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## Research Article

# Epidemiology of Injuries in Competitive Water-Skiing and Wakeboard Athletes in Greece: Retrospective Pilot Study

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## Abstract

**Background and Objective:** The demanded physical fitness for participation in water-ski and wakeboarding can exceed the athlete's adaptations and can cause injuries. Although the participation in these sports is massive both at the competitive level and recreation as well, no studies were conducted to record injuries. The present study aimed to record the Epidemiology frequency of injuries in competitive water-skiing and wakeboard athletes in Greece. **Materials and Methods:** Data were recorded retrospectively with an online questionnaire regarding the anatomical injury area, the type of injury, the anatomical area of sprains and the stress syndrome area was distributed to all-tournament license holders through the Hellenic Water-Ski and Wakeboard Federation. Athletes' data and essential injury information were extracted from the questionnaire and analyzed with SPSS, version 25. **Results:** There were 140 participants, 104 male (74.3%) and 36 female (25.7%), with 92 (65.7%) to be athletes of water ski and 48 (34.2%) to be athletes of the wakeboard. Several 291 injury cases were reported. The highest percentages of anatomical injury areas and the anatomical areas of sprains reported to be the knee (16.5%), the ankle (11.7) and the shoulder girdle (11.7), sprains, fractures, strains, are the most common type of injuries. No significant differences were recorded between the sexes in the total number of injuries. **Conclusion:** Pattern of injuries in competitive water-skiing and wakeboard athletes in Greece are similar to current literature. Future studies should focus on factors that contribute to and prevent these injuries.

**Key words:** Water-ski, wakeboard, athletic injuries, tournament, water sports, gender, epidemiology

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**Competing Interest:** The authors have declared that no competing interest exists.

**Data Availability:** All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Participation in sports and leisure activities is an important factor in improving public health. Injury is an unwanted but potential side effect of participation, which has the potential to reduce the benefits of participation and act as a deterrent to future participation<sup>1</sup>. There has been a lot of research on sports injuries in all sports and they all agree that engaging in sports increases a person's chances of injury<sup>2,3</sup>. At any age, professional and amateur athletes suffer from a wide variety of injuries. Injuries can be found in the soft tissues such as ligaments, tendons, bones, as well as injuries to the nervous tissue, which are caused either by direct trauma or due to repeated high loads<sup>4,5</sup>. Especially in water-ski and wakeboard the highly coordinated movements, the extreme upper body torques and the isometric contractions put a significant strain on athletes' bodies<sup>6</sup>.

The chance of injury is quite high for water skiing athletes in the event of a fall. High accelerations combined with the boat's constant but high speed, which can reach up to 58km/h, as well as the unpredictable nature of falls can lead to various types of injuries<sup>6</sup>.

During the sport, the force exerted on the upper extremities exceeds 1.5 times the weight of the body, so it is easy to understand the load borne (bearing) to the respective muscle groups (forearm, arm, shoulder girdle), while in case of pre-existing injury increases the likelihood of recurrence<sup>7</sup>. According to a survey of athletes competing in the UK championships, sprains and strains were the most common form of injury (64.6%), while the part of the body that suffered the most injuries was the torso and lumbar spine (38.8%)<sup>8</sup>. Hostetler *et al.*<sup>9</sup> reported in their results that the most common injury in water skiing athletes are fractured and sprains with a rate of 36.3% while craniocerebral injuries occur less frequently with a rate of 2.4%. In a study by Jung *et al.*<sup>10</sup> the most common body parts injured among the collegiate water-ski athletes were the ankle/feet, knee and head/neck region. In the same study, it is reported that collegiate athletes had higher rates of chronic pain in the trunk (42.7%). In a study by Baker *et al.*<sup>11</sup>, injuries of the lower extremities were reported as the most common injuries for water-ski, especially strains and ankle sprains, laceration was the most common diagnosis for head and neck injuries, while the shoulder and upper extremity injuries were diagnosed as sprains or strains. Water-ski is associated with injuries to the hamstring muscles and it has been reported that hamstring injuries to elite water skiers are typically severe and involve partial or total rupture of the proximal hamstring muscles<sup>12</sup>. A study by Patel *et al.*<sup>13</sup>, mentions a positive correlation between years of involvement

