

Injuries Related to Wakeboarding in Brazil: A Cross-Sectional Study

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Abstract

Wakeboard is an aquatic sport that has been growing in number of participants in several countries last years. Like other aquatic sports with high-speed and tricks with complex movements, wakeboarding involves a series of risks to practitioners and there are few recent scientific publications, and most of them are case reports. **Method:** It is a prospective cross-sectional study among wakeboarders with more than one year of practice, in which it has been collected demographic data, riding profile and information regarding the types of injuries presented by the participants, aiming to identify the most frequent injuries and correlates with variables, such as age, sex, body mass index, modality, frequency, and level of practice. For this, an online questionnaire was used and the data were analyzed with chi-square test when applicable. **Results:** The research had 157 valid responses, from which 124 (79%) declared to have had at least one injury related to wakeboarding. From them, 88% reported at least one skin wound, 69% reported muscular injury, 53% sprain, 18% joint dislocations, 18% bone fractures, 15% concussions and 3% reported other, such as accidents with animals. Equipment failure, such as inadequate size of boots or binding loose fixation, was appointed by 8% of the participants as a predisposing factor for sprains. Men had a relative risk of 1.47 of getting injured compared to women (IC 1.06 - 2.05, $p = 0.002$). There were no statistically significant differences when comparing different ages, body mass index or modality (boat or cablepark). From the general musculoskeletal harms, 82% of the sprains and 50% of the bone fracture occurred on lower limbs, as the upper limbs were most affected on joint dislocation (87%). Sprains were most common on the knee (46%) and ankle joints (36%), and 70% of the sprains with ligament involvement affected the anterior cruciate ligament. Shoulder was the joint affected in 79.2% of the dislocations. **Conclusions:** Wakeboard has a high prevalence of injuries: most of them with skin wounds

and musculoskeletal ones. Men have a higher injury rate than women and there was no association with age, body mass index, or modality. Equipment failure is a predisposing factor for harms and the higher the frequency and level of practice, the higher the chances of getting injured.

Keywords

Athletic Injuries, Sports Medicine, Water Sports, Joint Dislocations, Knee Injuries, Epidemiology

1. Introduction

Wakeboard is an aquatic sport created in the 80s in the United States (Narita et al., 2004), using surf boards and a cable fixed in a boat and it became popular in the 90s, when proper equipment was developed, with specific design to this new sport and, in 2017, it was estimated 2.9 million practitioners (Bäcker, Shoap, Vasarhelyi, & Pánics, 2020).

In Brazil, it was consolidated in 1998 with the foundation of the Brazilian Wakeboard Association (Wake Brasil) and nowadays, it is estimated more than 1.500 practitioners in the country (ABW, 2019) and this number tends to grow every year.

It can be practiced on boat modality, in which the wakeboarder executes tricks with the wave created by the watercraft, which speed ranges from 30 to 40 km/h commonly (ABW, 2019; Hostetler, Hostetler, Smith, & Xiang, 2005). On cable modality, it is practiced on a lake or dam with an electric cable and towers' system that tows the practitioner in a linear or circular path with obstacles, as ramps and rails, for the tricks execution.

The combination of high kinetic energy, rotational movements, fixed feet bindings and the board's surface area can lead to a major risk of injuries, mainly on the lower limbs (Narita et al., 2004). Besides, the speed and height achieved by the wakeboarders are predisposing factors for traumatic injuries (Su, Lim, Tan, Chua, & Chui, 2007). The force applied to the arms and shoulders to grab the handle and sustain the boat or cables system speed can lead to muscle injuries on superior limbs (Barendse-Hofmann, Steenvoorde, van Doorn, & Zeillemaker, 2009; Draghi & Gitto, 2017; Knobloch, Gohritz, Altintas, Spies, & Vogt, 2009; Lim, Wee, & Lee, 2012; Pascual-Garrido, Swanson, & Bannar, 2012).

