Injury Patterns in Division I Collegiate Swimming

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Background: In the last 25 years, it is estimated that over 42,000 male and female swimmers have competed at the National Collegiate Athletic Association (NCAA) Division I-A level. Despite the magnitude of these numbers, little is known about the epidemiology of collegiate swimming injuries.

Purpose: To describe the pattern of injuries incurred for one NCAA Division I collegiate men's and women's swimming team over 5 seasons.

Study Design: Descriptive epidemiology study.

Methods: Musculoskeletal and head injuries reported in the Sports Injury Management System for a Division I swimming team from 2002-2007 were identified. Gender, body part, year of eligibility, position, stroke specialty, scholarship status, and team activity during which the injury occurred and lost time were recorded. Risk of injury was assessed relative to gender, stroke specialty, and year of eligibility.

Results: From 2002-2007, 44 male and 50 female athletes competed for the University of Iowa swimming and diving team. The overall injury rates were estimated as 4.00 injuries per 1000 exposures for men and 3.78 injuries per 1000 exposures for women. Thirty-seven percent of injuries resulted in missed time. The shoulder/upper arm was the most frequently injured body part followed by the neck/back. Freshman swimmers suffered the most injuries as well as the highest mean number of injuries per swimmer. A significant pattern of fewer injuries in later years of eligibility was also demonstrated. The relative risk (RR) for injury was higher among nonfreestyle stroke specialties (RR, 1.33 [1.00-1.77]). Injury most often occurred as a result of, or during, practice for all swimmers. However, 38% of injuries were the result of team activities outside of practice or competition, such as strength training. No significant relationship was found between occurrence of injury and gender or scholarship status. There was no significant relationship between body part injured and stroke specialty. An increased number of total injuries and an increased risk of injuries in freshman collegiate swimmers were found.

Conclusion: Particular attention should be given to swimmers making the transition into collegiate level swimming. These data also suggest that injury surveillance and potential prevention strategies should focus on the shoulder for in-pool activities and the axial spine for cross-training activities.

Keywords: swimming; injury; epidemiology; collegiate; stroke

In the last 25 years, it is estimated that a combined total of over 42 000 male and female swimmers have competed at the National Collegiate Athletic Association (NCAA) Division I-A level.[7] Despite the magnitude of these numbers, a lack of information exists regarding the epidemiology of musculoskeletal injury for collegiate swimming. Most previous studies have analyzed injuries incurred as a result of a specific stroke, evaluated a specific body part, or scrutinized the biomechanics of a particular swimming motion.[1,3,9,10] Limited information exists regarding the epidemiology of swimming injury patterns at the collegiate,[4] elite, amateur, and masters levels.[6,8-9] Some of these reports have relied on retrospective surveys or questionnaires rather than training room or physician records.[2,6] Very few studies have detailed the pattern of injury in terms of body location.

Modern collegiate level swimming has evolved into essentially a year-round sport. Swimmers typically continue to swim significant yardage even after the collegiate season has ended. In addition, strength training, dry-land conditioning, and cross-training have become a supplement to in-pool training more than ever before. Consequently, injuries occur outside of the pool as well. Little information

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exists documenting the number of injuries occurring as a result of dry-land training, cross-training, and weight training. Only 1 prior study has examined cross-training–related injuries in female swimmers more than 10 years ago.[4]

The purpose of the current study was to describe the pattern of injuries incurred for one NCAA Division I collegiate men's and women's swimming team over the course of 5 years. Additional goals of the study were to analyze time lost secondary to injury and to analyze patterns of injury relative to gender, team activity, position, stroke specialty, scholarship status, and year of eligibility.

MATERIALS AND METHODS

Following Institutional Review Board approval, a retrospective review of athletic training room injury reports and physician records was performed for male and female swimmers competing on the University of Iowa collegiate team from August 1, 2002 to July 1, 2007. All injuries were entered into the Sports Injury Monitoring System (SIMS-Med Sport Systems, Dimondale, Michigan) by an athletic trainer. The SIMS is a computer program in which the athletic training staff enters injuries into a central database for the university and the conference. This database then provides information for the local medical team to monitor injury status and progress by generating status reports. All medical-related issues for athletes are recorded in the SIMS database at the University of Iowa by a member of the athletic training staff.