in sports such as water skiing, especially in the jump event and the occurrence of spondylolysis and spondylolisthesis. There is also a high frequency of fractures in the jump event due to the high-speed impacts, either after a collision with the jumping ramp or after falling into the water<sup>14</sup>. Respectively in wakeboard, the wide board used by athletes, in combination with the binding system that secures the legs to the board that does not have a specific release mechanism, creates rotational forces of acceleration and deceleration during the fall of the athlete<sup>15</sup>. It has been observed that the severity of the injury increases according to the level of ability of the athlete<sup>16</sup>. The majority of injuries occur in the lower extremities with an incidence rate of 68%, followed by the upper extremity with a rate of 28%<sup>15</sup>. The most common injury occurs in the knee joint and specifically in the Anterior Cruciate Ligament<sup>15-17</sup>, while isolated cases of posterior cruciate ligament rupture have been reported<sup>18</sup>, total adductor rupture<sup>19</sup>, bone overuse injuries and the development of osteochondritis in young athletes<sup>20</sup>. Injuries to the upper extremities such as tendon ruptures in the shoulder girdle and muscle strains in the biceps have been observed<sup>11,21</sup>. Hostetler *et al.*<sup>9</sup> claim that the most common injury of wakeboard athletes are abrasions (31.1%) and specifically in the facial area (59.6%). In 7-year research by Baker *et al.*<sup>11</sup>, it is reported that in 18,967 recorded wakeboard injuries, 47.9% involved the head and neck area, 26.5% of the injuries were in the lower extremity area with the highest incidence of sprains and ruptures. Severe bodily injuries, such as upper limb amputations and cardiovascular hematomas during participation in the sport, have been reported less frequently<sup>22,23</sup>.

As we can see from the literature review, in many studies the condition of the injury is not determined, Also, the competitive sports population is not separated from the subjects, who participate in the sport for leisure purposes. More, no study is known to us to investigate the epidemiology of injuries in water sports in Greece.

Therefore, the aim of the present study was a present study aimed to record the epidemiology frequency of injuries in competitive water-skiing and wakeboard athletes in Greece.

## MATERIALS AND METHODS

**Study area:** The present retrospective investigation was carried out by the Lab of Health, Fitness and Disability Management, Faculty of Human Movement and Quality of Life, University of Peloponnese and started in January, 2018 and finished at the end of June, 2021. To conduct the study, the researchers took permission from the Central Committee

of the Hellenic Waterski and Wakeboard Federation. Then, they sent a research package to the Directors of mentioned Federations, who informed all the enrollments athletes about the study procedures. The package included a cover letter, the study details, the research questionnaire and the informed consent.

The main criterion of the athletes to participate in the study was to be active in national events of their category for the last two years. After this 140 athletes, 104 male (74.3%) and 36 female (25.7%), with 92 (65.7%) to be athletes of water ski and 48 (34.2%) to be athletes of the wakeboard signed the consent and participated in the study. The mean age of water ski and wakeboard male athletes was  $22 \pm 4.1$  years, the height  $1.78 \pm 2.2$  cm, the weight  $77.5 \pm 7.2$  kg and the BMI  $24.5 \pm 1.3$  and the years of participation  $12 \pm 3.7$ .

The mean age of water ski and wakeboard female athletes was  $23 \pm 3.4$  y, the height  $1.65 \pm 1.6$  cm, the weight  $57 \pm 5.4$  kg and the BMI  $21.2 \pm 1.9$  and the years of participation  $8 \pm 2.6$ .

**Definition of term skiing and wakeboard injury and collection of data:** After an extensive literature search and taken into the consideration the studies of Carson<sup>15</sup>, Hostetler *et al.*<sup>9</sup> Loughlin<sup>8</sup>, Baker *et al.*<sup>11</sup> we defined an injury that occurs as a result of participation in skiing or wakeboard activity to a muscle/tendon unit, that occurred (training, competition) and limits athlete's participation the following day of injury or requires further medical attention.

Also, the researchers constructed the research tool, according to the previous research (Moreno-Alcaraz *et al.*<sup>24</sup>, Park *et al.*<sup>25</sup>, Piri *et al.*<sup>26</sup>). The final instrument consisted of three parts: In the first part included questions about anthropometric characteristics of male and female athletes (region of residence, sex, age, height, body mass and body mass index). The second part included questions about the athletic profile of participants (sports participation class, hours of training per session, number of weeks of training and the number of participation games. The third part of the questionnaire included information about injuries (the total number of injuries per year if the injury occurred in the upper or lower extremities, the anatomical site, kind of injury, month of injury, pattern, degree, preliminary diagnosis and first aid.

The questionnaire was electronically formulated and the federation contacted, requested assistance in the electronic distribution of the questionnaires directly from its database. The ultimate goal of this action was not to let the researcher come in contact with the sensitive personal data of the athletes. In this way, he ensured the confidentiality of the sensitive personal data of the participants, as well as the anonymity of the answers. The answers were collected

through the system in an excel spreadsheet automatically and encoded as numerical data.

