddled. If the average paddle day is estimated to be 4 hours on river, the incidence of significant injury with WW paddling is 0.48 significant injuries per 1000 hours paddled.

In 2012, Wilson et al. reviewed the literature and reported 319 recreational paddlers with 388 acute injuries (1.2 per person) and 286 chronic injuries. There was a reported rate of 4.5 injuries per 1,000 participant days; 73.4% of these injuries were in males. Additionally, fatality rates for paddlers were identified as 2.9 fatalities per 100,000 participants per annum.

The literature review revealed a number of common injury types in canoeists. Strains/sprains and lacerations are reported to be the most common injury type (Diafas et al., 2012); (Wilson et al., 2012). In the study by Diafas et al. (2010) strains/sprains accounted for 26% of acute injuries, followed by lacerations and contusions (17% each). As for chronic injuries, tendinitis was the most common reported injury accounting for 44% of all injuries, followed by Giardia infections at

14%. Likewise, in the review by Wilson et al. (2012) it was noted that WW canoeing was associated with various acute and chronic injuries, including gastrointestinal illnesses, as well as external auditory canal exostoses (EACE). The most frequently reported acute injuries associated with canoeing were lacerations, sprains/strains, fractures, and dislocations; most these occurring while the paddlers were in their boats. It was also noted that most lower limb injuries occurred when paddlers were 'swimming after capsizing or during the hike to and from river access points'. Using either a survey or a physical examination, the review identified the most frequently identified chronic injuries associated with canoeists was tendonitis in frequent paddlers or professional competitors and deformation of the shoulder joint. It was identified that the novice paddler experiences more acute injuries whereas chronic injuries was associated more with the experienced canoer.

In 2010, Diafas et al. noted the shoulder, wrist/hand, and elbow/forearm to be the most common sites of injury. In 2012, Wilson et al. identified the shoulder and arm as the most acute injuries requiring attention while the back, chest and hip injuries were identified as more chronic injuries. Overall the injuries sustained were most likely in the upper body

### **Risk and Protective Factors**

No studies were found that examined specific factors associated with canoeing and injury outcomes. The primary studies reviewed that reported the incidence of injury and common mechanisms of injury in canoeing, speculate potential risk factors for injury in canoeing (Wilson et al., 2012); (Toit et al., 1999); (Diafas et al., 2010):

1. The grade of river (I to VI): Higher grades indicated more dangerous rivers; using rivers above skill level. (Wilson et al., 2012)
2. Level of experience: novice paddlers are reported to have predominantly more lower limb injuries compared to expert paddlers due to capsizing more frequently. (Wilson et al., 2012)
3. Poor technique: contributes to chronic injuries in the shoulders due to uneven movement in the scapula, creating a risk of tissue damage in the shoulder due to the unnatural movement. (Wilson et al., 2012; Toit et al., 1999)
4. Difficult paddling conditions. (Toit et al., 1999).
5. Level of fitness: Higher levels of fitness increases the likelihood of balancing an unstable canoe and maintaining optimum paddling style without repeated eccentric loading of the forearm tendons; this limits hyperextension of the wrist. (Toit et al., 1999).
6. Environmental conditions: Fast flowing water, high winds and choppy waters can increase the risk of injury in paddlers. (Toit et al., 1999).

### **Opportunities for Prevention: Effective Interventions, Cost-Effectiveness, Implementation and Evaluation**

There are currently no evidence-based injury prevention strategies to reduce the burden of injury in canoeing; however, there are opportunities for prevention based on the type and mechanism of injury occurring in canoeists. Studies reviewed for this report suggest balance training can be done to avoid overusing specific muscle and joint areas in paddling, in addition to ensuring adequate rest. (Wilson et al., 2012; Toit et al., 1999) Additionally, it is important to mandate proper equipment (ear plugs, helmets, faceguards) and correct technique to potentially prevent injuries (Wilson et al., 2012; Toit et al., 1999; Diafas et al., 2010). Additionally, routine training regimes (paddling more than 100 km/week) may be used to decrease injury prevalence. (Toit et al., 1999)

