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# Injuries in Competitive Swimming: Incidence and Risk Factors

Kristin I. Chase

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INJURIES IN COMPETITIVE SWIMMING: INCIDENCE AND RISK FACTORS

by

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Bachelor of Science, Minnesota State University, Mankato, 2007

A Thesis

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

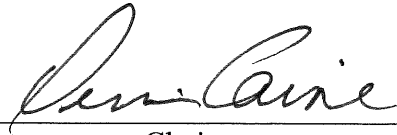
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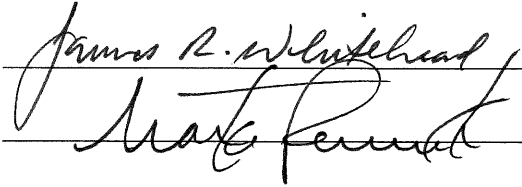
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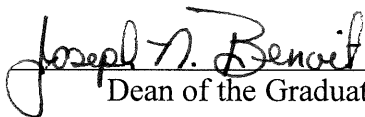
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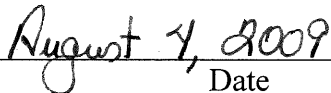
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This thesis meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.



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## ABSTRACT

**Objective:** To study the nature and incidence rate of injuries that affect collegiate competitive swimmers and to examine the relationship between these injuries and specific risk factors.

**Background:** Minimal research has been conducted on swimming-related injuries, with most studies being retrospective in nature. Only one study reported a calculated injury rate for athletic exposures. Past research reports that the shoulder is the most commonly injured location and that overuse injuries (e.g. tendonitis) is the most common injury type.

**Methods:** IRB approval obtained through the University of North Dakota. Swimmers from UND swim team were asked to participate. Once consent was obtained, baseline data in the form of participant information and a medical history questionnaire was gathered for each participant. Afterwards, the swimmers were followed for an entire season to report any injuries and their exposure to swimming (attendance records, yardage, etc.). Once the season was over, descriptive and analytical data analyses were completed based off information obtained from the participants.

**Results:** Of the 34 participants, 20 sustained a total of 31 injuries during the study period. Based on data found injury rates were calculated as being 5.55 injuries per 1000 AE's and 3.04 injuries per 1000 hours training. Risk factors included in this study were gender, years swimming competitively, history of any injury, and history of specific

injury. Risk factors that remained significant in the multivariate analysis were history of any injury and history of specific injury.

**Conclusions:** Injury rates reported in this study are higher than injury rates reported by previous swim-related studies. When compared to other overhead sports, swimming has a lower overall injury rate. As for distribution of injuries, the data reported in this study are similar to those that were reported in other swim-related studies.

## CHAPTER I

### INTRODUCTION

In 2008, USA Swimming reported 257,163 swimmers participating in their numerous swimming clubs throughout the country (USAswimming.org). Additionally, during the 2005-2006 season, the National Collegiate Athletic Association (NCAA) reported 18,782 student-athletes participating in collegiate swimming (NCAA.org). These participation numbers demonstrate the increased popularity of competitive swimming in the United States. Many researchers believe this is due to the fact that swimming gives the participants both an upper and lower body workout and also improves cardiovascular fitness (Fowler & Regan, 1986). Competitive swimming is different from its recreational counterpart in the sense that the swimmer is training and competing in numerous events throughout the season. Competitive swimming consists of four different swim strokes: butterfly, breaststroke, backstroke and free style.

Competitive swimming was first introduced as an Olympic sport in the summer of 1896 (McMaster, 1996) in which three events were held (underwater swimming, 200m obstacle swimming and plunge for distance) and were designed for men only. Women were not allowed to participate in the Olympic Games until 1912. Unfortunately, there were no rules or regulations specifically assigned to swimming during the first Olympic games. However, in 1908 a world-wide swimming association was formed to identify universal rules and regulations associated with competitive swimming. The first swimming association included representatives from eight European countries including

Germany, Belgium, Denmark, Finland, Great Britain, Hungary and Sweden (www.olympic.org). In 1937 competitive swimming became classified as an official sport of the National Collegiate Athletic Association (NCAA). Today competitive swimming is one of several sports offered to student-athletes at division I, II, and III colleges and universities in the United States. According to the NCAA, 509 schools sponsored women's competitive swim teams and 389 schools sponsored men's competitive swim teams during the 2007-2008 season, totaling 19,620 student-athletes (NCAA sports sponsorship and participation rates, 2009).

