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Traumatic and Overuse Injuries Among International Elite Junior Rowers

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ABSTRACT

Background: Junior rowers have competed internationally for over 4 decades, and there are no epidemiological data available on traumatic and overuse injury in this population.

Objective: To define the types of musculoskeletal problems present in international elite-level junior rowers and to determine whether gender, physical stature, rowing discipline, and training programs affect the incidence of reported injuries.

Study Design: Descriptive epidemiology study.

Methods: Injury data were obtained from a total of 398 rowers (42% female, 58% male) who completed a 4-page questionnaire on injury incidence while participating at the Junior World Rowing Championships in Beijing, People's Republic of China, in August 2007.

Results: Overall, 290 (73.8%) reported injuries involved overuse, and 103 (26.2%) were related to a single traumatic event. Female rowers were injured more frequently than male rowers (110.2 vs 90.5 injuries per 100 rowers). In both genders, the most common injury site was the low back followed by the knee and the forearm/wrist. The severity of reported injuries was incidental in 65.1%, minor in 21.4%, moderate in 10.4%, and major in 3.1% of cases. The rowers with traumatic injuries had less rowing experience than the uninjured rowers (median [C] ± interquartile range [Q] = 3 ± 3 years vs 4 ± 3 years; P = .043, Mann-Whitney test). Sweep rowers who changed rowing side during the current season had significantly more acute-onset low back injuries (P = .012, χ^2 test) than those who did not change rowing side during the same period. The incidence of traumatic injuries was significantly lower in rowers who regularly performed more than 10 minutes of posttraining stretching (P = .030, χ^2 test). Athletes who ran more than once a week had more overuse knee injuries than those who ran once or less per week (P = .033, χ^2 test).

Conclusion: Elite junior rowers attending the World Rowing Championships reported predominantly overuse injuries of low severity during the current rowing season. Low back injuries were the most frequent complaint of elite-level junior rowers.

Keywords: rowing; juniors; injury; epidemiology; sport

The first official regatta for male junior rowers, organized under the governance of the International Federation of Rowing Associations (Fédération Internationale des Sociétés d'Aviron [FISA]), was held in 1967.[8] The number of rowers and nations participating at the Junior World Rowing Championships has continuously increased since that time. These young rowers under the age of 19 years use the same rowing equipment, compete at the same race distance, and train with similar frequency and duration as elite senior rowers. The risk of injury among rowers has been shown to be relatively low,[3, 6, 9, 11, 16, 20, 27] but there are studies that report an increasing incidence of rowing-specific injuries among senior rowers, such as low back pain[12, 22, 23] and rib stress fractures.[4, 10, 26]

The purpose of this study was to perform an epidemiological study describing the variety of musculoskeletal problems in international elite-level junior rowers. The second goal was to examine the association of rowing performance, rowing achievement, training practices, and gender with the occurrence of reported injuries.

MATERIALS AND METHODS

Study Design

This was a retrospective survey based on completion of a novel rowing-specific questionnaire and interviews with rowers at the Junior World Rowing Championships held in Beijing, People's Republic of China, in August 2007. The 4-page questionnaires were distributed by the first author to team managers in attendance at a required regatta meeting before the start of the Junior

World Rowing Championships. The goals and methods of the research were explained to the team managers, who were asked to distribute the questionnaires to their national team rowers. The rowers were informed that participation was voluntary and assured that information provided could not be traced back to the individual or team. Rowers were informed about the place where they could ask any further questions regarding the research and where they could hand in the questionnaires. When they returned the completed questionnaire, the rowers were asked more specific questions about injuries sustained during the current rowing season (September 1, 2006 to August 2007). To facilitate participation in the research study, the questionnaire was available in 21 different languages (Bulgarian, Chinese, Croatian, Czech, Dutch, English, Estonian, Finnish, French, German, Greek, Hebrew, Italian, Japanese, Norwegian, Portuguese, Russian, Serbian, Spanish, Swedish, and Turkish). Additional communication with rowers who did not speak English was accomplished by their team managers, team physicians, or translators (students of Beijing Normal University preparing as volunteers for the Olympic Games in Beijing 2008).