## References

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- Toit, P., Bowerbank, P., Noakes, T.D. (1999). Incidence and causes of tenosynovitis of the wrist extensors in long distance paddle canoeists. *British Journal of Sports Medicine*, 33, 105-109. Retrieved from: <http://bjsm.bmj.com/content/33/2/105.short>
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**Evidence synthesis tool**

<b>SPORT:</b>	White water Kayaking		<b>Target Group:</b>	Recreational and professional kayakers (paddlers); majority male	
<b>Injury Mechanisms:</b>	<p><b>Common Injuries:</b> Tendonitis, external auditory canal exostoses, gastrointestinal illnesses, lacerations, sprains/strains, fractures, dislocations, deformation of the shoulder joint, fatalities.</p> <p><b>Common Mechanisms:</b> Swimming after capsizing, contaminated water, cold water, striking an object, drowning, submersion, sudden changes in weather, falling and/or rolling rocks, flash floods, fast moving rapids.</p>				
<b>Incidence/Prevalence</b>	<b>Risk/Protective Factors</b>	<b>Interventions</b>	<b>Implementation/Evaluation</b>	<b>Resources</b>	
<p><b>Overall</b></p> <p>In 2017, Zakharia et al., studied the types of injuries experienced by white water kayakers in Malaysia. Of all surveyed, 186 experienced injuries while kayaking. The injury rate was reported as 0.86 injuries per 1,000 participant hours.</p> <p><b>Recreational</b></p> <p>In 2012, Wilson et al. reported 388 acute injuries (1.2 per person) and 286 chronic injuries in 319 paddlers. This represented a rate of 4.5 injuries per 1,000 participant days. 73.4% of the injured were male. Additionally, fatalities rates for paddlers were identified as 2.9 fatalities per 100,000 participants per annum.</p> <p><b>Competitive Paddlers</b></p>	<p>No studies were found that examined specific factors associated with kayaking and injury outcomes. The primary studies reviewed speculate the following risk factors for injury in kayaking: (Wilson et al., 2012; Zakharia et al., 2017; Stemberga et al., 2013)</p> <ol style="list-style-type: none"> <li>1. The grade of river (I to VI): Higher grades indicate more dangerous rivers.</li> <li>2. Using rivers above skill level.</li> <li>3. Level of experience: Novice paddlers report more lower limb injuries due to capsizing more frequently.</li> <li>4. Poor technique: Poor technique has been shown to contribute to chronic injuries in the shoulders.</li> <li>5. Contaminated water and/or cold water.</li> <li>6. Improper personal protective equipment (PPE).</li> <li>7. Water flow areas (high,</li> </ol>	<p>There are currently no evidence-based injury prevention strategies to reduce the burden of injury in kayaking; however, there are opportunities for prevention based on the type and mechanism of injury occurring in kayakers.</p> <p>Studies reviewed for this report suggest (Stemberga et al., 2013; Zakharia et al., 2017; Wilson et al., 2012):</p> <ol style="list-style-type: none"> <li>1. Appropriate equipment (ear plugs, helmets) and correct technique can potentially prevent injuries.</li> <li>2. Proper personal protective equipment (PPE).</li> <li>3. Practice and higher skill levels can help prevent injuries.</li> <li>4. Regulation and education for kayakers.</li> <li>5. Improvement of paddling technique.</li> <li>6. Strength and conditioning.</li> <li>7. To reduce chronic injuries,</li> </ol>	<p>No studies were found that have evaluated strategies to prevent injury in this sport.</p>	<p><b>Websites</b></p> <p><a href="https://www.betterhealth.vic.gov.au/health/healthyliving/canoeing-and-kayaking-preventing-injury">https://www.betterhealth.vic.gov.au/health/healthyliving/canoeing-and-kayaking-preventing-injury</a></p>	