The majority of competitive swimmers begin competing between five and six years of age (Jones, 1999). Depending on the swimmers age and level of participation, training and competing can run 10 to 11 months each year. Collegiate competitive swimmers can train between 8,000 and 20,000 yards daily and an average of 20 to 30 hours a week (Johnson et al., 1987). In addition to water based training, collegiate competitive swimmers are also required to participate in weight training regimens (Kammer et al., 1999). Typically, competitive swimmers compete in 10 minor competitions and 2 major competitions throughout the year (Grote, Lincoln, & Gamble, 2004). Overall, the majority of competitive swimmers have a career life span between 10-15 years (Johnson et al., 1978).

Given the intensive and long-term training regimens of many competitive swimmers, concern has been raised regarding the incidence and severity of injury, particularly overuse injury affecting this population (Johnson et al., 1987). However, there have only been a handful of studies (Kennedy & Hawkins, 1974; Kennedy et al., 1978; Mutoh et al., 1988; Bak et al., 1989; Grimmer et al., 1996; McFarland & Wasik, 1996; and Richardson, 1999) that have investigated the epidemiology of injury in

competitive swimming. In addition, many of the studies that have been conducted suffer from methodological short-comings which include the following:

- The use of retrospective data collection which depends on memory recall and thus has the risk of “retrospective contamination”. It has been shown that retrospectively collected data tend to miss the more minor injuries, thereby resulting in lower overall injury rates
- Data sources are variable and range from self-report forms, athletic trainers and therapists, physicians, and injury registries
- Populations were diverse with regards to level of competition, age, gender, coaching techniques, and training routines
- Measurement bias associated with self-reporting of injuries
- Participants were selected non-randomly or arose from convenience samples in most studies
- Injury rates were reported primarily as clinical incidence (i.e., injuries per 100 participants) which does not account for the exposure of participants to risk factors
- Little information on collegiate swimmers
- Inconsistent injury definitions across studies

In summary, competitive swimming is an extremely popular sport in the United States. This popularity is also evident in the numerous colleges and universities across the nation that sponsor competitive swimming. On average, collegiate competitive swimmers train about 10 to 11 months, swim 8,000 yards daily, and compete in 12 competitions throughout the year. Against this background, there is concern about the risk and severity

of injuries affecting collegiate swimmers. However, there is a lack of prospective epidemiological research which provides these data for competitive collegiate swimmers.

#### Statement of the Problem

This study will attempt to determine: (a) the nature and incidence rate of injuries that affect the University of North Dakota male and female competitive swimmers during the 2008-2009 season and (b) the relationship between injuries affecting collegiate competitive swimmers and the following potential risk factors: (i) gender, (ii) previous years of competitive swimming, and (iii) previous injuries.

#### Definitions

##### *Injury*

An injury was defined as one that (1) occurred as a result of participation in organized swimming practice or competition, (2) resulted in restriction of the student athlete's participation or performance and/or (3) required the student athlete to seek medical attention by a Certified Athletic Trainer or team physician. This definition is a modified version of the definition used by the NCAA injury surveillance system (Dick, Agel, & Marshall, 2007).

##### *Exposure*

A) A time exposure: actual duration of training in hours

B) An athlete-exposure (A-E) was defined as one swimmer participating in one practice or competition in which he or she was exposed to the possibility of athletic injury.

##### *Incidence Rate*

A) Total number of injuries per 1000 hours exposure

B) Total number of injuries per 1000 athlete-exposures.

### *Time Loss*

Time loss was defined as the exact time (in days) between the original injury and the return to full practice/competition. Time loss was categorized as followed: <7 days (mild), 7-21 days (moderate), >21 days (severe).

### Limitations

The first limitation identified in this study would be the sample chosen to participate. The sample is a convenience sample since the swimmers at the University of North Dakota were available to participate, accessible to the researcher, and Division I caliber athletes. This sample is not necessarily an exact representation of all competitive swimmers or swimmers within the NCAA organization in terms of age, level, experience, injury history, etc. However, they could be considered a representative of other Division I swimmers. Another limitation of this study is the length of this study. Ideally, an epidemiological study of sport injuries should be conducted over several years or seasons to ensure stability of data.

### Significance of Problem

To date, there are only a few of epidemiological studies that have investigated the incidence rate and distribution of injuries affecting competitive, collegiate swimmers. In addition, there is only one study that has analyzed risk factors associated with the overall incidence of injury affecting swimmers. Unfortunately, these studies suffer from methodological limitations which limit the reliability and comparability of data. The poor quality of the existing research combined with the large population of swimmers exposed to the risk of injury underscores the need for this study. This study will be the first study that is prospectively designed to identify the extent of the injury problem and test risk factors related to injury in competitive, collegiate swimmers. The results of this study

will contribute to the research which describes the nature and incidence of injuries affecting competitive collegiate swimmers. Additionally, this research may help to identify injury risk factors which if controlled could help to reduce the risk and severity of injuries affecting swimmers.