The questionnaire consisted of 3 parts. The general information section characterized the participants by country, age, height, weight, gender, age at the onset of training and competitive rowing, and previous rowing achievements. The rowing section described the boat type, rowing discipline (sweep vs sculling), and training practice during the current rowing season. Data were gathered concerning the number of training sessions, amount of training time in the boat, training on the rowing ergometer, the kind of oar and ergometer, other sport activities used for cross-training, and the amount of time for warm-up before training and stretching after training. These variables were analyzed in relation to injury type and frequency. The final part of the

questionnaire dealt with traumatic and overuse injuries. Reported incidents were subdivided by anatomical region and differentiated as traumatic or overuse injury.[17] A traumatic injury was defined as any sudden tissue damage (contusion, laceration, fracture, cerebral concussion, sprain, strain, and dislocation) resulting from trauma. An overuse injury was defined as chronic, long-lasting pain usually connected to the sport activity for which the rowers could not report a specific inciting event. All injuries were classified by the loss of training time, if present. Using previously published criteria,[15] "incidental" injury was defined as one that resulted in no time lost from competition or training, "minor" injury as one that interrupted participation for a period of less than 1 week, "moderate" injuries as those necessitating absence for more than 1 week but less than 1 month, and "major" injuries as those causing absences of greater than 1 month. The study was approved by the local ethics committee and the FISA Sports Medicine Commission.

Study Participants

A total of 596 rower competitors and spares from 49 countries present at the FISA Junior World Rowing Championships (Beijing, People's Republic of China, August 8-11, 2007) were invited to take part in the study. Thirty-nine percent were female, and 61% were male. Coxswains were not included in the research. A total of 398 junior rowers, 167 (42%) female and 231 (58%) male, from 45 countries completed and returned their questionnaires and were interviewed (response rate of 67%). Five participants (1.3%) were spares. Interviewed rowers included 55 winners and medalists (39.9%) as well as 145 finalists (52.5%) of the 2007 Junior World Rowing Championships. The median age for study participants was 18 years, with an interquartile range of 1 year for both males and females. The median height was 188 cm (interquartile range [Q] =

6) for men and 177 cm (Q = 6) for women. The median weight for men was 83 kg (Q = 8) and 69 kg (Q = 7) for women.

Statistical Methods

Continuous variables were represented by median and interquartile range (C ± Q, respectively), and categorical variables by absolute and relative frequencies. The Mann-Whitney test was used for comparisons of continuous variables, and the χ^2 test for categorical variables. When appropriate, the Yates continuity correction was applied in calculation of χ^2 tests. Difference between male and female injury rates was calculated using a Fisher exact test and was performed using the OpenEpi module for comparing rates (http://www.openepi.com/Menu/OpenEpiMenu.htm). All other analyses were performed using SPSS 16.0 for Windows (SPSS Inc, Chicago, Illinois). Level of statistical significance was set at $P < .05$ for all analyses..

RESULTS

Injury Incidence

A total of 217 rowers (98 female and 119 male) reported a total of 393 injuries during the 2006 to 2007 rowing season. The annual aggregate injury rate was 0.99 injuries per rower (2.1 injuries per 1000 training sessions per rower). Men reported an injury rate of 0.90 injuries per rower (1.95 injuries per 1000 training sessions per rower), and women reported an injury rate of 1.10

injuries per rower (2.36 injuries per 1000 training sessions per rower). Comparison of the 2 rates revealed no statistically significant difference (P = .467).

Of the injured rowers, 104 suffered 1 injury, 69 suffered 2 injuries, 29 suffered 3 injuries, 10 suffered 4 injuries, and 4 suffered 5 injuries. No rower reported more than 6 injuries in the current rowing season.

