Injuries in Competitive Dragon Boating

Swarup Mukherjee,*† MD, PhD, Hin Fong Leong,† Simin Chen,†
Yong Xiang Wayne Foo,† and Hong Kiat Pek†

Investigation performed at Nanyang Technological University, Singapore

Background: Dragon boating is a fast-growing team water sport and involves forceful repetitive motions that predispose athletes to overuse injuries. Despite the rising popularity of the sport, there is a lack of studies on injury epidemiology in dragon boating.

Purpose: To investigate the injury epidemiology in competitive dragon boating athletes.

Study Design: Descriptive epidemiological study.

Methods: A total of 95 dragon boaters (49 males, 46 females) representing their respective universities took part in this study. Data were collected retrospectively using a reliable and valid self-report questionnaire. The study period was from August 2012 to July 2013.

Results: A total of 104 musculoskeletal injuries were reported (3.82 injuries/1000 athlete-exposures), 99% of which occurred during training. The most commonly injured regions were the lower back (22.1%), shoulder (21.1%), and wrist (17.3%). The majority of injuries were due to overuse (56.3%), and incomplete muscle-tendon strain was the most prevalent type of injury (50.5%). The time loss from injuries varied. In addition, a significant majority of the dragon boating athletes incurred nonmusculoskeletal injuries, with abrasions (90.5%), blisters (78.9%), and sunburns (72.6%) being the most common.

Conclusion: Competitive dragon boating has a moderately high injury incidence, and there seems to be a direct relationship between exposure time and injury rate. A majority of the injuries are overuse in nature, and the body parts most actively involved in paddling movement are at higher risk of injuries. The high incidence of nonmusculoskeletal injuries in dragon boaters suggested that these injuries are likely outcomes of participation in the sport.

Keywords: competitive dragon boating; injuries; musculoskeletal; nonmusculoskeletal; epidemiology

Dragon boat racing is a modern sport with rich history and traditions that can be traced back to over 2000 years ago in ancient China.[19] Since the establishment of the International Dragon Boat Federation (IDBF) in 1991 as the sport's governing body, dragon boating has evolved into a high-performance and competitive international sport. Currently, dragon boat racing is among the fastest growing team water sports, with 74 member countries and world championships being organized since 1995. The sport has also been increasingly adopted as a team-building activity, as it is known to foster teamwork among participants.

As a team sport, dragon boat racing requires precise coordination of paddlers, a drummer, and a helmsman to propel the boat (Figure 1). The standard racing crew for a standard-size boat and small boat comprises 18 to 20 paddlers and 8 to 10 paddlers, respectively.

During tournaments in Singapore, races are held over 2 days to accommodate the large number of events and participants. Varsity-level events are recognized to be the highest level of competitive dragon boating locally. Among the approximately 8 nationwide championships held annually, the Singapore Dragon Boat Festival is the largest. Dragon boat races have at least 2 boats competing against each other over distances from 200 to more than 2000 meters.

Besides coordination, good anaerobic capacity and aerobic endurance, power, flexibility, and technical competency are key requisites for dragon boating. The paddling technique involves repetitive trunk flexion and rotation, followed by extension and derotation, as well as overhead arm abduction followed by flexion and extension.[22] The stroke being 1-sided overloads specific anatomical parts of a dragon boater. Constant repetitive paddling motions during training and competitions makes the bodily structures especially vulnerable to overuse injuries.[21] In addition, off-water training for dragon boat racing involves similar repetitive activities, such as resistance training, running, stair climbing, and ergometer rowing. These activities further add to the risk of overuse injuries in dragon boaters.

Injuries in sport can have debilitating consequences to both the individual and the team, including loss of participation and work time, reduced performance, the risk

*Address correspondence to Swarup Mukherjee, MD, PhD, Nanyang Technological University, 1 Nanyang Walk, Singapore 637616 (e-mail: swarup.mukherjee@nie.edu.sg).

† Nanyang Technological University, Singapore, Singapore.

The authors declared that they have no conflicts of interest in the authorship and publication of this contribution.

The Orthopaedic Journal of Sports Medicine, 2(11), 2325967114554550
DOI: 10.1177/2325967114554550

Figure 1. A competitive dragon boating event.

of recurrence and aggravation, and the resultant reduced quality of life. This emphasizes the significance of relevant epidemiological data to gain insights on the nature, type, and body part distribution of injuries for the development of effective injury prevention strategies. However, despite the fast-rising popularity of the sport, there is a lack of studies on dragon boating injuries. Therefore, the purpose of this study was to investigate the epidemiology of injuries in competitive dragon boaters in Singapore. Gaining insights on the injury characteristics will allow the identification of potentially modifiable risk factors and aid in the development of effective injury prevention programs in the sport.