## CHAPTER II

### LITERATURE REVIEW

Competitive swimming is defined as a non-contact sport that requires participants to be highly dedicated and maintain an extensive dry-land and water-based training regimen. On average, collegiate competitive swimmers train and compete 10 to 11 months out of the year and participate in roughly 10 minor and 2 major competitions (Grote, Lincoln, & Gamble, 2004). A collegiate swimmer's training schedule can consist of swimming between 8,000 and 20,000 yards each day and an average of 20 to 30 hours a week (Johnson et al., 1987). In addition to water based training, collegiate competitive swimmers are also required to participate in weight training regimens that are designed to increase muscular strength and endurance (Kammer et al., 1999). This aggressive training and competition schedule wears on the body making the swimmers more susceptible to overuse injuries. This review will discuss the current published research on the epidemiology of competitive swimming injuries according to: who is affected by injury, where injury occurs, when injury occurs, outcome of injury, risk factors, inciting events, and prevention.

#### Who is Affected by Injury?

Table 1 summarizes the studies that reported injury rates in competitive swimming. Most of these studies reported the number of injuries sustained by the swimmers within the study. This allowed for the calculation of overall rates per 100 participants, ranging from 4.5 to 194.7 injuries per 100 participants. Unfortunately, these

Table 1. Overall Injury Rates in Competitive Swimming

Authors	Year	Study Design	Method	Gender	Level	N of Swimmers	N of Injuries	Rate per 100 Athletes*	Rate per 1000 AE
Kennedy et al.	1978	R	S		O	35	43	122.9	
		R	Q		NS	2496	261	10.5	
Mutoh et al.	1988	R	Q	10F 9M	E/N	19	37	194.7	
Bak et al.	1989	R	Q		NS	268	100	37.3	
Lanese et al.	1990	P	IR	21F 36M	C	57	29	50.9	
Grimmer et al.	1996	R	Q	193F 159M	N	352	16	4.5	
McFarland & Wasik	1996	L	S	68F	C	68	56	82.4	1.05
Richardson	1999	R	S		A	1500	886	59.1	

A=Age Group Swimmers  
 C=Collegiate Swimmers  
 E=Elite Swimmers  
 M=Masters Swimmers  
 N=National Swimmers  
 O=Olympic Swimmers  
 NS=Not Specified

Study Design: R=Retrospective P=Prospective L= Longitudinal  
 Methods: Q=Questionnaire S=Survey IR=Injury Report E=Examination

\* This number was manually calculated from the data

Athlete-Exposure (AE) = 1 athlete at 1 practice or competition

rates are difficult to compare because they do not account for the varying exposure of swimmers to the risk of injury. There were several other factors which make cross-study comparisons difficult. First, the competitive level of swimmers varied among studies. Second, all but two studies were retrospective studies and were therefore subject to recall bias. Finally, these studies either did not define injury or the injury definition varied across studies. Only one study, McFarland and Wasik (1996), reported an overall exposure-based injury rate of 1.05 injuries per 1000 exposures from swimming.

### Where Does Injury Occur?

#### *Anatomical Location/Injury Type*

A summary of the distribution of injury by anatomical location is provided in table 2. This research indicates that the body part most affected by injury is the shoulder, ranging from 3% to 55% of all injuries (Richardson, 1999 & McFarland & Wasik, 1996), followed by the back (16% to 37%) (McFarland & Wasik, 1996 & Mutoh et al., 1988) then knee (5% to 28%) (Richardson, 1999 & Kennedy et al., 1978). In addition to studies identifying injuries to all anatomical locations, multiple studies have looked at specific anatomical injury locations. A summary of these studies is provided in table 3 and described below. An important shortcoming of most of these retrospective studies was that they depended on surveys therefore rendering them subject to recall bias.

#### *Shoulder Injuries*

Injuries to the shoulder complex are the most common musculoskeletal injuries that affect competitive swimmers and accounted for 3-55% of all injuries (table 2). The most frequently diagnosed shoulder injury is called "swimmer's shoulder", which is an impingement syndrome that occurs when either the supraspinatus muscle tendon, biceps brachii tendon or both become compressed by the acromion of the scapula making any

Table 2. A Percent Distribution of Injuries by Anatomical Location

Authors	Year	Study Design	N of Athletes	N of Injuries	Head/ Neck	Shoulder	Arm/ Hand	Thigh/ Adductor	Knee	Ankle/ Foot	Back	Other
Kennedy et al.	1978	R	35	43		37			28	19		16
		R	2496	261		31			26.8	32.5		9.7
Mutoh et al.	1988	R	19	37	3	31.3	3		20	5.6	37.1	
Grimmer et al.	1996	R	352	16		47	5.8	5.8	23.5		17.4	0.5
McFarland & Wasik	1996	L	68	56	7	55	4	5	11		18	
Richardson	1999	R	1500	886	26	3	18		5	32	3	13