Mechanism of Injury

The dominant self-reported injury was overuse, while trauma was reported to be the mechanism of injury in 26.2% of cases (Table 1). Traumatic-onset injuries were significantly more frequent among male junior rowers (P = .023), while overuse injuries were significantly more frequent among female junior rowers (P = .011) (Table 1).

TABLE 1
Mechanism of Injuries

Injuries		Female N (%)	Male N (%)	Total N (%)
Traumatic	On water	14 (7.6)	21 (10.0)	35 (8.9)
	On ergometer	3 (1.6)	4 (1.9)	7 (1.8)
	In the gym	8 (4.3)	15 (7.2)	23 (5.9)
	Cross-training	10 (5.4)	28 (13.4)	38 (9.7)
Overuse		149 (81.0)	141 (67.5)	290 (73.8)
Total		184 (100)	209 (100)	393 (100)
Ratio traumatic vs. overuse injuries		1 : 4.3	1 : 2.1	1 : 2.8

Anatomic Distribution

The most common site of injury in the junior rowers was the low back, followed by knee and forearm/wrist injuries. Low back injury was predominant in both traumatic and overuse injuries. Incidence rates by location can be seen in Table 2.

TABLE 2

Traumatic and Overuse Injuries in International Elite-Level Junior Rowers by Anatomical Region*

	Traumatic injuries N (%)			Overuse injuries N (%)			Total N (%)		
Injured area	Female	Male	Total	Female	Male	Total	Female	Male	Total
Head	2 (5.7)	2 (2.9)	4 (3.9)	0 (0)	0 (0)	0 (0)	2 (1.1)	2 (0.9)	4 (1.0)
Neck/Cervical spine	0 (0)	1 (1.5)	1 (1.0)	2 (1.3)	1 (0.7)	3 (1.0)	2 (1.1)	2 (0.9)	4 (1.0)
Shoulder/Upper arm	2 (5.7)	6 (8.8)	8 (7.8)	13 (8.7)	7 (5.0)	20 (6.9)	15 (8.2)	13 (6.2)	28 (7.1)
Elbow	1 (2.9)	0 (0)	1 (1.0)	2 (1.3)	6 (4.3)	8 (2.8)	3 (1.6)	6 (2.9)	9 (2.3)
Forearm/Wrist	3 (8.6)	6 (8.8)	9 (8.7)	22 (14.8)	14 (9.9)	36 (12.4)	25 (13.6)	20 (9.6)	45 (11.5)
Hand	2 (5.7)	1 (1.5)	3 (2.9)	1 (0.7)	8 (5.7)	9 (3.1)	3 (1.6)	9 (4.3)	12 (3.1)
Chest/Thoracic spine	0 (0)	3 (4.4)	3 (2.9)	12 (8.1)	3 (2.1)	15 (5.2)	12 (6.5)	6 (2.9)	18 (4.6)
Trunk/Abdomen	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Low back	14 (40.0)	23 (33.8)	37 (35.9)	41 (27.5)	49 (34.8)	90 (31.0)	55 (29.9)	72 (34.4)	127 (32.3)
Pelvis/Groin/Buttock/ Hip/Thigh	3 (8.6)	5 (7.3)	8 (7.8)	13 (8.7)	12 (8.5)	25 (8.6)	16 (8.7)	17 (8.1)	33 (8.4)
Knee	0 (0)	5 (7.3)	5 (4.8)	33 (22.1)	36 (25.5)	69 (23.8)	33 (17.9)	41 (19.6)	74 (18.8)
Lower leg	2 (5.7)	3 (4.4)	5 (4.8)	7 (4.7)	3 (2.1)	10 (3.4)	9 (4.9)	6 (2.9)	15 (3.8)
Ankle	6 (17.1)	10 (14.8)	16 (15.5)	2 (1.3)	0 (0)	2 (0.7)	8 (4.3)	10 (4.8)	18 (4.6)
Foot	0 (0)	3 (4.4)	3 (2.9)	1 (0.7)	2 (1.4)	3 (1.0)	1 (0.5)	5 (2.4)	6 (1.5)
Total	35 (100)	68 (100)	103 (100)	149 (100)	141 (100)	290 (100)	184 (100)	209 (100)	393 (100)