METHODS

A retrospective study design was used to collect the injury records of dragon boaters from the 4 local universities in Singapore. Written informed consent was sought from all the participants for the study.

Participants

A total of 95 athletes (49 males, 46 females) took part in the study. The mean ages of the male and female athletes were 23.3 ± 0.2 years and 21.5 ± 0.2 years, respectively. All participants were varsity-level athletes who represented their respective universities in National Dragon Boating championships. The period of study was from August 2012 to July 2013. On average, each athlete took part in 5 competitions throughout the season. In addition, many athletes were also a part of the national team, representing the country in regional and international events. The average duration of sport participation was 3.1 ± 0.2 years.

Questionnaire

The injury data related to dragon boating competition and training-related activities during the 2012-2013 season were collected using a self-report questionnaire developed by the research team, which was administered within 1 month of the completion of the competitive season. The questionnaire was partially adapted from the National Collegiate Athletic Association (NCAA) Injury Surveillance System.[6] It included information on the athlete's sex, age, anthropometry, role(s) in the boat, and training and competition volume. Owing to the study being retrospective in nature, the injury registration questionnaire was constructed with the approach to minimize recall bias. A clear and specific injury definition was provided so that the participants could recall events and injuries through specific prompts.[10] For the purpose of this study, an injury was defined as one that (1) occurred as a result of participation in organized dragon boating training or competition; (2) resulted in functional or performance limitations, that is, unable to maintain usual training load; and (3) irrespective of medical attention or time loss. In addition, the length of time was limited to only the past season (12 months), thus limiting the period of recall and hence minimizing recall bias.[12]

The injury registration questionnaire had clearly stated criteria for new/acute, recurrent, aggravation, and overuse injuries. An acute injury was defined as an outcome of trauma resulting from a specific and identifiable event and had a sudden onset[18] while an overuse injury was defined as a gradual-onset injury without a specific and identifiable traumatic event attributable to the occurrence.[3] Moreover, the injury registration form also required the participants to provide a short description of the injury, its occurrence, and progress, thus providing a clearer picture of the nature of the injury. Regarding the anatomical location of injury,

the registration form provided a clear and specific indication of body part and the type of injury to minimize the recall-related challenge. Moreover, research team members were present during all injury registration sessions and helped the athletes clarify questions and doubts related to nature of onset and the type of injury as well as making sure that non–dragon boating–related injuries were excluded.

In addition to the musculoskeletal injuries, the questionnaire also had a section on specific nonmusculoskeletal injuries commonly sustained by dragon boaters. These included heat illnesses, sunburn, abrasion, blisters, and splinters. The majority of athletes maintained a personal diary and recorded training-related information on a daily basis. This was not unusual, as dragon boaters spend a significant majority (98%) of their time in training and maintaining a record of their progress. In addition, the team captains maintained a weekly log of events. These records were used as reference during the injury registration sessions, further increasing the accuracy of injury recall and minimizing recall bias.

The reliability of the questionnaire was assessed in 25 competitive dragon boaters who completed the injury registration form twice within a 1-week interval with reference to recent injuries (within the past 2 months). The average kappa coefficient was 0.778 ± 0.106 ($P < .05$), suggesting a high degree of reliability.

The validity of the injury registration system was determined by comparing the responses of the 25 athletes with the sports physician's report. The information related to the location of injury (Cramer $V = 0.902$, $P < .05$) and the type of injury (Cramer $V = 0.864$, $P < .05$) were found to be of high validity.

Total athlete-exposure (AE) was calculated as the sum of all training sessions and competitions during the season. In addition, total training hours were calculated as the sum of all water training, off-water strength training, and off-water aerobic training hours during the season.

RESULTS

The overall exposure time was 27,223 sessions. A total of 104 musculoskeletal injuries were reported. At least 74 (71%) injuries that occurred during the season were medically diagnosed and recorded in the athletes' training logs. The overall injury incidence rate was 3.82 injuries/1000 AEs (Table 1).

The total training amounted to 53,089 hours, and there were 1.94 injuries/1000 training hours (Table 2). Female dragon boaters had a higher injury rate than males both in terms of AE and number of training hours.

An interesting finding was that of the 104 injuries recorded, 103 (99%) were sustained during training, and only 1 injury (1%) was sustained during competition (Table 3).

The most commonly injured body part was the lower back (22.1%), followed by the shoulder (21.1%). The most common injury was a muscle-tendon strain, which accounted for 50.5% of all injuries sustained during training. The only injury that was sustained during competition was also a muscle-tendon strain of the shoulder.