Definitions

An *injury* was defined as any musculoskeletal problem suffered as a consequence of team-related activity that resulted in a visit to an athletic trainer or physician. Concussions were also included as an injury. Systemic illnesses and injuries that did not occur as a result of swimming-related activity were not included in this study. A *season* was defined to reflect the academic year from August 1 to July 31 of the next year. The athlete's *eligibility* was defined as freshman, sophomore, junior, or senior. Injuries, reported by body part, were recorded as a result of a particular team-related *activity* including regular practice, competition, strength training, conditioning, or cross-training. An athlete's *position* was defined as either sprinter or distance based on team media guides, with sprinters typically participating in events of 200 m or less. A swimmer's *stroke specialty* was defined as breaststroke, backstroke, butterfly, freestyle, or individual medley based on the team media guide. A swimmer was considered on scholarship if he or she received any financial support related to swimming. An *exposure* was defined as participation in one game, practice, strength training, conditioning, or cross-training activity.

The SIMS database was reviewed from the time period from August 1, 2002 to July 31, 2007 including all swimmers for 5 consecutive seasons. All injuries were scrutinized by 3 of the authors for inclusion or exclusion. Systemic illnesses and injuries not related to team-related activities were excluded. Injuries were then categorized for body part involved. For each injury, it was also noted whether the athlete missed participation time as a result of the injury. Swimmers were considered to have missed time if the injury resulted in no participation in a practice or meet or if the swimmer was already missing time due to another injury. Furthermore, for every injury, that athlete's position was noted, along with his or her stroke specialty. The team activity during which the injury occurred was categorized. Lastly, scholarship status and year of eligibility were noted for injured swimmers. Exposures were calculated by the SIMS database.

The Mantel-Haenszel χ^2 test for trend was used to analyze for significance in the relationship of injury occurrence and time missed from injury with gender, position, stroke specialty, scholarship status, and year of eligibility. The relative risk (RR) of injury was also calculated for year of eligibility, gender, and stroke specialty. A $P < .05$ was considered significant.

RESULTS

From 2002-2007, 94 swimmers competed for the University of Iowa swimming team. Among the 44 male swimmers, there were 90 injuries sustained by 32 different male swimmers (72.7%). In the same time period, 50 athletes competed for the University of Iowa women's swimming team. For women, 76 injuries occurred overall by 35 individual swimmers (70.0%). The average number of exposures per year was estimated at 4526 for men and 4651 for women. The injury-exposure rate for men was estimated at 4.00 injuries per 1000 exposures. The injury-exposure rate for women was estimated at 3.78 injuries per 1000 exposures.

The risk of suffering injury was not significantly different between male and female swimmers (RR, 1.33 [0.81-1.37]). The proportion of injuries that resulted in missed time also was similar between genders. Overall, 31 of 90 (34.4%) injuries to male swimmers resulted in missed time due to injury. These 31 injuries resulting in missed participation time were suffered by 17 different male athletes. For female swimmers, 30 of 76 (39.5%) injuries resulted in lost time. These 30 injuries resulting in missed time were suffered by 18 different female swimmers. Four male swimmers underwent a total of 9 surgeries during this time period. There were 4 shoulder surgeries, 4 elbow surgeries, and 1 foot surgery. Four female swimmers underwent a total of 5 surgeries, all of which were shoulder procedures. Overall, 9 of 14 surgeries on swimmers involved the shoulder. One female swimmer retired from swimming after her sophomore season during this time period following repeated injuries and 2 shoulder surgeries.

