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Abstract

Objectives: To investigate the prevalence, nature and factors associated with injury among adult amateur rowers.

Design: Retrospective cross-sectional study.

Setting: UK-based amateur rowing clubs.

Participants: 160 amateur rowers.

Main outcome measures: Frequency, type, location, severity and associated rowing-related factors associated with injury.

Results: Injury rate was 5.7 per 1000 sessions, with no effect of sex (χ^2 = 0.195, P = 0.659) or weight class (χ^2 = 0.800, P = 0.371). The lower-back demonstrated an epidemiological incidence proportion (IP) of 0.39 (95% CI = 0.33 to 0.46). The IP for water- and land-based training was 0.39 (95% CI = 0.31 to 0.47) and 0.57 (95% CI = 0.49 to 0.65), respectively. IP was highest between January and March (0.13 to 0.15), whilst time loss was 0.49 (95% CI = 0.42-0.57). The IP for 'overuse' and 'traumatic' injuries was 0.71 (95% CI = 0.65 to 0.78) and 0.22 (95% CI = 0.16 to 0.27), respectively. Training volume was associated with the number of injuries (r = 0.418, P < 0.001).

Conclusions: Injury rates appear higher among amateur rowers with the most common injury site being lower-back. Our results suggest several factors influence injury risk including seasonal phase, training type and training volume.

Key words: prevalence, athlete, overuse injuries, sport, training volume

Introduction

The sport of rowing has greatly increased in popularity with approximately 83,400 people aged 16 or over participating at least once per week between 2015 and 2016 across England.[1] As one of the first modern Olympic events, rowing has become a well-recognised sport that has gained in professionalism as well as being a popular recreational activity.[2] Rowing is categorised as sweep rowing or sculling and is considered an endurance sport with year-round training and competition. During the head season, land-based activity such as resistance and ergometer training are the focus, with the aim developing key physiological characteristics (i.e. VO_{2max}, economy and technical proficiency).[3-5] In contrast during the regatta season activities are largely water-based and involve training and competition.

Presently, epidemiology studies focusing on elite rowing populations have indicated that rowing is a low injury risk sport.[6,7] In a retrospective study of international rowers, injury rate was reported as 1.8 per 1000 sessions[7] whereas using a prospective study with international rowers, injury rate was reported as 3.7 per 1000 hours.[8] Given the differences in expression of injury incidence (i.e. hours or sessions), comparisons are difficult to make, though use of injuries per 1000 sessions is likely to be more intuitive for coaches and athletes. In addition, it was reported by Wilson et al.[8] that a greater number of injuries were reported in the lumbar spine (31.8%) followed by the knee (15.9%) and cervical spine (11.4%), with these injuries positively related to the volume of ergometer training (r = 0.68). Conversely, a review of the literature revealed no existing studies on injury rates and risk factors among amateur rowers competing at national level despite the variances in training schedules and high participation rates.[9]

Research in rowing has demonstrated that a greater number of overuse injuries are reported when compared to traumatic injuries.[10-13] For example, Verrall & Darcey[13] compared the differences in injury rates between national level and international level rowers in Australia, indicating that national level rowers sustained more overuse injuries and greater time-loss than international rowers. Such findings might suggest that amateur level rowers are at greater risk and experience greater disruption to their working and sporting lives. In addition to this, season phase has been reported as an important consideration with regards to injury rates in rowing, with a greater proportion of injuries occurring between November and January, corresponding with an increase in land-based training such as resistance and ergometer sessions.[8] However, with regards to injury site, mechanism and season phase, research is currently limited to National and International rowers, with no current data available on the amateur population.

As much of the literature is currently based in national and international athletes, there is limited information available for those involved in amateur rowing including medical personnel and coaches with regards to injury incidence and contextual factors associated with injury risk. Such information could provide vital information for the management on injury in amateur rowers. Therefore, the aim of the present study was to examine the nature, prevalence and predictors of rowing injuries including training volume, training type, season phase, sex and weight class in a group of adult amateur rowers.