TABLE 1
Number of Injuries, Exposure Time, and Injury Incidence Rate per 1000 Athlete-Exposures

	Number of Injuries	Exposure Time (No. of Sessions)	Injury Rate per 1000 Athlete-Exposures
Female (n = 46)	61	14,434	4.23
Male (n = 49)	43	12,789	3.36
Total (n = 95)	104	27,223	3.82

TABLE 2
Number of Injuries, Training Hours, and Injury Incidence Rate per 1000 Training Hours

	Number of Injuries	Training Hours	Injury Rate per 1000 Training Hours
Female (n = 46)	60	28,001	2.14
Male (n = 49)	43	25,088	1.71
Total (n = 95)	103	53,089	1.94

Female dragon boaters sustained the majority of musculoskeletal injuries (28.2%) during water training, while most injuries (21.3%) in male athletes were reported during off-water strength training (Figure 2). Results also showed that injuries sustained during off-water aerobic training were almost 4 times higher in female than male dragon boaters.

Most (58.1%) injuries in male dragon boaters were due to overuse, while 41.9% were acute injuries. Remarkably, 63.5% of injuries with a medical diagnosis were overuse in nature. The lower back was the most vulnerable body part (25.6%) with respect to overuse injuries, followed by the shoulder (9.3%). The upper extremity seemed more prone to acute trauma in male athletes, with the wrist (14%) and the shoulder (11.6%) accounting for the majority of the acute injuries. The most common injuries sustained by males occurred during water training, off-water strength training, and off-water aerobic training were to the lower back (52.9%, mostly overuse), wrist (40.9%, mostly acute), and knee (50.0%, all overuse), respectively. Overall, the lower back was the most commonly injured body part in male dragon boaters.

In female dragon boaters, 55.0% of all injuries were due to overuse, while 45.0% were acute injuries. The pattern of injury in female dragon boaters was similar to that observed in males, with the lower back accounting for most (11.7%) of the overuse injuries followed by injuries to the shoulder (10.0%) and wrist (6.7%). The most common acute injury in female dragon boaters was also of the shoulder (11.7%) and wrist (8.3%). Additionally, acute injuries to the ankle and Achilles tendon were also common in female dragon boaters, contributing to 8.3% of the total injuries. The most common injuries sustained by female athletes during water training, off-water strength training, and off-water aerobic trainings were to the shoulder (27.6%, acute and overuse), wrist (40%, acute and overuse), and ankle (43.8%, mostly acute),

TABLE 3
Distribution of Training and Competition Injuries by Body Part and Injury Type

Body Part	Type of Injury	Frequency	Percentage of All Injuries	Injury Rate per 1000 Training Hours
Training				
Neck	Muscle-tendon strain (incomplete)	2	1.9	0.038
Shoulder		22	21.1	0.420
	Muscle-tendon strain (incomplete)	16	15.3	
	Dislocation (partial)	2	1.9	
	Tendonitis	2	1.9	
	Ligament sprain (incomplete)	1	1.0	
	Stress fracture	1	1.0	
Upper arm		6	5.8	0.110
	Muscle-tendon strain (incomplete)	5	4.8	
	Nerve injury	1	1.0	
Ribs/sternum		2	1.9[a]	0.038
	Muscle-tendon strain (incomplete)	1	1.0	
	Stress fracture	1	1.0	
Upper back	Muscle-tendon strain (incomplete)	1	1.0	0.019
Lower back		23	22.1	0.430
	Muscle-tendon strain (incomplete)	16	15.3	
	Nerve injury	3	2.9	
	Ligament sprain (incomplete)	1	1.0	
	Contusion	1	1.0	
	Spinal disc herniation	2	1.9	
Pelvis/hip/groin		3	2.9	0.057
	Muscle-tendon strain (incomplete)	2	1.9	
	Ligament sprain (incomplete)	1	1.0	
Knee		7	6.7[a]	0.130
	Torn cartilage	1	1.0	
	Ligament sprain (complete)	1	1.0	
	Ligament sprain (incomplete)	1	1.0	
	Tendonitis	3	2.9	
	Muscle-tendon strain (incomplete)	1	1.0	
Shin		2	1.9[a]	0.038
	Stress fracture	1	1.0	
	Periostitis	1	1.0	
Ankle/Achilles tendon		8	7.7	0.150
	Muscle-tendon strain (incomplete)	1	1.0	
	Ligament sprain (incomplete)	5	4.8	
	Tendonitis	2	1.9	
Foot		3	2.9	0.057
	Muscle-tendon strain (incomplete)	1	1.0	
	Contusion	2	1.9	
Elbow		2	1.9[a]	0.038
	Muscle-tendon strain (incomplete)	1	1.0	
	Tendonitis	1	1.0	
Forearm	Nerve injury	1	1.0	0.019
Wrist		18	17.3	0.340
	Muscle-tendon strain (incomplete)	5	4.8	
	Ligament sprain (incomplete)	9	8.7	
	Tendonitis	4	3.8	
Hand		3	2.9	0.057
	Ligament sprain (incomplete)	1	1.0	
	Tendonitis	2	1.9	
Total		103	99.0	1.940
Competition				
Shoulder	Muscle-tendon strain (incomplete)	1	1.0	Not applicable
Total		104	100.0	Not applicable