Table 1 presents the distribution of injuries to different body regions and related time missed. The body region most often injured by both male and female swimmers was the shoulder and upper arm, which accounted for 31% and 36% of the injuries for each group, respectively. Back and neck injuries were the second most frequent area injured for both men and women. The shoulder also was the most frequent injury to result in lost time. However,

TABLE 1
Distribution of Injuries and Number of Injuries Resulting in Missed Time by Body Part

Body Part	Injuries Causing Missed Time/Total Injuries, n		
	Male Swimmers (n = 44)	Female Swimmers (n = 50)	Total Swimmers (n = 94)
Shoulder/upper arm	11/28	12/27	23/55
Back/neck	7/22	5/16	12/38
Elbow/wrist/hand/finger	6/18	1/6	7/24
Knee/leg	1/12	5/13	6/25
Ankle/foot	2/4	2/6	4/10
Concussion	3/3	0	3/3
Hip/thigh	0/2	3/5	3/7
Chest/abdomen	1/1	2/3	3/4
Total	31/90	30/76	61/176

TABLE 2
Distribution of Injuries by Year of Eligibility

	No. of Swimmers	Swimmers Suffering Injury (%)	Total Injuries	Mean No. of Injuries
Men				
Freshman	24	13 (54)	29	1.21
Sophomore	28	16 (57)	27	0.96
Junior	27	13 (48)	19	0.70
Senior	21	9 (43)	15	0.71
Women				
Freshman	31	18 (58)	37	1.19
Sophomore	28	19 (68)	13	0.46
Junior	23	12 (53)	14	0.61
Senior	26	9 (34)	12	0.46
Total				
Freshman	55	31 (56)	66	1.20
Sophomore	56	35 (63)	40	0.71
Junior	50	25 (50)	33	0.66
Senior	47	18 (38)	27	0.57

there was no statistically significant relationship between body part injured and the likelihood of missing time.

Table 2 shows the distribution of total number of injuries by year of eligibility. Freshman athletes suffered the highest number of total injuries and highest average number of injuries per athlete for both women's and men's teams. Freshman women and men suffered a mean of 1.21 and 1.19 injuries per swimmer, respectively. The mean number of injuries per swimmer decreased in later eligibility seasons for both teams. In addition, the risk of suffering an injury significantly decreased with subsequent years of eligibility for the women (χ^2, $P = .03$) and for the combined men's and women's teams (χ^2, $P = .04$).

Table 3 presents the distribution of injuries by position for sprinters and distance swimmers. Male distance swimmers had a relatively high mean number of injuries at 2.5 injuries per athlete. Female distance swimmers and all sprinters suffered approximately 1.5 injuries per swimmer or less. However, the risk of suffering an injury was not significantly different between sprinters and distance swimmers (RR, 1.26 [0.93-1.70]). Also, the proportion of injuries that resulted in missed time occurred with approximately the same frequency between sprinters and distance swimmers (RR, 0.95 [0.63-1.44]).

Table 4 presents the distribution of injuries and risk of injury by stroke specialty. Freestyle was by far the most common stoke specialty and was also associated with the highest total number of injuries overall. Accordingly, freestyle also had the highest total number of injuries resulting in time missed. However, freestyle was less likely to result in injury than other stroke specialties. In terms of risk for injury by stroke specialty, those swimmers specializing in strokes other than freestyle exhibited a 33% greater risk (RR, 1.33 [1.001-1.77]) of injury than swimmers primarily specializing in freestyle. The distribution of injuries by body part relative to stroke specialty is shown in Appendix 1 (available in the online version of this article at http://ajs.sagepub.com/supplemental/). There was no significant association between stroke specialty and time missed and no clear association between stroke specialty and body region injured.

The team activity during which injury occurred is presented in Appendix 2 (available in the online version of this article at http://ajs.sagepub.com/supplemental/). For both men and women, the activity causing the most injuries was swimming practice in the pool, representing 55.6% and 60.5% of men's and women's injuries, respectively. Strength training was the activity of injury for 30% of male swimming injuries and 28% of female swimming injuries. Thirty-eight percent of injuries for both the men and women were a result of team activities out of the pool. Practice and strength training activities also represented the majority of the injuries resulting in time lost from participation. Time missed from injury relative to team activity during which the swimmer was injured is also presented in Appendix 2. The 2 team activities that resulted in the majority of injuries were practice and strength training. The distribution of injuries for these 2 activities is presented in Table 5. Shoulder injuries were the most often injured body part during practice for both men and women. Back and neck injuries, followed by shoulder, were the most common injuries with strength training for both men and women swimmers.