Among reported injuries related to wakeboarding in the literature, there are anterior cruciate ligament tear, shoulder dislocation, ankle's sprains (Carson Jr, 2004; Narita et al., 2004), bone fractures (Baker, Griffin, Brauneis, Rue III, & McGwin Jr, 2010), intracranial bleeding (Chia, Goh, & Chan, 2000), talar head fracture (Ibrahim, Jordan, Lotfi, & Chapman, 2015), proximal brachial biceps tendon rupture (Pascual-Garrido et al., 2012) and traumatic hand amputation (Woodacre & Marshall, 2011).

In research realized among orthopedic surgeons in the American state of Florida, 15% from the more than 150 participants affirmed that had no knowledge about wakeboard (ABW, 2019), showing a significant rate of healthcare professionals that don't know the injuries mechanisms and risk factors of wakeboarding.

Considering the scarcity of recent scientific publications, the growing popularity and its risks, this study aims to identify the main injuries related to wakeboarding in Brazil, and correlate with variables, such as age, sex, body mass index, modality, frequency, and level of practice, for a better understanding and development of strategies for prevention and rehabilitation.

2. Methods

It's a prospective cross-sectional study, in which was considered eligible wakeboarders from both genders, that practices for at least 1 year, from all levels of experience and modality. There was no age limit. The data were collected by Google Forms questionnaire, e-mailed to 597 wakeboarders associated with Brazilian Wakeboard and Aquatic Ski Confederation (WakeBrasil) and it was also divulgated on social media related to wakeboarding. The participation was anonymous and self-reported, and the form had questions about demographic data, riding profile, such board base, frequency and level, and injury history and characterization. For level stratification, it was used the established rules for WakeBrasil's championships, according to the tricks' complexity.

Injury definition was adapted from Nickel e Watson, and it's defined as a damage to a part of the body, occurring suddenly while wakeboarding and that resulted in the incapacity to keep practicing it for at least one day (Nickel et al., 2004; Watson, 1996).

The obtained data were tabulated, and the numeric values were analyzed by corrected chi-square test, with a confidence interval of 95% and p -value < 0.05 .

3. Results

It was collected 214 fully responded questionnaires, in which 157 were eligible after excluding duplicity and riders with less than one year of practice. From them, 128 (82%) were answered by men and 28 (18%) by women. The mean Body Mass Index (BMI) was 25 kg/m² and the mean age, 33.5 years, ranging from 14 to 64 years old. The majority (66%) practices for more than five years, 11% for four years, 12% for three years, 7% for two years and 4% for at least one year and less than two.

About the riding profile, 32% of the participants practices more than once per week and 52% rides on cableparks, 38% on boat and 10% on both modalities. According to the trick's complexity, 28% self-reported as beginner, 34% as intermediate, 27% as advanced and 12% as professional riders. As shown in **Table 1**, the more expert and the more often the practice, the more likely to have an injury. The legs' board base, goofy or regular, appeared as 49% and 51% respectively.

Table 1. Level and frequency of practice versus injury odds ratio.

Level*	Odds ratio	Frequency	Odds Ratio
Beginner	1.00	<1×/month	1.00
Intermediate	2.10	1 a 2×/month	1.38
Advanced	8.00	3 a 4×/month	3.13
Professional	11.07	>4×/month	6.27

***Beginner:** spin until 180° on boat and until 360° and sliders on cablepark; **Intermediate:** spins until 360° and basic inverts on boat and raley and inverts on cablepark; **Advanced:** raley and inverts on boat and spins until 540° and inverts with 180° spins on cablepark; **Professional:** more complex tricks than advanced.

From the 157 participants, 124 (79%) declared to have had at least one injury while wakeboarding. Among the ones with injury history, 108 were men and 16 were women. Male riders showed a relative risk of getting injured of 1.47 in comparison to females (IC 1.06 - 2.05, $p = 0.002$). There was no statistically relevant association between injuries and BMI, age, or board base.