[a]Values differ by 0.1 due to rounding.

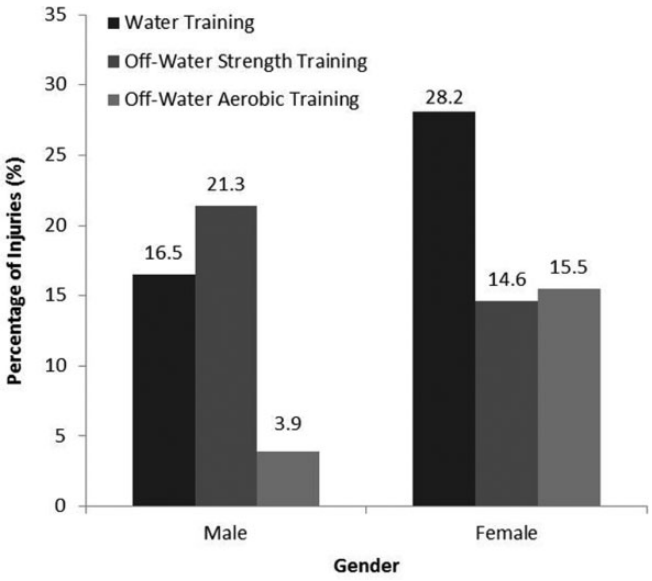

Figure 2. Distribution (percentages) of injuries by sex for water training, off-water strength training, and off-water aerobic training.

respectively. Overall, the shoulder was the most commonly injured body part in female dragon boaters.

At least 74 injuries required some degree of medical attention, with 10 injuries requiring referral to a specialist and 7 injuries requiring confirmatory magnetic resonance imaging. About 64% of injuries requiring medical attention were overuse in nature.

The majority of the injuries in competitive dragon boaters led to some degree of time loss; 58.7% of acute injuries and 63.8% of overuse injuries resulted in time loss to varying extent (Table 4). Generally, injuries in female dragon boaters were less severe than their male counterparts.

An interesting finding of this study was that there were a greater number of nonmusculoskeletal injuries compared with musculoskeletal injuries (Table 5): 90.5% of dragon boaters were affected by abrasion, with the buttocks being the most common site, and blisters affected 78.9% of dragon boaters, with hand blisters being the most prevalent.

DISCUSSION

The most noteworthy findings of the study were that training rather than competitions accounted for all but 1 of the injuries, and that in addition to the musculoskeletal injuries, the dragon boating athletes also have a high incidence of nonmusculoskeletal injuries.

Dragon boating is a fast-emerging competitive sport gaining global popularity. The present study on Singaporean varsity-level competitive dragon boaters found the injury incidence of 3.82 injuries per 1000 AEs during the season. This was higher compared with the incidence rate of 3.48 musculoskeletal injuries reported in elite dragon boaters.[22] This might be due to 2 reasons: First, a problem with retrospective studies is that the athletes tend to predominantly recall only major injuries, leading to underreporting of injuries.[14] Our injury definition included injuries leading to functional or performance limitations irrespective of medical attention or time loss, thus maximizing the chance of recalling both minor and major injuries during the season. Second, elite dragon boaters have superior technique, which may have allowed for better movement coordination and synchronization, thus reducing the extent of overload on specific body parts.[11] In addition, it can be reasonably assumed that being elite athletes there may be more resources available to them in terms of scientific support, better facilities, supervised training programs, and medical care that may have prevented as well as minimized the aggravation of minor injuries.

Despite the high intensity of dragon boat races and the participants having taken part in at least 5 competitions during the season, only 1 of 104 injuries recorded was sustained during competition. This could be due to the direct relationship between exposure time and injury rate,[5] as the dragon boaters spent a significantly larger proportion of time training than competing. On average, each paddler accumulated about 559 hours of training.