Methods

With informed consent and ethical approval, a cross-sectional retrospective survey was used with an invitation letter sent to all British Rowing-affiliated clubs in England (*n* = 353) that participated in slide-seat rowing. Surveys were constructed in, and distributed via, the Google Forms function in Google Documents (Google, LLC) and looked at participant characteristics and injury information in the previous 12 months from those training/competing until March/April 2018. Participants above the age of 19 years were sent the survey and were considered amateur; that is, participants without any remuneration. The survey is provided in supplementary material along with the terminology and definitions used.

Descriptive information, training patterns and injury history for the participants over the past 12 months was collected via the survey. An injury was defined as a musculoskeletal issue which led to adaption/missing two or more training sessions and/or at least one visit to a healthcare professional.[8] A reinjury was identified when a participant indicated injury to the same body part more than once within the 12 months and was not necessarily a recurrence of the same injury or a duplicate. Injury to multiple sites was recorded when a participant reported injury to more than one body part within the 12 months. Training volume was calculated as the absolute number of training sessions completed per week during a ‘typical week’, which was multiple by the number of weeks participants estimated they training to provided total number of sessions. Other information gathered looked at when the injury occurred to help identify at what point in the season rowers may be at higher risk, if the injury occurred during water- or land-based training, what body part(s) was/were impacted and whether time loss or medical contact was experienced.

Participants were anonymised on data entry and assigned a number to minimise bias. One hundred and sixty-two online responses (male, *n* = 75; female *n* = 85) were received, two responses were omitted; one was a duplicate and the other was from a participant below the age of 19. As such, 160 responses were included in the analysis. Participants were categorised as open-weight (OW) and lightweight (LW) with all descriptive data presented in Table 1.

****INSERT TABLE 1 ABOUT HERE****

Total numbers of sessions was divided by the total number of injuries to calculate injury prevalence per 1000 sessions. Epidemiological incidence proportion (IP) was calculated to provide a measure of the probability of injury risk for the 12-month period using the equation $\sqrt{\frac{IP\ x\ (1-IP)}{n}}$.[14] Data analysis was performed using Statistical Package for Social Sciences (Version 24). Descriptive statistics including percentages, mean and standard deviation, and injury rates per 1000 sessions for the full sample and sub-groups (sex and weight class), were calculated. Normality was assessed using the Kolmogorov-Smirnov test. Differences in injury incidence, overuse and traumatic injuries between males and females, and between weight classes, was determined using a Mann Whitney U test due to violations of normality. Bivariate comparisons for sex (male/female) and weight class (OW/LW) with injury (yes/no), re-injury (yes/no) and injury to multiple sites (yes/no), was assessed using a chi-squared (x^2) test. Logistic regression was used to determine the odds ratio with 95% confidence intervals. Spearman’s rank correlation coefficient was used to determine any correlations in the injury rate and participants age, performance level, years rowing and volume of training. In all instances, alpha was set at 0.05.

Results

Of the clubs who were approached, 29 (~ 8%) clubs provided consent to invite their affiliated members to participate and a total of 160 athletes completed the questionnaire. A total of 101 (65%) amateur rowers experienced at least one injury. In total, 198 injuries were reported in the previous 12 month-period, with a mean injury incidence of 5.7 ± 10.2 per 1000 sessions. Injury incidence for males and females were 6.7 ± 13.2 and 4.9 ± 6.6 injuries per 1000 sessions (z = -0.251, P = 0.802). No significant difference in injury incidence was observed between LW (4.8 ± 7.0 per 1000 sessions) and OW (5.9 ± 10.8 per 1000 sessions) (z = -0.753, P = 0.452).

