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Original article

Orthopedic injuries associated with jet-skis (personal watercrafts): A review of 127 inpatients

C.J. Donnally III^{a,*}, P.M. Rothenberg^a, G. Metser^a, D.H. Massel^a, A.J. Butler^a,
D. Damodar^a, S.H. Shin^b, T.L. Zakrison^b

^a Department of Orthopedics, university of Miami hospital, 1400 NW 12th avenue, 33136 Miami, US

^b Department of Surgery, Jackson Memorial hospital, 1800 NW 10th avenue, 33136 Miami, US

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ABSTRACT

Background: Personal watercrafts (PWC) account for a disproportionate amount of water based injuries. Current literature suggests those with less PWC experience are more at risk for injury. Previous studies have not specifically evaluated the orthopedic implications of PWC usage or how various mechanisms of injury (MOI) contribute to different injury patterns.

Hypothesis: PWC injuries will frequently require orthopedic intervention. The presence of an orthopedic injury will result in increased injury severity score (ISS), hospital and intensive care unit (ICU) length of stay (LOS). Patients visiting our region will have less PWC experience and so are more prone to serious injuries.

Materials and methods: Retrospective cohort study at a single Level 1 trauma center of admitted patients sustaining PWC injuries from 02/2004–03/2017. The following were studied: demographics, mechanism, season, ISS, hospital and ICU LOS, follow-up, fracture characteristics and management.

Results: Hundred and twenty-seven patients were admitted due to PWC injury, 66 (52.0%) sustained an orthopedic injury, totaling 103 fractures (48 [46.6%] lower extremity, 26 [25.2%] upper extremity, 14 [13.6%] vertebral, 11 [10.7%] pelvic ring and 4 [3.9%] acetabulum). The mean age of orthopedic patients was 29 years (range 8–62). Handle bar injuries were significantly associated with open fractures, (13 of 25 open fractures, 3 of which became infected). Injuries occurring during the winter were associated with a higher ISS, yet more injuries occurred in the summer. A patient being a “visitor” to the region did not influence ISS. The mean LOS was 12.6 days for orthopedic patients. Eighteen orthopedic patients (27.3%) required ICU admission and 36 (54.5%) patients required orthopedic surgery (mean 2.11 operations).

Discussion: A majority of PWC injuries resulted in extremity fractures with a moderate percentage requiring orthopedic surgery. Correlations between PWC experience and injury incidence can provide information for increased safety.

Level of evidence: IV; retrospective.

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1. Introduction

Personal watercraft (PWC), also known as jet-skis and wave runners, are water vehicles that by definition are under 13 feet long and are operated by an individual sitting, standing, or kneeling on the body of the vehicle rather than within the confines of a hull [1]. PWCs are increasingly popular in United States as a form of

outdoor recreation among adults and unfortunately young adolescents [2–4]. The PWC concept originated in the 1960s. In the early 1970s, Kawasaki Motors Corp. U.S.A. introduce the Jet-Ski watercraft and today other common brand names are WaveRunner and Sea-Doo. PWC technology continues to improve with current models accommodating 3 or more passengers, achieving a horsepower over 340 and reaching top speeds of 80 mph.

In 2014, 47,900 units of PWC were sold nationwide, the highest number since 2008 [5]. In 2014 it was estimated that there are currently roughly 1.2 million units of PWC in operation [5]. While PWCs accounted for just 11% of all registered boating vessels nationally in 2015, they are attributed to 24% of all marine

* Corresponding author at: Department of Orthopedics, university of Miami hospital, 1400 NW 12th avenue, 33136 Miami, United States.

E-mail address: Chester.Donnally@jhsMiami.org (C.J. Donnally III).

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injuries and 18% of all water collisions [6]. It is clear that PWCs are responsible for a disproportionate amount of injuries and it has been previously shown these state and government statistics grossly underreport the true injury incidence [4]. With the increasing trends in PWC prevalence, manufactures, policy makers and healthcare employees should all work towards improving equipment and usage rules to protect PWC users and by-standers.

This study is the largest single center review of PWC injuries, as well as the first that attempts to correlate risk factors such as experience level, season and specific orthopedic variables. Our level I trauma center was well equipped to study PWC injuries due to its location in a major costal city that receives roughly 15.5 million tourist visiting the area annually [7]. Riding PWCs is especially popular among tourist and as a result numerous inexperienced operators will take to the crowded waters in these high powered aquatic vehicles. Many fail to adhere to critical laws requiring PWCs to not produce a wave/wake within a certain amount of feet next to another motorized vehicle, structure, or shoreline [8]. While it is thought that those inexperienced users are more at risk of injury, currently there are no high level studies showing how PWC experience effects collisions rates. As an imperfect method to evaluate experience level, we proposed that patients local to our area will have year round access to PWCs, possibly allowing for more riding experience. Those who do not reside in the county or boarding county of our treating center are likely less experienced due to their decreased PWC access compared to locals. Additionally, there is very little data describing how these PWC injuries specifically occurred. The primary objective was to describe common patient characteristics, detail the specific mechanism of injury (MOI) and analyze the anatomic distribution of injury for each mechanism with a focus on orthopedic fractures. Secondary objectives were to identify risk factors for orthopedic injuries and patient outcomes. Use of such information could assist with suggestions about possible safety measures that may prevent or mitigate the consequences from the injuries.