From the 124 participants with injury history, 109 (88%) reported at least one skin wound (laceration or blunt wounds), 85 (69%) reported muscular injury, 66 (53%) sprain, 22 (18%) joint dislocations, 22 (18%) bone fractures, 18 (15%) concussions and 4 (3%) reported others, such as accidents with animals. Equipment failure, such inadequate size of boots and binding loose fixation, was reported by 8% of the participants.

In general, 423 injuries were reported, and, from them, 41% occurred on lower limbs, 38% on the upper limbs, 12% on the trunk (abs, chest and back) and 9% on head and neck. In **Figure 1**, the types of injuries are stratified by the local of occurrence, showing that the lower limbs are more affected by sprains (82%), bone fractures (50%) and skin wounds (50%), while the upper limbs are more affected by joint dislocations (87%). Muscular injuries occur mostly on the upper limbs (35%) and trunk (32%).

From the 103 skin wounds in which the participant reported the affected body segment, 37% occurred on lower limbs, 31% on head or neck, 27% on upper limbs and 5% on the trunk.

It was reported a total of 186 muscular injuries, by 82 participants, and only 55 of the cases had a medical evaluation. From them, 50.8% was diagnosed as muscle strains or partial tear, 36.4% as contusion, 7.3% was tendon tear and 5.5%, tendonitis or bursitis. Ten muscle injuries (5.3%) needed surgical treatment and 24.1% were treated with physiotherapy. Only 37% of the muscle injuries had the mechanism described on the questionnaire, and 11.8% of them occurred due to the impact with the water or obstacle after falling, 8.6% while executing spins, 5.9% with inverts, 5.4% due to the cable's traction, 3.2% due to fatigue or overtraining, and 2.2% due to air tricks attempt. The rest had no mechanism reported.

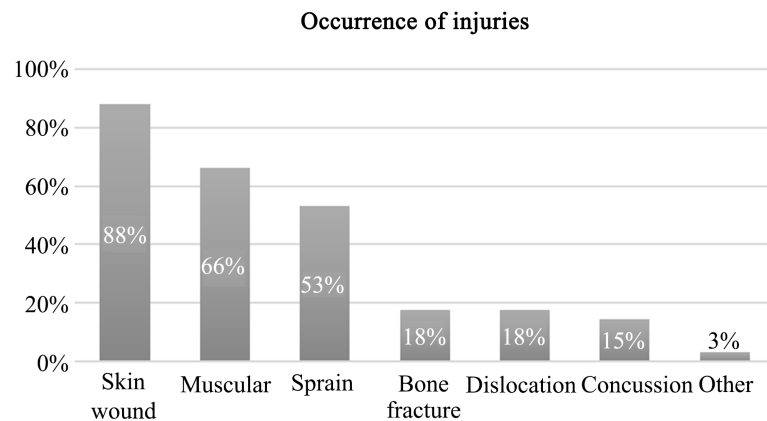


Figure 1. Occurrence by type of injury among participants with injury history.

Sixty-six wakeboarders reported a total of 88 sprains, from which 45.5% affected knees, 36.4% ankles and 18.2% shoulders. Healthcare was needed for 69.7% of the cases and 60% of the diagnosed sprains had ligament injury. From this, 70% occurred on the knee and affected the anterior cruciate, the medial collateral was injured in 29% and the lateral collateral on 10%. Spins were reported as the cause in 24% of the sprains, as impact against water or obstacle was in 18%, inverts in 18%, jumps in 15%, 3% due to air tricks, 2% to fatigue and 2% to cable's traction. The other 18% of the sprains had no injury mechanism reported.

Twenty-four joint dislocations were reported by 22 participants and 79.2% of them occurred on shoulders, 8.3% on ankles, 8.3% on fingers and 4.2% on toes. Healthcare was searched on 18 cases and 22% occurred while executing inverts, 17% due to impact with the water or obstacle, 17% due to the cable's traction, 13% to spins and 4% to jumps. Others had no injury mechanism described.