<p>In 2012, Wilson et al. identified injury rates for competitive paddlers (canoe and kayak) in which a total of 271 injuries were reported and an overall rate of 0.08 injuries/participant/year.</p> <p><b>Common Injury Types</b></p> <p>In a review by Wilson et al. (2012) white water paddling was associated with various acute and chronic injuries as well as external auditory canal exostoses (EACE) and gastrointestinal illnesses. The most frequently reported acute injuries associated with canoeing were lacerations, sprains/strains, fractures, and dislocations. The majority of injuries occurred while the paddlers were in their boats. It was noted that most lower limb injuries occurred when paddlers were swimming. These injuries most often occurred after capsizing or during the hike to and from river access points. Using either a survey or a physical examination, the review identified the most frequently identified chronic injuries associated with canoeist was tendonitis, as well as deformation of the shoulder joint. It was identified that</p>	<p>medium, low): Most kayakers were injured when they were in the medium water flow area (48%), followed by high water flow areas (38%).</p>	<p>balance training has been suggested reduce injury risk. Allowing for adequate rest should also be considered for kayakers; however, any structured guidelines have yet to be implemented or evaluated.</p>		
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<p>novice paddlers experience more acute injuries whereas chronic injuries were associated more with the experienced canoer.</p> <p>In 2017, Zakharia et al., noted the most common types of injury in kayakers were contusions (31%), sprains (24%), dislocations (17%), tendinitis (10%), abrasions (10%), fractures (3%), and near drowning (3%).</p> <p><b>Common Injury Regions</b></p> <p>In 2012, Wilson et al. identified the shoulder and arm as the most common location of acute injuries, while the back, chest and hip injuries were identified as more chronic injury locations. Overall, the injuries sustained most often occurred in the upper body.</p>				
<p><b>Works Cited:</b> Wilson, I., McDermott, H., Munir, F. (2012). Injuries, ill-health and fatalities in white water rafting and white water paddling. <i>Sports Medicine</i>, 43, 65-75.</p> <p>Zakaria, J., Yasim, M.M. et al. (2017). White water kayaking risk: Malaysian perspective. <i>Open Access Library Journal</i>,</p>	<p><b>Works Cited:</b> Wilson, I., McDermott, H., Munir, F. (2012). Injuries, ill-health and fatalities in white water rafting and white water paddling. <i>Sports Medicine</i>, 43, 65-75.</p> <p>Zakaria, J., Yasim, M.M. et al. (2017). White water kayaking risk: Malaysian perspective. <i>Open Access Library Journal</i>, 4.</p>	<p><b>Works Cited:</b> Wilson, I., McDermott, H., Munir, F. (2012). Injuries, ill-health and fatalities in white water rafting and white water paddling. <i>Sports Medicine</i>, 43, 65-75.</p> <p>Zakaria, J., Yasim, M.M. et al. (2017). White water kayaking risk: Malaysian perspective. <i>Open Access Library Journal</i>, 4.</p>		

4.		Stemberga, V., Cuculic, D., Petaros, A., Sosa, I. (2013). Kayaking fatalities: could more appropriate helmets prevent fatal consequences? <i>Sports Medicine</i> , 43, 1201-1202.		
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## Review of Sport Injury Burden, Risk Factors and Prevention

### Kayaking (Whitewater)

In the United States, data from 2010 showed that over 1.8 million people participate in whitewater (WW) kayaking. This is an increase of almost half a million people from the previous year. (Wilson et al., 2012) The unique demands of the sport, navigating down the river and/or playing in WW hydraulics (holes and waves) in a small plastic boat, may place the kayaker at an increased risk for injury. (Wilson et al., 2012; Zakaria et al., 2017) It has been noted that WW kayaking requires a large amount of physical exertion; thus, practice and skill level may help kayakers avoid injuries during a paddling session. (Zakaria et al., 2017) Although kayaking is often considered a dangerous sport, research examining injuries within WW activities has been overlooked, and there is a lack of prospective studies assessing true injury and fatality rates. (Wilson et al., 2012)

### Incidence and Prevalence

To date, there is a paucity of literature examining injury incidence rates in kayakers. The studies that have examined injury rates in kayaking have used varying methodology and study designs. This literature; therefore, needs to include those considerations when interpreting injury rates. In 2017, Zakharia et al., studied the types of injuries experienced by WW kayakers in Malaysia. Data were collected from 217 participants, of these, 186 experienced injuries while kayaking. The injury rate was estimated at 0.86 injuries per 1,000 participant hours.