Male dragon boaters had a lower injury rate (1.71 vs 2.14 injuries/1000 training hours) than female athletes. Analysis of the training programs throughout the season revealed that male dragon boaters engaged in more strength training than their female counterparts. Dragon boaters tend to have a dominant side in the sport, and the constant 1-sided paddling during water trainings may cause muscle imbalance due to the asymmetrical loading.[2] Moreover, a study of biomechanical parameters of female dragon boaters reported that most paddlers suffered from postural deviations and uneven shoulders.[16] Therefore, dragon boating may cause muscle imbalance, increasing the risk of injuries.[4] However, strength training has been shown to reduce the risk of musculoskeletal injuries through the strengthening of bones, muscles, and connective tissues.[9] By engaging in more strength training, male dragon boaters may have gained greater immunity against injuries through the physiological and musculoskeletal adaptations and correction of muscle imbalances.

Similar to that reported by other studies,[5,13,22] the lower back and shoulder were the most commonly injured in dragon boaters. To achieve high boat speeds, a paddler must engage the upper body to hit the blade of the paddle into the water and pull it back swiftly.[11,22] Competitive dragon boaters typically paddle at a high intensity of 80 to 90 strokes per minute, requiring a great degree of trunk flexion, extension, and rotation. Such rapid repetitive movements of the lower back coupled with the explosive force required to generate an effective stroke puts the lower back under tremendous stress, making it vulnerable to injury.

In dragon boating especially, the action of the inside arm consists predominantly of overhead movements, which is characterized by the lift of the arm during the recovery phase and then a forceful downward pressing movement during the pulling phase against the resistance of water. This exerts a greater concentric force on the agonists in the

TABLE 4
Acute and Overuse Injuries by Sex and Severity[a]

	Time Lost to Acute Injuries					Time Lost to Overuse Injuries				
	No Time Lost	Mild	Moderate	Severe	Total	No Time Lost	Mild	Moderate	Severe	Total
Male	6 (13.0)	2 (4.4)	4 (8.7)	6 (13.0)	18 (39.1)	7 (12.1)	7 (12.1)	2 (3.5)	9 (15.5)	25 (43.1)
Female	13 (28.3)	7 (15.2)	3 (6.5)	5 (10.9)	28 (60.9)	14 (24.1)	12 (20.7)	1 (1.7)	6 (10.3)	33 (56.9)
Total	19 (41.3)	9 (19.6)	7 (15.2)	11 (23.9)	46 (100)	21 (36.2)	19 (32.8)	3 (5.2)	15 (25.8)	58 (100.0)

[a]Values are reported as n (%). Injury severity was defined as *no time lost* if an athlete lost no time, *mild* = 1-6 days lost, *moderate* = 7 to 9 days lost, and *severe* = 10 or more days lost.[6]

TABLE 5
Distribution of Nonmusculoskeletal Injuries in Competitive Dragon Boaters[a]

	Athletes Affected			Distribution of Injuries Based on Body Part, n (%)[b]						
Type of Injury	Male, n	Female, n	Total, n (%)	Hand	Shoulder	Axilla	Waist/Hip	Buttocks	Feet	Other
Heat Illness	1	5	6 (6.3)	NA	NA	NA	NA	NA	NA	NA
Sunburn	31	38	69 (72.6)	NA	NA	NA	NA	NA	NA	NA
Abrasions	43	43	86 (90.5)	6 (6.3)	15 (15.8)	13 (13.7)	13 (13.7)	60 (63.2)	6 (6.3)	21 (22.0)
Blisters	38	37	75 (78.9)	63 (66.3)	0	0	1 (1.1)	11 (11.6)	16 (16.8)	0
Splinters	12	19	31 (32.6)	31 (32.6)	0	0	0	0	0	0
Total	125	142	267 (NA)	NA	NA	NA	NA	NA	NA	NA

[a]NA, not applicable.
[b]Each athlete reported injury of more than 1 body part.

shoulder of the inside arm as compared with the eccentric force of the antagonists, and a strength imbalance between them can increase the risk of injury. Thus, multiple factors such as poor technique, lack of strength, strength imbalance, and forceful repetitive movements can increase the vulnerability of the shoulder to both acute and overuse injuries in dragon boating. This also implies that improvements in technique and strength could potentially reduce the incidence and severity of injuries in the sport.