It was reported 24 bone fractures, by 22 participants (17%). Twelve affected the lower limbs (7 on legs and 5 on ankles), five were on the upper limbs, five on the trunk (5 on hips and 1 on vertebrae) and 2 on teeth. The main injury mechanism reported was spins (41%), followed by inverts (27%) and impact with water or obstacles (14%). **Figure 2** shows the distribution of type of injuries and its local of occurrence.

4. Discussion

This unprecedented study in Latin America aims for a better understanding of this relatively new sport that has been growing in number of practitioners in many countries around the world (Bäcker et al., 2020). Wakeboarding demands aerobics and anaerobic metabolism and involves a large range of movements, recruiting different muscles' groups in moderate and high intensity during its practice (Hostetler et al., 2005). Besides the intense muscular activity, the tricks offer a high risk of falls, contusions, and twists inherent to its execution, enhancing, thus, the injury occurrence in any part of the body, affecting muscles, ligaments, skin and bones (Carson Jr., 2004).

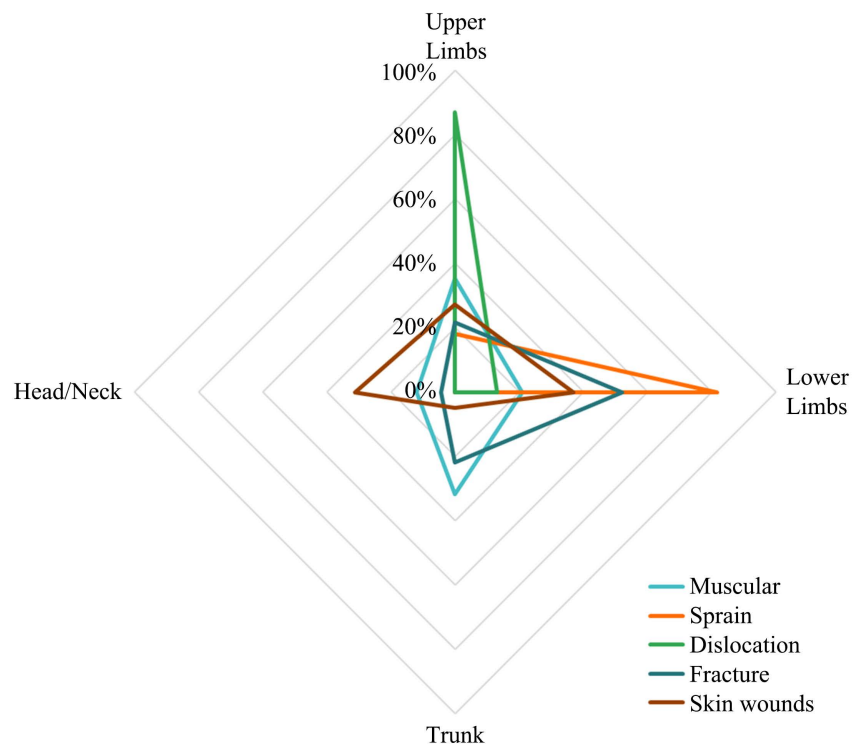


Figure 2. Type of injury and local of occurrence.

From data collected in this study, the wakeboarder profile is a eutrophic adult, that practices for more than five years and once a week at least. It was identified a prevalence of 79% of injuries related to wakeboarding, reinforcing data published in 2004, of 77% (Carson Jr., 2004).

Lower limbs were most affected, mainly by sprains, skin wounds and bone fractures, followed by the upper limbs, that were most injured by shoulder dislocations and muscles harms. From this analysis, joint dislocation and bone fractures were the main reasons for medical care. Besides of the high occurrence of injuries on the limbs, previous studies analyzed hospital records due to wakeboard injuries in the United States and related that head and face trauma were the most common, followed by lower limbs and hips (Baker et al., 2010; Hostetler et al., 2005). This indicates that although head and neck trauma are less common than in other segments of the body, they tend to be more severe, requiring healthcare services.