There did not appear to be any relationship between scholarship status and the pattern of injury or time missed from injury. There were 33 male athletes on scholarship and 11 nonscholarship athletes (25%). Of the 90 total injuries among male swimmers, 57 (63%) injuries were suffered by scholarship athletes, whereas 33 (36%) were incurred by nonscholarship athletes. Thirty-six percent of injuries resulted in missed time for scholarship male swimmers versus 25% for nonscholarship male swimmers. There were 37 female scholarship swimmers and 13 nonscholarship athletes (26%). Of the 88 total female swimming injuries, female scholarship athletes suffered 68 (77.3%) injuries while nonscholarship athletes suffered 20 (22.7%)

TABLE 3
Distribution of Injuries and Injuries Resulting in Missed Time by Position

	No. of Swimmers at Position	Total Injuries	Injuries Resulting in Missed Time	Injuries per Swimmer by Position
Men's distance	26	66	23 (35%)	2.54
Men's sprinters	18	24	8 (33%)	1.33
Women's distance	27	42	16 (38%)	1.55
Women's sprinters	23	34	14 (41%)	1.47

TABLE 4
Risk of Suffering Injury at Different Stroke Specialties

	Swimmers Who Suffered Injury/Swimmers at Stroke Specialty, n (%)					
Team	Freestyle	Backstroke	Breaststroke	Butterfly	Individual Medley	Total
Men	13/18 (72)	5/7 (71)	7/8 (88)	5/8 (63)	2/3 (67)	32/44 (73)
Women	16/32 (50)	6/7 (86)	2/2 (100)	3/5 (60)	4/4 (100)	31/50 (62)
Total swimmers	29/50 (58)	11/14 (76)	9/10 (90)	8/13 (62)	6/7 (86)	63/94 (67)

TABLE 5
Distribution of Strength Training and Practice Injuries by Body Part

	Concussion	Elbow/ Wrist/Hand	Shoulder/ Upper Arm	Back/ Neck	Knee/ Leg	Hip/ Thigh	Ankle/ Foot	Chest/ Abdomen	Total
Men									
Strength training	0	4	6	14	2	0	1	0	27
Practice	3	13	18	7	6	2	0	1	50
Women									
Strength training	0	1	4	8	4	1	1	2	21
Practice	0	5	23	8	5	2	2	1	46
Total team									
Strength training	0	5	10	22	6	1	2	2	48
Practice	3	18	41	15	11	4	2	2	96

injuries. Thirty-seven percent of injuries resulted in time lost for scholarship swimmers versus 50% for nonscholarship female swimmers. There was no statistically significant relationship between scholarship status and injury.

DISCUSSION

The results of this study provide several interesting findings. There were no significant differences in the number of injuries per team-related exposures when comparing injuries by gender. In addition, similar injury patterns were seen between genders in terms of stroke specialty, position, and activities during which an injury occurred. Injuries and time missed related to injury were similar between scholarship and nonscholarship athletes for both genders as well.

The relationship of injury and year of college eligibility was a remarkable finding in this group of swimmers. The highest total number of injuries and the highest mean number of injuries per swimmer occurred during the freshman year of eligibility. Both genders demonstrated a general decrease in the number of injuries and injury rates after the freshman season. This decrease was more gradual in the men's team and more dramatic for the women's team. In addition, we also found a significant decrease in the risk of suffering an injury with later years of eligibility. The high prevalence of injuries during the early college years is likely explained by the transition from high school training regimens to that of the collegiate level. The yardage required of

college swimmers and additional cross-training activities are often substantially greater than what an athlete was accustomed to in high school and club swimming. This can lead to overuse-type injuries early in a swimmer's college career. As the swimmers become accustomed to the yardage and workout routine, fewer injuries are incurred. A second possible explanation for fewer injuries after the freshman season is that frequently injured freshman swimmers may subsequently decide to no longer swim. We did not find this to be the case in our group of swimmers. One athlete discontinued swimming secondary to medical issues, but this occurred following the sophomore season.