The highest injury incidence in female athletes was reported during water training sessions. As previously mentioned, repetitive 1-sided paddling movements can lead to muscle imbalance in dragon boaters. This risk factor may have been further compounded by a lesser degree of strength training by the female athletes. Moreover, the boats used and the number of paddlers are standardized across sexes. This implies that female dragon boaters, with lesser strength and power due to their smaller musculature and inadequate strength training, required greater effort against the same resistance during trainings across the same distance, making them more susceptible to injuries during water training. These results suggest that musculoskeletal injuries in female dragon boaters are largely preventable by inclusion of structured and progressive strength training programs during the season.

Contrary to that in female dragon boaters, off-water strength training contributed to the majority of musculoskeletal injuries (21.3%) in male athletes. It was a perplexing finding, as the male athletes seemed to have lesser injuries attributable to greater engagement in strength training. Analysis of their training program revealed that the off-water strength training regimen predominantly consisted of high resistance and low repetitions at a rapid rate during the general and maximal strength phases of the periodization program. Such repetitive movements of explosive nature are likely to increase the risk of overload injuries during off-water strength training. Moreover, male athletes did not have much expert or scientific support and maintained personal training logs to monitor the training program. Therefore, better structured, periodized, and progressive strength training with adequate recovery[8] and some expert supervision might lead to prevention of injuries and enhanced performance in these athletes.

An interesting finding of this study was that while there were no lower limb injuries during off-water strength training, all musculoskeletal injuries sustained during off-water endurance training were to the lower extremities. This suggests that the strength training programs of dragon boaters focused mainly on the upper body, with minimal emphasis on lower body strength. Furthermore, off-water aerobic training programs typically comprised repetitive activities, such as running and stair climbing, which predominantly activate the lower limbs. Therefore, the lack of strength training and conditioning of the lower body may have contributed to the vulnerability to injury.

The number of lower extremity injuries sustained during off-water aerobic training by female dragon boaters was 4 times that of their male counterparts. This can be partly explained by greater off-water training exposure in female dragon boaters (5977 sessions vs 4630 sessions in males

through the season). Moreover, biomechanical characteristics unique to the female body, such as wider pelvis, greater quadriceps angle, and increased foot pronation, can also be attributed to the risk of lower extremity injuries in female athletes.[17]

We found that the majority of injuries in competitive dragon boating were overuse in nature, accounting for 56.3% of injuries. This finding is consistent with a previous study[21] reporting that low-contact sports that involve long training sessions or repetitive movements typically lead to more chronic overuse injuries than traumatic injuries. Unlike acute injuries, which result from a specific identifiable macrotraumatic event, overuse injuries are an outcome of repetitive microtrauma. Moreover, an overuse injury occurs when inadequate time is available for the injured body part to heal completely.[19] This likelihood was high in our participants, as they were required to undergo intensive training year-round with dragon boat competitive events being organized throughout the year. Moreover, the onset of overuse injuries is gradual, with no specifically identifiable event, and symptoms can vary based on the frequency and intensity of activity or may even be asymptomatic.[1,3] It is noteworthy that approximately 64% of injuries with medical diagnosis were overuse in nature. This was suggestive that the athletes had endured a period of pain, functional limitation, and training adaptation before the injury worsened to a stage where medical attention was sought to prevent significant time loss from training.[3]

The results also found that medical advice was not sought for 30 (26%) injuries, of which 17 were overuse in nature. While access to medical support was not difficult, it is likely that these athletes chose to rest and/or adapted their training and techniques and/or trained and competed through pain and discomfort. This may have been due to financial constraints and/or time constraints due to academic commitments or eagerness to participate in competitions. Generally, dragon boating races last from 2 to 8 minutes, with an average of 1 competitive event each month. This provides the athletes adequate time and opportunity to rest and recover and hence the athletes choosing to rest/adapt training rather than getting medically examined and treated was not surprising.

The majority (61.5%) of the injuries in competitive dragon boaters led to some degree of time loss. Of all injuries reported, 25 injuries (24%) categorized as severe prevented dragon boaters from training for at least 10 days. It is also noteworthy that overuse injuries led to more time loss than acute traumatic injuries, thus suggesting that the severity of injuries was related to functional limitations affecting training and paddling performance. A previous study on elite dragon boaters[22] reported that 87.0% of injuries were time loss injuries, and a quarter of those were injuries that disrupted training for 10 or more days. Collectively, the high incidence of time loss injuries in the present and cited study suggests a possible lack of knowledge and awareness among athletes and coaches about identifying the early symptoms and signs of overuse and continuing to load the injured part. This implies that the severity, especially related to the overuse injuries in the sport, can be minimized through athlete education.