* *Some rowers reported multiple injuries.*

Severity of Injury

The majority of reported injuries among international elite-level junior rowers did not result in time lost from training or competition (Table 3). The low back and knee were the most common site of minor injuries (n = 84, 21.4%). Moderate injuries accounted for 10.4% (n = 41) of all injuries. Low back and knee injuries were the most common cause of absence from rowing. In this group, there were only 3 reported rib stress fractures among elite junior rowers. The majority of reported major injuries (n = 12, 3.1%) were overuse (n = 9) and included 6 low back and 4 knee injuries. Of the 12 rowers who sustained major injury during the rowing season, only 1 athlete won a medal at the Junior World Rowing Championships.

TABLE 3

Severity of injury by location*

Severity of injury / Injured area	Incident N (%)	Minor N (%)	Moderate N (%)	Major N (%)
Head	1 (0.4)	1 (1.2)	2 (4.9)	0 (0)
Neck/Cervical spine	4 (1.6)	0 (0)	0 (0)	0 (0)
Shoulder/Upper arm	25 (9.8)	3 (3.6)	0 (0)	0 (0)
Elbow	8 (3.1)	1 (1.2)	0 (0)	0 (0)
Forearm/Wrist	40 (15.6)	5 (6.0)	0 (0)	0 (0)
Hand	12 (4.7)	0 (0)	0 (0)	0 (0)
Chest/Thoracic spine	9 (3.5)	4 (4.8)	5 (12.2)	0 (0)
Trunk/Abdomen	0 (0)	0 (0)	0 (0)	0 (0)
Low back	62 (24.2)	39 (46.2)	20 (48.8)	6 (50.0)
Pelvis/Groin/Buttock/Hip/Thigh	28 (10.9)	3 (3.6)	2 (4.9)	0 (0)
Knee	49 (19.1)	14 (16.7)	7 (17.1)	4 (33.4)
Lower leg	8 (3.1)	5 (6.0)	1 (2.4)	1 (8.3)
Ankle	6 (2.4)	8 (9.5)	3 (7.3)	1 (8.3)
Foot	4 (1.6)	1 (1.2)	1 (2.4)	0 (0)
Total	256 (100)	84 (100)	41 (100)	12 (100)

* *Classified according to Morgan and Oberlander.*[15]

Traumatic Injuries Sustained During Rowing-Specific Training

Rowing in the boat or on a rowing ergometer resulted in 42 (40.8%) traumatic injuries among elite junior rowers. The most often injured site during training in the boat was the low back (n = 19), followed by the thigh (n = 3), shoulder (n = 2), thoracic spine (n = 1), wrist (n = 1), hand (n = 1), knee (n = 1), and lower leg (n = 1). Traumatic injuries sustained during on-water training were predominantly incidental (n = 11) and minor injuries (n = 10). The only major injury was a lateral meniscal tear that occurred as the athlete was getting out of the boat. Boat collisions resulted in 6 additional injuries in 5 rowers. There were 4 low back injuries, 1 wrist injury, and 1 head injury that occurred when the athlete was struck by an oar.

A statistically significant difference in experience was seen between rowers with and without traumatic-onset injuries. Elite junior rowers who were injured during the on-water training had rowed for a shorter time than the rowers who did not sustain injuries (C ± Q = 3 ± 3 years vs 4 ± 3 years; P = .043, Mann-Whitney test). There was a significantly higher incidence of traumatic low back injuries among sweep rowers who changed rowing side during the current season (P = .012, χ^2 test) compared with sweep rowers who did not change rowing side during the same period.

Ninety-nine percent of elite junior rowers used a rowing ergometer during the current rowing season. The 7 injuries sustained during ergometer training included 5 low back and 2 shoulder injuries. The majority of those injuries were either incidental (n = 3) or minor injuries (n = 3). No significant association between the average length of training sessions on the ergometer (30 minutes and longer) and low back injury was found among elite-level juniors (P = .117)..