As for recreational kayakers, Wilson et al. (2012) reviewed the literature and reported 319 recreational paddlers with 388 acute injuries (2.1 per person). There were 286 chronic injuries reported, at a rate of 4.5 per 1,000 participant days. Additionally, fatality rate for paddlers was reported as 2.9 fatalities per 100,000 participants per annum. Competitive canoers report an injury rate of 0.08 injuries per participant per year.

There were noticeable trends throughout the literature in the common types of injuries that occur in kayakers and it was identified that sprains/strains were the most common injuries. (Wilson et al., 2012; Zakaria et al., 2017)

Likewise, in the review by Wilson et al. (2012) it was noted that kayaking is associated with various acute and chronic injuries, including gastrointestinal illnesses, as well as external auditory canal exostoses (EACE). The most frequently reported acute injuries associated with kayaking were lacerations, sprains/strains, fractures, and dislocations; and most these occurred whilst the paddlers were in their boats. It was noted that most lower limb injuries occurred when paddlers were swimming. These injuries often occurred after capsizing or during the hike to and from river access points. Using either a survey or a physical examination, the review identified the most frequently identified chronic injuries associated with kayakers was tendonitis as well as deformation of the shoulder joint. It was identified that the novice paddler experiences more acute injuries whereas chronic injuries as associated more with the experienced paddler.

Furthermore, Zakaria et al., (2017) noted the most common types of injury in kayakers were contusions (31%), sprains (24%), dislocations (17%), tendinitis (10%), abrasions (10%), fractures (3%), and near drowning (3%). The trends in these injuries could be due to the unforeseen objects in the water, and the unpredictability of the weather and water conditions.

In 2012, Wilson et al. identified the shoulder and arm as the most common area to acute injuries, while the back, chest and hip were identified as more chronic injury locations. Overall the injuries sustained were most likely in the upper body.

## **Risk and Protective Factors**

No studies were found that examined specific factors associated with kayaking and injury outcomes. Of the primary studies reviewed, the following are risk factors speculated to contribute to injury in kayaking: (Wilson et al., 2012; Zakharia et al., 2017; Stemberga et al., 2013)

1. The grade of river (I to VI): Higher grades indicated more dangerous rivers. (Wilson et al., 2012; Zakharia et al., 2017)
2. Using rivers above skill level. (Wilson et al., 2012; Zakharia et al., 2017)
3. Level of experience: Novice paddlers report more lower limb injuries due to capsizing more frequently. (Wilson et al., 2012)
4. Poor technique: Poor technique has been shown to contribute to chronic injuries in the shoulders due to uneven movement in the scapula. (Wilson et al., 2012)
5. Contaminated water and/or cold water.
6. Improper personal protective equipment (PPE). (Stemberga et al., 2013).
7. Water flow areas (high, medium, low): Most kayakers were injured when they were in the medium water flow areas (48%), followed by high water flow areas (38%). (Zakaria et al., 2017)

## **Opportunities for Prevention: Effective Interventions, Cost-Effectiveness, Implementation and Evaluation**

There are currently no evidence-based injury prevention strategies to reduce the burden of injury in kayaking; however, there are opportunities for prevention based on the type and mechanism of injury. The studies reviewed for this report suggest ensuring the use of appropriate personal protective equipment (PPE) such as ear plugs and helmets. (Wilson et al., 2012; Zakharia et al., 2017) In addition, ensuring that paddlers perform the correct technique, especially for novice paddlers, can potentially prevent injuries. (Wilson et al., 2012; Zakharia et al., 2017) In the review by Wilson et al. (2012), it was reported that balance training may be used as a prevention technique to avoid chronic injuries. Kayakers should also ensure that they are getting adequate rest. Additionally, Zakharia et al. (2017) underlined the need for strength and conditioning to reduce the number of injuries occurring in kayakers. Lastly, it is suggested that regulations and education for kayakers needs to be mandated to ensure safety measures are taken to limit the number of injuries. (Zakharia et al., 2017)

## References

- Stemberga, V., Cuculic, D., Petaros, A., Sosa, I. (2013). Kayaking fatalities: could more appropriate helmets prevent fatal consequences? *Sports Medicine*, 43, 1201-1202. doi: 10.1007/s40279-013-0109-y.
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