One of the key findings of the study was the higher incidence of nonmusculoskeletal injuries in competitive dragon boating athletes. These injuries, seemingly minor, affected the majority (90%) of athletes. These injuries are not related to loading of the anatomical parts but are an outcome of the environment and conditions related to participation in dragon boating. Previous studies[20,22] have also reported that these injuries were of high likelihood in dragon boating but could be substantially avoided with simple preventive measures.

Analysis of the data revealed that the incidence of nonmusculoskeletal injuries were quite comparable between male and female (125 vs 142) dragon boaters. This strongly suggests that such injuries are outcomes of participation in the sport rather than being predisposed by any intrinsic or extrinsic risk factors related to poor strength, improper techniques, or training errors. While previous studies[22] have reported these injuries together with the musculoskeletal injuries, both injury categories have different etiology in terms of risk factors and mechanisms. Moreover, the preventive approaches for the nonmusculoskeletal injuries are also different from that of musculoskeletal injuries. Therefore, epidemiological studies presenting both these injury categories collectively would inflate the data, resulting in an overestimation of the incidence of injuries and making dragon boating seem a higher risk sport. Reporting of the 2 categories of injuries separately would facilitate the development of specific recommendations and prevention strategies to target nonmusculoskeletal injuries.

Abrasion was the most common nonmusculoskeletal injury (90.5%), with the buttocks being the most common site of abrasion. This is attributable to the nature of the sport, which involves vigorous body movements while being seated causing friction between the skin over the buttocks against the seat. Furthermore, there are often little opportunities for paddlers to change their sitting positions while paddling. Use of cushioned seat pads or padded paddling tights during water training can minimize friction and the risk of developing abrasions on the buttocks. Alternatively, a lubricant can be used to reduce friction between the skin and the contact surface. Maintaining good skin hygiene, wound asepsis, and waterproofing might be additional strategies to minimize the risk of wound infection.

The second most common nonmusculoskeletal injury was blisters (79%), especially on the palmar surface of the hand. Dragon boaters are prone to blisters from friction due to the rubbing of hands against the shaft and handle portion of a paddle during water trainings, as well as against the weight bars during off-water strength training. In addition, blisters form more easily on moist skin and are aggravated by hot and humid conditions in Singapore.[20] While hand blisters can cause significant pain and discomfort during paddling, it can be largely prevented with the use of protective gloves when performing repetitive movements.

The present study also found that dragon boaters were commonly affected by sunburn due to overexposure to ultraviolet (UV) radiation. With one of the highest UV

indexes in the world, participating in outdoor activities in Singapore puts participants at a high risk of sunburn injuries.[15] Dragon boaters, who can spend up to 150 minutes under the sun during a single water training session, are often exposed to high levels of UV radiation. Sunburn is a painful condition that can be effectively prevented with the use of sunscreen lotions with high sunburn protection factor. It has been shown that the best protection is achieved by applying sunscreen 15 to 30 minutes before sun exposure, followed by frequent reapplications after being exposed to the sun.[7] In addition, outdoor training should be avoided during the times of high radiation index, such as late mornings and afternoons.

While this study provides a comprehensive account of sports injuries in competitive dragon boaters, there were a few limitations. First, being a retrospective epidemiological study increases the chance of recall bias. The second limitation was that it involved self-report of the type of injury by the athletes. While prospective studies have a greater acceptance regarding the validity of injury epidemiology data, a retrospective approach was adopted in this study due to feasibility, time, and resource efficiency and issues related to athlete availability. However, several measures were taken to minimize the extent of recall bias. A clear and specific injury definition was provided for the athletes to recall the events through specific prompts. Moreover, the injuries were documented within 1 month from the end of season, and the length of time for recall was limited to only the past 12 months. In addition, the personal training diaries of the athletes and weekly logs maintained by the team captains were used as references during the injury registration exercise. The injury registration form had clear and specific indication of body part and the type of injury, thus reducing the recall-related challenge. We also provided the criteria for new/acute, recurrent, aggravation, and overuse injuries in the injury registration form. Furthermore, the injury registration form required participants to provide a short description of the injury, its occurrence, and progress, thus providing a clearer picture of the injury. Clear prompts regarding medical attention and time loss were also provided in the questionnaire, making it easier for the athletes to categorize their severity of their injuries. At least 71% of the injuries were medically diagnosed with athletes having a record in their personal logs. In addition to the above, the research team members were present during all injury registration sessions and helped the athletes clarify questions and doubts related to the nature of onset and the type of injury as well as making sure that non–dragon boating–related injuries were excluded. Therefore, while we acknowledge that some recall bias would have been inevitable, we believe that its extent was minimized due to the methodological approaches in our study.