2. Methods

A retrospective cohort study of all admitted patients with personal watercraft (PWC) related injuries at single Level I Trauma Center from February 1st, 2004 to March 28th, 2017 was performed. "Orthopedic injuries" were defined as deep wounds violating a joint capsule, joint dislocations, lacerated tendons and all fractures except those of the face/skull and ribs. Patients with a MOI of PWC that presented to our emergency room and were then discharged without needing an admission were not included. Patients that expired [9] prior to arrival or shortly thereafter were also excluded as their fracture work-up and history was incomplete. Traumatic limb amputations were counted as a single open fracture in that frequently the limb is never radiographed or detailed in the medical records. Potentially additional fractures within this extremity will be unreported.

Per institutional protocol, all patients with an open fracture receive a 3-day course of IV antibiotics (1g Ceftriaxone, daily) starting immediately at presentation. Those with an open fracture occurring in a salt-water environment would also receive 100mg doxycycline, every 12 hours, due to the increased risk of *Vibrio* species in salt-water injuries.

Charts were reviewed for information regarding age, gender, location of residence, mechanism of injury, hospital length of stay (LOS), ICU duration, follow-up time, injury severity score (ISS), orthopedic injuries, hospital course, and outcomes. Four specific mechanisms of PWC injury were defined as: axial load (i.e. landing forcefully after a wave or jump), direct collision (into another PWC, boat, structure), fall/ejection off the PWC, or

handle bars as a blunt contact force. These were determined based on patient records. Patients from the county of our hospital or the 4-surrounding/neighbor counties were considered "locals". Patients residing from any other county than the 5 we considered local were designated as "visitors".

Statistical analysis was performed using SAS University Edition. Correlations were determined using either ANOVA, Chi² or Fisher's Exact Test, for parametric and non-parametric data, respectively. Means, medians and frequencies were analyzed and *P*-values of <0.05 were considered significant.

3. Results

Of 127 patients admitted for PWC related injuries, there were 66 (52.0%) patients that had sustained an "orthopedic injury", totaling 103 fractures. The mean age of the orthopedic patients was 29 years (range 8–62), with the majority males (57.6%) (Tables 1 and 2). Amongst these 66 patients, 70.0% were "local" residents, while 30.0% were not from the greater area and the location of residence did not influence ISS rates. The mean ISS for orthopedic patients was 15.0 (SD ± 9.67). Eighteen (27.3%) orthopedic patients were admitted to the ICU with a mean ICU LOS of 7.7 days. Of those orthopedic patients admitted > 24 hours (90.1%), their average hospital LOS was 12.6 days.

There were 36 patients (54.5%) that required surgery with the orthopedic team (mean 2.11 trips to operating room; range 0–12). Interestingly 11 (31%) of these 36 surgical patients underwent staged irrigation and debridement (I&D) (mean 3.18 I&Ds; range 0–7). The need for a repeat I&D was usually based on intraoperative wound assessment of contamination and tissue viability. There were 5 (7.58%) known infections – 3 occurring in patients with an open fracture (two patients cultured *Pseudomonas aeruginosa*, the other patient had no growth) and 2 other infections were noted in surgically treated patients with a closed fracture (only one having a positive culture of Group G Beta-Hemolytic Streptococcal). Of those patients with at least 8 days of follow-up (42 patients; 63.6%) and after excluding an outlier of 9.4 years, the mean follow-up time was 114.9 days (SD ± 147.7 days).

There were 48 (46.6%) lower extremity fractures (16 femur, 13 tibia, 12 fibula, 3 foot, 2 patella), 26 (25.2%) upper extremity fractures (8 radius, 4 scapula, 3 clavicle, 3 hand, 5 ulna, 2 humerus), 11 (10.7%) pelvic ring injuries, 14 (13.6%) vertebral fractures and 4 (3.9%) acetabulum fractures (Table 3). Of the 66 patients with fractures, 17 (25.8%) patients sustained an open fracture, with 6 patients having multiple open fractures (Table 4). There were 25 open fractures and 3 (12%) developed an infection. A traumatic limb amputation was seen in 3 (4.5%) patients (Fig. 1).

Table 1
Demographics of patients that sustained injuries from personal watercraft (PWC) accidents.

	Total	Sustained orthopedic fracture
Total patients	127	66
Sex		
Male	81 (63.8%)	38 (57.6%)
Female	46 (36.2%)	28 (42.4%)
Age (years)	21	29
Race		
White	60 (47.2%)	30 (45.5%)
Black	10 (7.9%)	6 (9.1%)
Latin	55 (43.3%)	28 (42.4%)
Other	2 (1.6%)	2 (3.0%)
Mean ISS	14.7 (± 11.9)	15.0 (± 9.7)
Mean ICU (days)	7.9 (± 6.1)	7.7 (± 5.1)
Mean LOS (days)	9.9 (± 9.2)	12.6 (± 10.3)

ISS: injury severity score; ICU: intensive care unit; LOS: length of stay.

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