Not surprisingly, practice was the most common activity that led to injury, accounting for nearly 60% of injuries. Approximately 38% of injuries in this study resulted from team activities out of the pool, including strength training and dry-land workouts. This is similar to what was reported by McFarland and Wasik,[4] who found that 44% of all injuries were caused by cross-training in a cohort of collegiate female swimmers. Cross-training is thought to be additive to an athlete's overall fitness and a way to enhance a swimmer's ability to compete. It is impossible to assess from our data how many injuries may have been prevented or how much swimming performance was enhanced by cross-training. Yet, swimmers are often not accustomed to the particulars of nonswimming workouts, and this may explain our high incidence of out-of-pool injuries. Our results suggest that these programs need to be scrutinized closely given that nearly 40% of injuries continue to occur out of the pool. The cost/benefit ratio for cross-training and related injuries may be reason to alter some out-of-pool training activities.

Overall, although our results show that collegiate swimming has a low injury per exposure rate, there can still be important time loss resulting from such occurrences. We found an injury rate of 4.0 and 3.78 per 1000 exposures for men and women, respectively. McFarland and Wasik[4] previously had found an injury rate of 2.12 per 1000 exposures for a collegiate female cohort. This increase in the number of injuries suffered by collegiate swimmers likely reflects the trend that is occurring with all sports in which intensive training persists essentially all year, even in the out-of-season months.

Our results show that the shoulder was the most frequently injured body part. This is consistent with a previous study in which shoulder injury comprised 55% of swimming-related injuries but only 9% of cross-training injuries in collegiate female swimmers.[4] No such literature exists for men. There has been some implication that the shoulder is the body part that has the greatest incidence of injury in swimmers in general, although studies range from 3% to a high of 67%, and these were not specific for the collegiate level.[2,5] In the current study, the shoulder accounted for 36% of men's injuries and 50% of women's injuries suffered during practice. Shoulder injuries are likely reflective of the repetitive strain on the shoulders produced by swimming. We found that injury to the shoulder is the most frequent cause of injury and missed time. The shoulder also was the body part on which swimmers most commonly had surgery. Given these results, it seems reasonable to consider the development of preventive training programs focused on shoulder injuries. Back and neck injuries were also relatively frequent in our group. However, these injuries were most commonly associated with cross-training activities.

Interestingly, stroke specialties other than freestyle were associated with a higher risk for injury. However, our cohort had substantially fewer swimmers with non-freestyle specialties listed in the media guides. Our data did not demonstrate any clear relationship between specific stroke specialties and injuries to particular body parts. Our stroke specialty designations and distance versus sprinter designations were based on listings in the team media guides for each season. It should be noted that distance events are almost exclusively freestyle events. We fully recognize that many swimmers participate in races in several strokes and different distances. It is likely that many of the swimmers categorized for a particular stroke in our study actually participated in many stroke specialty events. Additionally, specialists in nonfreestyle events usually do significant freestyle yardage on a daily basis in practice. Therefore our information on injuries related to particular stroke specialty should be viewed accordingly.

Our study is limited in several ways. This retrospective analysis deals only with one collegiate team over the course of 5 seasons and therefore may suffer from sampling error related to local factors for this particular team. This team had relatively consistent training regimens comparable with other collegiate programs across the country during this time, although 2 different head coaches and coaching staffs presided over the team for 2 and 3 years, respectively. Also, our data may be difficult to generalize to a noncollegiate swimming population. In addition, although our data allowed for describing injuries in terms of whether time was lost due to injury, we were unable to consistently determine exactly how much time was lost with a number of cases. Therefore we cannot present an average time lost per injury. Lastly, our data rely on the data entry over the course of 5 years during which several athletic trainers documented injuries, which led to variability in the detail of data that was reviewed.

In summary, we found interesting injury information regarding a previously poorly understood group: collegiate swimmers. Injury patterns for men and women largely were similar in scope. We found a larger number of injuries in early eligibility years for both male and especially female swimmers. The shoulder was the most commonly involved body part. We feel there are 2 areas where swimming injury prevention could be attempted. First, the incorporation of freshman swimmers into collegiate training programs should be carefully monitored. Those freshman swimmers who are unaccustomed to significant cross-training activities or collegiate level yardage appear to be prone to injury. Training regimen adjustment and close assessment of freshmen athletes for signs of overuse injury may decrease injury occurrence and time missed. Secondly, our data suggest that injury prevention should focus on the shoulder for in-pool activities and the axial spine for cross-training and strength activities.

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