There was no significant effect of sex (χ^2 = 0.195, P = 0.659) or weight class (χ^2 = 0.800, P = 0.371) for participants reporting at least one injury. Reinjuries were experienced by 29% of injured participants (IP = 0.29; 95% CI = 0.20-0.38) and was unaffected by sex (χ^2 = 0.285, P = 0.594) or weight class (χ^2 = 1.096, df = 1, P = 0.295). Injuries to multiple body sites was reported by 39% (n = 39/101) of all participants (IP = 0.24; 95% CI 0.18-0.31), with no significant effect of sex (χ^2 = 0.010, P = 0.922) or weight class (χ^2 = 0.482, P = 0.488). No significant odds ratio was observed for males compared to female for injury (0.865; 95%CI = 0.455-1.646) reinjury (0.762; 95% CI = 0.337-1.721) or injury to multiple body sites (0.962; 95% CI = 0.467-1.985). The lower-back was the most frequently injured site (IP = 0.39; 95% CI = 0.33-0.46), followed by knee (IP = 0.13; 95% CI = 0.08-0.17) and shoulder (IP = 0.10; 0.05-0.14). No significant odds ratio was observed for OW compared to LW for injury (1.464; 95%CI = 0.633-3.385), re-injury (0.732; 95%CI = 0.266-2.014) and injury to multiple sites (0.905; 95%CI = 0.351-2.336). (Table 2).

****INSERT TABLE 2 ABOUT HERE****

One hundred participants reported the impact of injury with 79% experiencing some disruption to their training or competition and 21% reporting no time loss. Of the 79% who reported disruption, 31 participants (39.2%) reported time loss from training or competition of greater than 21 days. The IP for time loss injuries was 0.49 (95% CI 0.42-0.57). Advice regarding their injury was sought by 83 participants (82.2%), with Physiotherapists being the most utilised profession (n = 62), followed by Doctors (n = 23) and then other rowers (n = 20).

The majority of injuries reported were classed as either overuse (n = 141; IP = 0.71; 95% CI = 0.65-0.78) or traumatic injuries (n = 43; IP = 0.22; 95% CI = 0.16-0.27) (Table 2), with a small proportion (7.1%) of responses not classified. There was no significant difference between sexes for overuse (men = 73.5%, women = 79.2%; z = -0.066, P = 0.947) or traumatic (men = 26.5%, women = 20.8%; z = -0.897, P = 0.370) injuries. Further, there was no significant difference between OW and LW for overuse (OW = 74.5%, LW = 85.7%; z = -1.675, P = 0.094) or traumatic (OW = 25.5%, LW = 14.3%; z = - 0.509, P = 0.611).

Total number of injuries reported was higher in the head season with majority of injuries being in January (n = 20), February (n = 24) and March (n = 21) (Figure 1). Fewer total number of injuries were reported in the regatta season; albeit, high in March, which represents a transition period between seasons. The IP for injury sustained in January (0.13; 95% CI = 0.07-0.18), February (0.15; 95% CI = 0.09-0.21) and March (0.13; 95% CI = 0.08-0.18) was higher than the all other months (IP = 0.01 to 0.11). Water-based activities results in 58 injuries of injuries (IP = 0.39; 95%CI = 0.31-0.47), whilst ergometer training, non-rowing cardiovascular training, resistance training and Pilates/yoga accounted for 84 injuries (IP = 0.57; 95% CI = 0.49-0.65) and 6 injuries were unclassified.

****INSERT FIGURE 1 HERE****

Spearman's Rank Correlation revealed a weak, statistically significant correlation between the number of injuries experienced by participants and their age (r_s = -0.363, P < 0.001) and the level rowed at (r_s = -0.236, P = 0.003). There was no statistically significant correlation between the number of years participants rowed for and the number of injuries experienced (r_s = 0.33, P = 0.675). A significant moderate correlation between the volume of training and the number of injuries experienced by participants was observed (r_s = 0.418, P < 0.001).