In this analysis, there was no significant difference between the injury prevalence on cable park and boat modalities. Although there is no previous study focusing on boat modality for comparison, a six-month period prospective study of cable parks' injuries reported that 14% and 15% were classified as severe or very severe, respectively. From all injuries, knees and shoulders were most affected, mainly for dislocations and contusions. Further studies could contribute for a better understanding of the differences in injury mechanism and prevalence between both modalities.

Compared to similar sports, wakeboard has an incidence of injuries and trauma

in the head 6.8 times higher and a lower incidence on the superior limbs than aquatic ski (Hostetler et al., 2005). In comparison to snowboard, which board style and posture are similar, knee injuries while wakeboarding are more common due to the greater impact force on its tricks when reaching the water surface, that is on horizontal plane (Narita et al., 2004). Skateboarding presented a prevalence of 87.8% of injuries and kitesurfing, 64%. The lower limbs were most affected on these both sports and the sprain were the main type of injury reported, affecting more commonly ankles, followed by the knees (Baumbach et al., 2017; de Oliveira Berneira, Domingues, de Medeiros, & Vagheti, 2011; Nickel et al., 2004; Rodríguez-Rivadulla, Saavedra-García, & Arriaza-Loureda, 2020; van Bergen, Weber, Kraal, Kerkhoffs, & Haverkamp, 2020). These literature data contribute to the ones obtained in this study regarding the higher occurrence on lower limbs, although sprains on wakeboard affects mainly knees, followed by the ankles. Most wakeboarders are male, so it was expected a higher prevalence of injuries in this population. However, it was found that men get 1.47 times more injured than females. The reason for this difference is not clear by this analysis, but it could correlate with the fact that 86% of women that answered this survey reported its level as beginner or intermediate, which predispose less for injuries.

Even though a higher frequency of practice leads to a better musculoskeletal performance and proprioception, practicing more than once a week showed increased injuries rates, which might be related to a greater exposure to its risk or to a fatigue situation.

Inadequate equipment, such loose boots, bindings, or helmet, was appointed as a related factor for injuring 8% of the participants of this study. As any other sportive activity that demands individual protection equipment, its correct use is extremely important for the rider's safety. As stated by Carson, loose bindings can lead to the creation of a lever arm by having one foot tightly fixed and the other coming out of the boot, as well as an uncontrollable wakeboard situation (Carson Jr., 2004). Besides, loose boots allow rotational movement of the feet and ankles while executing a spinning trick, predisposing to traumatic injuries, such as sprains and bone fractures. Too tight bindings, on the other way, appear to create a resistance force upon the lower extremity that can lead to an increased risk for ACL injury (Narita et al., 2004).

Skin wounds were the most frequent type of injuries, and it occurred mainly on lower limbs, followed by head and neck and upper limbs. The trunk is less affected, especially due to the regular use of life jackets, which also protects this region.

Injuries related to wakeboarding took most riders off the practice for up to six months. 39.4% returned after one month and 42.4% in between 2 to 6 months. Longer periods off were more related to head trauma and sprains, 24.3% and 26.8% of the cases, respectively. Besides specific treatments for a better and faster rehabilitation, prevention actions are important to decrease the rate of injuries and time off from sports practice and daily activities.

5. Conclusion

This study showed that 79% of wake boarders have had an injury history related to this sport's practice. The main injuries are skin wounds, muscular and sprains. There was no association between risk of getting injured to body mass index, age, board base, or modality, although it was identified that men have a higher injury risk than women. The higher the level and frequency of practice, the higher the injury's prevalence, due to greater exposition and movement's complexity.

Equipment failure, as loose bindings or inadequate size for its rider, seems to be a predisposing factor to sprains.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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