Traumatic Injuries Sustained During Cross-Training

Multiple types of cross-training were used by 95% of the junior rowers during the current rowing season. Elite junior rowers who cross-trained without injury used multiple techniques including swimming (n = 155), StairMaster or stepper (n = 32), elliptical trainer (n = 23), Alpine skiing (n = 20), in-line skates (n = 11), hockey (n = 1), and sailing (n = 1).

Traumatic injuries sustained during cross-training (n = 38) were reported by 12 female and 24 male junior rowers and are shown in Table 4. The only major injury sustained during running was an ankle sprain, and a lower leg fracture was associated with cycling.

Traumatic injuries sustained in the gym (n = 23) were reported by 7 female and 15 male junior rowers. The most frequently injured area in the gym was the low back (n = 7), followed by the shoulder and wrist with 3 injuries. Eleven injuries were graded as incidents, 9 were minor, and 3 were moderate injuries. The use of more than 2 different methods of cross-training was significantly associated with overuse injury among junior rowers ($P < .001$). It is worth emphasizing that run training performed more than once a week was significantly associated with overuse knee injuries ($P = .022$).

TABLE 4

Cross-Training and Associated Traumatic Injury*,**

Cross-Training		Running	Cycling	Nordic skiing	Basketball	Soccer
Practicing rowers		359	163	90	13	6
Injured rowers		21 (5.8 %)	3 (1.8 %)	1 (1.1 %)	6 (46.1 %)	3 (50 %)
Severity of acute injuries	Incident	7	0	1	3	0
	Minor	8	1	0	3	3
	Moderate	7	1	0	0	0
	Major	1	1	0	0	0
Number of acute injuries		23	3	1	6	3
The most frequent area affected by more severe injuries among all injuries of that cross-training		Ankle 12 (52.2%)	Lower leg 1 (33.3%)	Groin 1 (100%)	Ankle 2 (33.3%)	Ankle 2 (66.7%)

* *Some rowers reported multiple injuries. ** Hockey and sailing resulted with one acute injury each.*

Demographics, Rowing Experience, Training Characteristics, and Injuries

Elite junior rowers who sustained traumatic injuries were significantly taller and heavier than rowers without injury (186 ± 14 cm vs 182 ± 11 cm, respectively, P = .002; 80 ± 12 kg vs 76 ± 14 kg, respectively, P = .001). No significant association was found between overall injury rate or low back injuries and the initiation of rowing before age 16 years (P > .050, for both).

The female junior rowers had fewer traumatic injuries (P = .023), more overuse injuries (P = .011), and more overuse chest injuries (P = .002) than the male rowers. All stress fractures reported in this survey (n = 5) were in female rowers (n = 4). One rower sustained 2 simultaneous rib stress fractures. Stress fractures were also reported in the tibia and the metatarsal resultant from running.

Rowers who averaged more than 7 training sessions per week had significantly more total injuries (P = .016) and more overuse low back injuries (P = .016) compared with those with fewer training sessions per week. An increase in months of on-water training was significantly associated with higher frequency of overall injury (P = .034) and low back injury (P = .011) among junior rowers.

Traumatic injuries occurred significantly less in rowers who stretched at least 10 min/d compared with those who stretched for a shorter period of time (P = .030). Regular stretching performed for longer than 15 minutes after training was significantly associated with a lower frequency of all injuries (P = .024).

Rowing Success and Injury

There was no significant association between the incidence or severity of the reported injuries and the final ranking of injured rowers compared with uninjured rowers. Junior rowers who did not sustain an overuse injury during the current rowing season achieved significantly better results on a 2000-m ergometer test when compared with injured rowers (395 ± 56 s vs 407 ± 61 s; P = .024). There was no significant difference when injured and uninjured junior rowers were compared within their gender.