Discussion

This study investigated the prevalence, nature and predictors of injury in amateur rowers. The results of this study revealed that the injury rate in amateur rowers over a 12-month period was 5.7 ± 10.2 injuries per 1000 sessions. The injury rate observed is higher than retrospective studies of elite adult (1.8 per 1000 sessions) and elite junior (2.1 per 1000 sessions) rowers.[15,16] Such differences might be explained by factors including the injury definition used; Smoljanovic et al.[15] included injuries where complete absences from training/competition was required. The higher prevalence of injuries might also be explained by the lack of external control over training volumes during the head and regatta phases of the season. Interestingly, the results of Verrall & Darcey,[13] who noted that national level rowers report greater overuse injuries than international rowers, suggesting the additional support available to elite athletes such as specialist coaches to address any strength deficits/imbalances, load monitoring, equipment set-up and correct technique, might play an important role in minimising injury.[9]

There was no significant difference in the mean injury rates, reinjury rate, injury to multiple sites, overuse injuries and traumatic injuries between men and women or between OW and LW rowers, which is consistent with previous research.[12,15,17] The lack of difference between sexes is further supported by minimal kinematic differences when normalised for maximum "slouch position".[18] These results do, however, contrast those of Hickey et al.[19] who observed greater prevalence of lower-back injuries in males compared to female (25.0% *cf.* 15.2%) and greater number of chest-wall injuries in females compared to males (22.6% *cf.* 6.0%). This contrast is likely influenced by participant-related risk factors;[19] albeit, confirming this is beyond the scope of this study. With regards to weight class, Bernardes et al.[17] reported that rowers competing in the OW category had higher injury rates compared to LW, though the imbalances between group numbers requires consideration.

An important aspect of injury burden is the time loss experienced by athletes. In this study, 79% of those who experienced an injury reported time loss of varying lengths, the most common being over 21 days. The average probability of suffering an injury that results in time loss was approximately 49.4%. These results suggest that injuries experienced by amateur rowers resulted in greater time loss, particularly when compared to those used by Wilson et al.[8] who likely modified their training due to injury. In agreement with our result, Verall & Darcey[13] reported that national level rowers experienced more time loss due to lower-back injury that international rowers, and likely reflects the increased access to medical advice, rehabilitation and strength and conditioning.

The lower-back has been identified as the most commonly injured site previously[11,12,15] across a range of athletes and might reflect the fact that rowers often exceed the static lower- and upper-lumbar range of motion during the initial drive phase with end-range strain being associated with lower-back pain.[18] In this study, the average probability of sustaining a lower-back injury was 39%. Interestingly, the shoulder was not identified in the majority of previous studies and our results revealed that 11 of the 15 participants reporting a shoulder injury were women, and might be explained by difference in the kinematics of the shoulder between men and women.[20] In addition to injury site, significantly more overuse injuries were observed compared to traumatic injuries, which concurs with previous research in rowing.[10,12,21] The average probability of sustaining an injury through repetitive overuse was 71%, whereas traumatic was 22%. Such findings are potentially explained by the association between training volume an injury incidence. As such, management of training volume in amateur athletes is likely important for managing the injury risk associated with rowing.[13,22]

There is a paucity of research available that explored the effects of season phase, whilst ours revealed higher injury rates between January and March, which corresponds to the end of the head season and the beginning of the regatta season. The average probability of sustaining an injury during this time was approximately 40%. These findings do, to some degree, agree with Wilson et al.'s[8] who observed a higher prevalence of injury's between November and January in international rowers, reflecting the increase in land-based training during the head season. In support of this, our results revealed that 152 injuries were attributed to a combination of cardiovascular, resistance and ergometer training, and concurs with previous research that observed an association between ergometer training and weight training with injuries.[8,23] Notwithstanding this, it is noteworthy that a large number of injuries were associated with water-based training and might be explained by poor technique and equipment set-up which is likely experienced in the amateur rowing population.[9]

A notable finding of this study concerns the medical advice sought by amateur rowers in the event of an injury. In all, 82% of rowers that reported an injury sought medical advice from at least one person/professional, with the most commonly used profession being Physiotherapist. Interestingly, a large proportion of amateur rowers sought advice from other rowers that may have experienced a similar injury rather than medical professionals. Such findings might be explained by a smaller "sportsnet"; a term introduced by Nixon[24] and discussed by Liston et al.[25] in the context of pain and injury in rugby union. Using this concept, smaller, loose and non-centralised medical care available to amateur athletes results in players seeking advice elsewhere, whereas in an elite environment the support is readily available. Therefore, amateur rowing clubs might consider signposting a medical professional for athletes affiliated with their clubs and encourage them to utilise this service.