CONCLUSION

Competitive dragon boating is a rapidly growing sport with both male and female athletes participating at various levels of performance. The key findings of this study were that the majority of the musculoskeletal injuries were training-related and the incidence of nonmusculoskeletal injuries is high. Although the overall injury incidence of musculoskeletal injuries in the sport was not alarmingly high, the majority of injuries were overuse in nature requiring medical attention and also led to some degree of time loss. The findings of our study help to identify modifiable risk factors that can be addressed to reduce the incidence and severity of injuries in dragon boating. Nonmusculoskeletal injuries such as abrasions, blisters, and sunburn are almost inevitable outcomes in dragon boating. Although these injuries are superficial and do not stop dragon boaters from participating in trainings or competitions, they may cause discomfort and functional limitations in paddling and affect performance. Use of protective wear and athlete education may be effective approaches to prevent the occurrence of nonmusculoskeletal injuries among dragon boating athletes.

ACKNOWLEDGMENT

The authors thank the Varsity Dragon Boating athletes for their commitment and dedicated participation in this study.

REFERENCES

1. Bahr R. No injuries, but plenty of pain? On the methodology for recording overuse symptoms in sports. *Br J Sports Med*. 2009;43:966-972.
2. Birdwell K, Lawrence GL. Determine the optimal time dependent sagittal spinal balance following adult lumbar deformity instrumentation and fusion from the distal thoracic spine to L5-S1. *J Sports Sci*. 2005;35:275-325.
3. Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology. *Br J Sports Med*. 2013;47:495-502.
4. Croisier J-L, Ganteaume S, Binet J, Genty M, Ferret JM. Strength imbalance and prevention of hamstring injury in professional soccer players. *Am J Sports Med*. 2008;36:1460-1475.
5. DeGraauw C, Chinery L, Gringmuth R. Dragon boat athlete injuries and profiles. *Med Sci Sports Exerc*. 1999;31:259.
6. Dick R, Agel J, Marshall SW. National College Athletic Association Injury Surveillance System commentaries: introduction and methods. *J Athl Train*. 2007;42:173-182.
7. Diffey BL. When should sunscreen be reapplied? *J Am Acad Dermatol*. 2001;45:882-885.
8. DiFiori JP. Overuse injuries in children and adolescents. *Phys Sportsmed*. 1999;27:75-90.
9. Fleck SJ, Falkel JE. Value of resistance training for reduction of sports injuries. *Sports Med*. 1986;3:61-68.
10. Gabbe BJ, Finch CF, Benell KL, Wajswelner H. How valid is a self-reported 12 month sports injury history? *Br J Sports Med*. 2003;37:545-547.
11. Ho SR, Smith R, O'Meara D. Biomechanical analysis of dragon boat paddling: a comparison of elite and sub-elite paddlers. *J Sports Sci*. 2009;27:37-47.
12. Jenkins P, Earle-Richardson G, Slingerland DT, May J. Time dependent memory decay. *Am J Ind Med*. 2002;41:98-101.
13. Kent H. Dragonboating: injuries and prevention. *Sports Aider*. 2002;18(2):13-14.
14. Kolt GS, Kirkby RJ. Epidemiology of injuries in elite and subelite female gymnasts: a comparison of retrospective and prospective findings. *Br J Sports Med*. 1999;33:312-318.
15. Nyiri P. Sun protection in Singapore's schools. *Singapore Med J*. 2005;46:471-475.

16. Pourbehzadi M, Sadeghi H, Alinejad HA, Rad LS. The relationship between posture and somatotype and certain biomechanical parameters of Iran women's national dragon boat team. *Ann Biol Res*. 2012;3:3657-3662.
17. Prather H, Hunt D. Issues unique to the female runner. *Phys Med Rehabil Clin N Am*. 2005;16:691-709.
18. Smoljanovic T, Bojanic I, Hannafin JA, Hren D, Delimar D, Pecina M. Traumatic and overuse injuries among international elite junior rowers. *Am J Sports Med*. 2009;37:1193-1199.
19. Sofield T, Sivan A. From cultural festival to international sport—The Hong Kong dragon boat races. *J Sport Tour*. 2003;1(3):9-20.
20. Walker DJ. Dragon boat injuries. *Br J Sports Med*. 1985;19:239.
21. Yang J, Tibbetts AS, Covassin T, Cheng G, Nayar S, Heiden E. Epidemiology of overuse and acute injuries among competitive collegiate athletes. *J Athl Train*. 2012;47:198-204.
22. Zandi S, Rajabi R, Tavanaei AR. Are gender, position in boat and training load associated with the injuries in elite dragon boat paddlers? *World J Sport Sci*. 2010;3:113-118.