DISCUSSION

The present study is the first to investigate injuries in international elite junior rowers (Table 5). Although it is problematic to compare annual aggregate injury rates between different studies that

use different units of measurement, the elite junior rowers' annual aggregate injury rate of 2.1 injuries per 1000 training sessions per rower is higher than the findings of Weightman and Browne,[27] in a British rowing club (1.4 injuries per 10 000 man-hours of play) but similar to the findings of Budgett and Fuller[3] in a British international selection (0.4 per 1000 hours for rowing and 4 per 1000 hours for running and weight and circuit training) and more recently of Parkkari et al.[16] in the general Finnish population (1.5 per 1000 hours of participation). It should be emphasized that the study of Weightman and Browne was conducted more than 37 years ago with questionable results, as 25 of 30 rowing clubs reported no accidents during the year.[27] In addition, it is difficult to determine the exact cause of overuse injuries between specific and rowing cross-training because the annual aggregate injury rate in this study was not separated in the same manner as Budgett and Fuller.[3] There are many factors that influence duration of training sessions, and as a result, we were unable to calculate annual aggregate injury rate based on hours of participation. The low individual injury risk per exposure time places rowing in a group with sports such as golf, dancing, swimming, and walking.[16]

TABLE 5

Studies on Injured Rowers.

First Author and Year	Number of rowers	Age of rowers	Gender of rowers	Performance level of rowers	Number of injuries	Period of follow up
Weightman D[27] 1975	N / A [A]	N / A	N / A	Rowing club	19 [B]	1 year
Howell DW[12] 1984	17	N / A	Female	United States national and international lightweight rowers	13	Present musculoskeletal symptoms
Budgett RG[3] 1989	69 [C]	18-33 years [D]	Male	British international selection	58	1 year
Hosea TM[11] 1989	N / A	18-22 years	Both	Intercollegiate rowers from Harvard and Rutgers	180	3 consecutive years
Reid RA[20] 1989	40	17-33 years [E]	Female	Rowers holding scholarship at Australian Institute of Sport	61	4 consecutive years
Coburn P[5] 1993	N / A	N / A	N / A	N / A	54	1 year
Pelham AW[18] 1994	50	18-34 years	Both	Canadian rowing team	49	Through the entire rowing career
Wajswelner H[25] 1995	N / A	N / A	N / A	National and international Australian rowers	222	1 year for national and 2 years for international
Hickey GJ[9] 1997	172	14-36 years [F]	Both	Rowers who held scholarship of Australian Institute of Sport	320	10 consecutive years
Parkkari J[16] 2004	77	15-74 years [G]	N / A	General Finnish population	4	1 year

N / A = not available; [A] = 30 of 32 rowing clubs responded; [B] = all 19 injured rower were male rowers; [C] = replies were received from 69 of a possible 81 oarsman; [D] = mean age was 24.6; [E] = average age at medical consultation was 20.2; [F] = average age at the start of scholarships was 20.1 years for the females and 21.3 years for the males; [G] = the exact age, gender and performance level of rowers was not presented in the article.

Although the observed risk of an injury per training session among elite-level junior rowers is low, due in part to the high number of training sessions per season per rower (n = 465), the 217 participants in this study sustained a total of 393 injuries during the 2006 to 2007 rowing season. The aspirants for the 1987 British Senior National Rowing Team (n = 69), in a retrospective study of illness and injury, had a higher percentage of injured athletes (78.3%).[3] Rowing injuries contributed 8.3% to the total of 1186 injuries treated over 2 years at a sports injury clinic at Cambridge in the study of Devereaux and Lachmann.[6]

The injury location frequency in elite junior rowers corresponds to the order of injuries among British senior rowers in the study of Budgett and Fuller with low back injuries followed by knee and wrist injuries.[3] The low back injuries comprised 32.3% of all injuries of elite level junior rowers and these findings are in agreement with published reports in older rowers of 25% [6, 9, 11] to 50%[1, 3, 5, 25] The frequency of low back injuries among elite male junior rowers was greater when compared to female (34.4% vs. 29.9%) as has previously been reported by Hickey et al.[9] The distribution of traumatic and overuse low back injuries among genders follows the trend observed in that study, with traumatic low back injuries more frequent in female rowers and overuse injuries more frequent in male rowers.[9]