**Statistical analysis:** All injuries data were coded for male and female athletes using age, sport, gender, as categorical variables. Statistical analyses were carried out using Statistical Package for Social Sciences (version 25, SPSS) software. Frequencies of injuries were calculated for the aforementioned categorical variables<sup>27</sup>. Statistical significance of differences among the variables was estimated using the non-parametric  $\chi^2$  test (applying Fisher's exact test where appropriate). Statistical significance was set at  $p < 0.05$  for all analyses.

## RESULTS

Of the 140 athletes who took part in the study, 109 (77.9%) stated that they have been injured at least once while 31 (22.1%) stated that they have never been injured. It is worth noting that 291 cases of injuries were reported. 28.6% of injuries occurred during the pre-season, 44.3% during training and the rest 5.0% during the competition (Table 1).

Thirty-two athletes (22.9%) sustained 2 injuries, 23 (16.4%) 1 injury, 20 (14.3%) three injuries, 16 (11.4%) reported that had been injured up to seven times (Table 2). The mean training absent from sports participation was 70,63 days.

Of particular interest are the results on the cause of the injury. The cause with the highest frequency of injury is that of jump-fall (44 cases, 22.6%), followed by the phase of fall and impact (41 cases, 21%), in third place is the injury related to binding (38 cases, 19.5%) and in the fourth the rope injury (22, 11.3%) (Table 3).

In the present study, 51.4% suffered acute injuries, 16.4% suffered chronic injuries and 12.1% had both types of injuries (Table 4).

The comparison of the total injuries between male-female showed that there are no statistically significant differences ( $\chi^2 = 1.140$ ,  $p > 0.05$ ) (Table 5).

Regarding the anatomical site area of injury, the most frequently injured area is that of the knee (48 cases, 16.5%), followed by the ankle (43 cases, 14.8%), the shoulder girdle (34, 11, 7%) and the spine (31, 10.7%), while the rest of the injury areas follow with percentages lower than 10% (Table 6).

In terms of the type of injury, muscle strains (grade 1) occur more frequently (49 cases, 21.3%), followed by sprains (40, 17.4%) and muscle strains (grade 2 and 3) (39, 17%), stress syndromes (33, 14.3%), tendon ruptures (27, 11.7%), bone fractures (23.10%), while lower are hematomas (11.4.8%) and abrasions (8, 3.5%) (Table 7).

Table 1: Frequency of injuries regarding the time of the season

When the injury occurs	Absolute frequency	Relative frequency (%)
Pre-season	40	28.6
Training	62	44.3
Competition	7	5.0
Total injuries	109	77.9
No injury	31	22.1
Total	140	100

Table 2: Frequency of number of injuries regarding the athlete

Number of injuries	Absolute frequency	Relative frequency (%)
0	28	20.0
1	23	16.4
2	32	22.9
3	20	14.3
4	10	7.1
5	5	3.6
6	6	4.3
7	16	11.4
Total	140	100.0

Table 3: Frequency of injuries regarding the cause of injury

Cause of injury	Absolute frequency	Relative frequency (%)
Collision with floating object	8	4.1
Collision with jump ramp	9	4.6
None	15	7.7
Ski equipment	18	9.2
Rope	22	11.3
Binding	38	19.5
Direct fall	41	21.0
Jump-Fall	44	22.6
Total	195	100.00

Table 4: Frequency of type of injuries

Type of injury	Absolute frequency	Relative frequency (%)
Acute	72	51.4
Chronic	23	16.4
Acute/chronic	17	12.1
Total injuries	112	80.0
No injury	28	20.0
Total	140	100.00

Table 5: Pearson correlation between gender and number of total injuries

	F	df	p	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson chi-square	0.33 <sup>a</sup>	1	0.855		
Continuity correction <sup>b</sup>	0.000	1	1.000		
Likelihood ratio	0.033	1	0.856		
Fisher's exact test				0.797	0.521
Linear-by-linear association	0.033	1	0.856		
N of valid cases	140				

<sup>a</sup>0 cells (0.0%) have an expected count less than 5, the minimum expected count is 5.66 and <sup>b</sup>Computed only for a 2×2 table

In particular, about sprains, the largest percentage of participants stated that they had not suffered a corresponding injury (42 participants, 32.8%), while the anatomical areas that showed the highest rates of this injury were the ankle joint (38, 29.7%), the knee joint (23, 18%), the shoulder girdle (21, 16.4%) and finally the fingers (4, 3.1%) (Table 8).

Regarding the distribution of overuse syndromes, most participants stated that they did not suffer any such injuries (51, 33.1%), while the highest rates of such injuries are in the elbow joint (24, 15.6%) and the supraspinatus (20, 13%). The remaining eight anatomical areas show injury rates of less than 10% (Table 9).