The use of retrospective questionnaires relies on the accuracy of participants in recounting their experiences over the past 12 months and may be subject to recall bias. Participants were asked to report their training volume as number of sessions per week rather than hours in an attempt to reduce the error in recall. That said, there is likely to a degree of error associated with recalling volume as well as potentially not reflecting the weekly variations given the term 'typical week' was used. Related to this, using 'injuries per 1000 sessions' has made it difficult to compare our injury rates with other literature that have used 'injuries per

1000 hours,' but recalling number of sessions instead of duration of training likely improves the recall accuracy of participants.[15] The injury rate was calculated as an estimate by multiplying the number of sessions completed each week and the number of weeks participants trained in the year. This estimation may have led to some inaccuracies in participant's reported training volume, as schedules may have changed, especially in those that reported injury and subsequent time loss. Due to the inclusion criteria and reliance on third party information to indicate prospective participants within the clubs that consented it was not possible to achieve an accurate estimate of the response rate for individuals. Therefore, generalising these findings to the entire amateur rowing population may not be appropriate but we do believe it gives so insight into injuries facing the amateur rowing population. The sample population varied in ages within each sex or weight class, which might have influenced the between-sex and between-weight class analysis, and therefore replication studies are required to corroborate these findings.

This study has several practical implications worthy of discussion. The results provide a descriptive injury profile specific for the amateur rowing population; an area of research that is limited but is necessary for appropriate management in amateur rowers. Furthermore, we note that amateur rowers appeared to be more susceptible to injury when compared to previously reported data in elite athletes, with no differences observed between sex and weight class for injury prevalence, re-injury and injury to multiple sites. Finally, the majority of injuries include lower-back and knee injuries and appears to be influenced by training volume, training type and season phase; thus, requiring consideration when planning training programmes with amateur rowers.

Conclusion

In all, these result highlight that no significant difference in injury prevalence was observed between sex and weight; albeit, further research is needed to investigate differences in injury rates between these groups within the amateur population using a prospective longitudinal study and accounting for age. Result also indicated that overuse injuries were significantly more common than traumatic injuries and the lower-back and knee were the most commonly injured body sites. Further, the highest frequency of injuries occurred during the transition from head season into regatta season and there was as association with training volume. Finally, water-based training appeared to result in most injuries for amateurs; therefore, further consideration on equipment, volume and technique may help in reducing injury rates within amateurs.

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Table1 Descriptive information of the participants

		Female	Male
Light-weight (LW)	*N*	13	14
	Age (years)	39.9 ± 15.2	37.6 ± 20.1
	Stature (cm)	166.5 ± 6.1	179.6 ± 6.5
	Body mass (kg)	60.5 ± 5.7	71.4 ± 3.9
Open-weight (OW)	*N*	72	61
	Age (years)	37.0 ± 15.2	48.3 ± 17.8
	Stature (cm)	170.3 ± 6.8	184.0 ± 7.5
	Body mass (kg)	69.2 ± 9.7	85.9 ± 16.3

Data expressed as mean ± SD.

Table 2. Absolute number of injuries and reinjuries experienced stratified for injury site and sex

Injury site	Female			Male			
	No. Injuries	Reinjuries	Total	No. Injuries	Reinjuries	Total	Total incidences
Head	0	0	0	0	0	8	0
Neck	3	1	4	3	1	4	8
Thoracic	5	0	5	4	2	6	11
Lumbar	30	12	42	24	12	36	78
Shoulder	11	4	15	4	0	4	19
Elbow	0	0	0	4	0	4	4
Wrist/hand	6	0	6	6	3	9	15
Chest/rib	8	4	12	4	0	4	16
Hip	5	0	5	0	0	0	5
Knee	10	3	13	11	1	12	25
Ankle/foot	4	0	4	2	0	2	6
Soft tissue upper-limb	3	1	4	2	1	3	7
Soft tissue lower-limb	0	0	0	3	0	3	3
Other	1	0	0	0	0	0	1

Figure 1. Seasonal variations in the number of injuries reported.