The association between earlier start of rowing in life and low back injuries observed among intercollegiate rowers[22] was not found among junior rowers. There are several potential explanations: the junior rowers are a relatively homogeneous population who

are younger in age, and the junior elite rowers may be more experienced than a heterogeneous population of collegiate rowers who have not reached an elite level. It is also possible that the junior rowers will experience back pain as they continue rowing into their early and mid twenties. The higher incidence of traumatic-onset injuries sustained in the boat among less experienced junior rowers may be because those rowers are at higher risk for limb and back strains due to sudden unexpected motions of the boat, which occur more frequently in less experienced rowers.[14] The sudden motions and time needed for adjustment might also play a role in the significantly higher incidence of low back injuries observed in sweep rowers who changed side during the current season.

The previously reported association between participation in a regular stretching program and incidence of low back symptoms in lightweight women rowers[12] was not found among junior rowers. In contrast, junior rowers who performed more than 10 minutes of stretching exercises after completion of training sustained fewer traumatic injuries. Improved hamstring flexibility allows proper positioning of pelvis during the stroke and diminishes the need for increased low back flexion which has been suspected as a potential cause of low back injuries among rowers.[19]

In contrast to the study of Hickey et al.,[9] chest and thoracic spine injuries were less frequent in elite level junior rowers compared to the rowers training at the Australian Institute for Sports (4.6% vs. 21.6%). Overuse injuries to the chest were more common than traumatic and were more frequent in female rowers in both studies. The most frequent chest injury seen in female rowers from AIS was rib stress fractures, while only

three rib stress fractures were reported in female junior athletes in this study. The lower incidence of rib stress fractures is in agreement with other published literature in athletes over the age of 18 years.[21] Only recently Dragoni et al. reported a case of a 17 year old rower with a rib stress fracture.[7]

Stress fractures in other sites (three ribs, one tibia, and a fifth metatarsal bone) were only reported in female athletes in this study which is in agreement with an apparent gender predisposition observed in females in all skeletal sites.[2] These data are also consistent with published reports of rib stress fractures in rowing where the majority of injured athletes were female.[9, 10, 13, 24]

Although Budgett and Fuller reported that the rate of injury in rowers was related to the type of training almost 20 years ago,[3] there continues to be a significant proportion of acute injuries related to cross-training (59.2%). Because the origin of surveyed elite junior rowers is worldwide, a large variety of alternative training was reported during the rowing season. Running still contributed the most to acute-onset injuries among elite junior rowers and may be due to the fact that 358 junior rowers (89.9%) run as a form of cross-training.

In summary, the majority of injuries reported in this research study were incidents and minor injuries, and only 12 rowers (3.1%) lost more than 30 days' training during the rowing season. The low proportion of major injuries and the absence of catastrophic (life-threatening) injuries reported by rowers at the World Rowing Championships is in

agreement with a prior study that reported no rowers who had lost more than 30 days' training were selected for the senior national team.[3] This study does carry some notable limitations. It is a retrospective study that relies on the accuracy of the reporting athlete, and this is a source of bias. It is also possible that we are under-reporting the incidence of severe rowing injury as severely injured rowers may not recover and compete at the international level. Thus, the data from this research can be interpreted only as indicative of the subgroup of junior rowers sampled at the World Rowing Championships. The study is also limited by the assumption that the injury information received was medically valid and accurate. Although a physician interviewed the participating athletes, the results have to be considered self-reported and thus subjective.

CONCLUSIONS

Rowing is a benign sporting activity for elite juniors who reached the Junior World Rowing Championships. Although 54.5% of these elite rowers were injured during the current rowing season, only 3.1% of those were major injuries. The most commonly reported injuries are to the low back, the knee, and the forearm/wrist. Our data demonstrate that rowing injuries are most commonly overuse problems, as the majority of the traumatic injuries were sustained during cross-training.

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