Table 6: Frequency of injuries regarding the anatomical area

Anatomical injury area	Absolute frequency (cases reported)	Relative frequency (%)
Shin bone	5	1.7
Arm	6	2.1
Trunk	6	2.1
Elbow	10	3.4
Fingers	11	3.8
Metacarpals	11	3.8
Carpal	11	3.8
Wrist	13	4.5
Inguinal hip	14	4.8
Neck	23	7.9
Head	25	8.6
Spine	31	10.7
Shoulder girdle	34	11.7
Ankle	43	14.8
Knee	48	16.5
Total	291	100.00

Table 7: Frequency of type of injury

Type of injury	Absolute frequency (cases reported)	Relative frequency (%)
Abrasions	8	3.5
Hematomas	11	4.8
Bone fractures	23	10.0
Tendon ruptures	27	11.7
Overuse syndromes	33	14.3
Muscle strains (grade 2 and 3)	39	17.0
Sprains	40	17.4
Muscle strains (grade 1)	49	21.3
Total	230	100.00

Table 8: Anatomical area of sprains

Joints	Absolute frequency (cases reported)	Relative frequency (%)
Fingers	4	3.1
Shoulder girdle	21	16.4
Knee	23	18.0
Ankle	38	29.7
None	42	32.8
Total	128	100.00

Table 9: Frequency of overuse syndromes

Overuse syndromes area	Absolute frequency (cases reported)	Relative frequency (%)
Cotter	1	0.6
Sciatica	1	0.6
Leg	2	1.3
Achilles tendon	6	3.9
Carpal	11	7.1
Disc	12	7.8
Lumbago	12	7.8
Knee	14	9.1
Supraspinatus tendon	20	13.0
Elbow	24	15.6
None	51	33.1
Total	154	100.00

## DISCUSSION

The purpose of the study was to approach the prevalence of injuries in water sports athletes in Greece. The results show that the most common musculoskeletal areas where injuries occur are the knee, the ankle, the shoulder girdle and the spine among the 15 areas reported. Similar findings can be observed in previous researches results, where the above mentioned anatomical areas had a higher prevalence of injuries that occurred in water sports<sup>8,11,15,20</sup>.

Concerning the type of injury, fractures, sprains, muscle strains and stress syndromes, are the most common types presented in the results. The results are in line with the results of previous research findings which show that these types of injuries occurred in a higher percentage in watersports athletes<sup>8,9,11,15,16</sup>.

Even if a higher percentage of the participants in the survey declares that they suffered no sprain injury, the findings show that ankle, knee and shoulder girdle sprains are the most common among watersport athletes<sup>8,9</sup>. For the lower extremities, knee and ankle, this may be caused due to high accelerations combined with the boat's high speed<sup>9</sup> and the rotational forces of acceleration and deceleration<sup>15</sup>, while for the upper extremities this may happen due to the exerted force which exceeds 1.5 times the weight of the body in the respective muscle groups (forearm, arm, shoulder girdle)<sup>7</sup>.

Finally, although the highest percentage of the participants declare that they had never had suffered a stress syndrome, the anatomic area of the elbow and the supraspinatus are presented as the areas in which stress syndromes occur most commonly. This may be the result of high accelerations in a short time with the corresponding forces from the handle being applied in small size muscles and soft tissues of the areas reported from one side, while from the other side is the positive correlation between years of involvement and the occurrence of overuse injuries from the chronic application of forces in the specific anatomical areas<sup>7</sup>.

This study discovered the need for specific physical conditioning according to the sports of water-skiing and wakeboarding to prevent future injuries and improve performance<sup>6</sup>. Educating the athletes and the coaches on which is the most vulnerable anatomical area of injury and type of injury will have significant importance on future prevention and in planning the training before and after the season.

The weakness of the study is the accuracy of the diagnosis and categorization of the injury when self-report data are used, which are based on the knowledge of the participants.

## CONCLUSION

In conclusion, injuries in Greek watersports athletes show that they occur both in the upper but mainly in the lower extremities. The anatomical areas with the higher percentages of occurred injuries are the knee, the ankle and the shoulder girdle and the most common injury that occurred in these areas are muscle strains and sprains. The anatomical areas where overuse syndromes occurred are the elbow and the supraspinatus tendon. Future research should focus on factors that contribute to or/and prevent injuries.

## SIGNIFICANCE STATEMENT

This study discovers the injuries that occur among the water-ski and wakeboard athletes in Greece and can be beneficial for understanding the factors that lead to injuries and also is the first study to collect data regarding the Greek water-ski and wakeboard athletes. This study will help the researcher to uncover the critical areas of sports injuries in high-intensity non-submersion sports that many researchers were not able to explore. Thus, a new theory on these injuries among water sports may arrive at.

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