Study Design: R=Retrospective L= Longitudinal

Table 3. Injury Rates to Specific Anatomical Locations

Authors	Year	Study Design	Method	Specific Location	Gender	Level	N of Swimmers	N of Injuries	% of Athletes Injured	Rate per 100 Athletes
Dominguez	1978	XC/R	E	Shoulder	133F 130M	A	263	90		34.2
Richardson et al.	1980	XC/R	Q/E	Shoulder	83F 54M	N	137	58		42.3
McMaster & Troup	1993	R	S	Shoulder		A/E/N	1262		10-26	
Burchfield et al.	1994	R	Q	Shoulder	54F 46M	NS	100	29		29
Stocker et al.	1995	R	Q	Shoulder		C/M	927	445		48
Bak & Fauno	1997	XC/R	Q/E	Shoulder	22F 14M	N	36	49		136.1
McMaster et al.	1998	R	Q	Shoulder	13F 27M	N	40	23		57.5
Stulberg et al.	1980	XC	E	Knee	14F 9M	A/E	23	18		78.3
Rovere & Nichols	1985	R	S	Knee	17F 19M	A/C	36	27		75
Vizsolyl et al.	1987	R	S	Knee	216F 175M	A	391	209		53.5
Hahn & Foldspang	1998	R	Q	Knee		C	53	33		62.3
Loosli & Quick	1992	R	Q	Thigh/Adductor	16F 14M	C	30	10		33.3
Grote et al.	2004	R	S	Thigh/Adductor	98F 198M	C/N	296		21.5-42.7	
Soler & Calderon	2000	XC	E	Back		N	176	18		10.2

A=Age Group Swimmers  
 C=Collegiate Swimmers  
 E=Elite Swimmers  
 M=Masters Swimmers

N=National Swimmers  
 O=Olympic Swimmers  
 NS=Not Specified

Study Design: R=Retrospective P=Prospective XC= Cross Sectional  
 Methods: Q=Questionnaire S=Survey IR=Injury Report E=Exam

shoulder motion extremely painful and making swimming almost impossible (Johnson et al., 1987). Other shoulder injuries that can affect a swimmer include directional instability, glenohumeral labral injuries, brachial plexus injuries, acromioclavicular joint pain, arthritis, and rotator cuff injuries (McMaster, 1999).

As shown in table 3, five studies specifically studied the frequency of shoulder injuries in competitive swimming with rates ranging from 42.3 to 136.1 injuries per 100 athletes. In one study, the majority (75%) of swimmers reported the most painful phases of the stroke were the 'pull through' and 'recovery' (Richardson et al., 1980).

McMaster & Troup (1993) reported that the frequency of shoulder injury was related to the swimmer's competitive level. Their study of 993 competitive swimmers representing three competitive levels (national aged group, senior elite development group, and US national swimming team) revealed that the US National team swimmers had the highest percent of shoulder injuries (26%) compared to both the national aged level (10%) and the senior elite level (13%) swimmers. The US National team also had the highest percentage of shoulder injury history (73%) among the three groups (McMaster & Troup, 1993).

Bak and Fauno (1997) performed complete physician examinations on 36 swimmers with a history of shoulder injuries and found that 23 swimmers had a unilateral injury and 13 had bilateral injuries. Additionally, 39 of the 49 shoulders had a positive Hawkins' test, 19 had a positive Neer test, and 13 had a painful arc. Each of these positive tests indicates that the swimmer has some form of impingement syndrome however further diagnostic tests may need to be performed. Final clinical diagnoses for 12 swimmers were classified as having a primary impingement and 25 swimmers were classified as having a secondary impingement.

McMaster et al., (1998) studied 40 swimmers from the US Swimming Senior National Team. Fourteen swimmers (35%) indicated a current shoulder injury in the questionnaire. Nine of those swimmers expressed pain bilaterally and five had pain unilaterally (McMaster, Roberts, & Stoddard, 1998).

#### *Elbow Injuries*

It is believed that the two most common elbow injuries acquired by competitive swimmers are lateral epicondylitis (inflammation of the wrist extensor muscle group that attaches to the lateral epicondyle) and medial epicondylitis (inflammation of the muscles attached to the medial epicondyle) (Fowler & Regan, 1986). However, this literature search did not reveal any studies that looked specifically at the rate or type of elbow injuries in competitive swimming.

#### *Thigh (Adductor) Injuries*

As shown in table 2, thigh and adductor muscle strains have been reported to account for about 5% of all injuries sustained in competitive swimming (McFarland & Wasik, 1996 & Grimmer et al., 1996). Two studies (as shown in table 3) have specially reported on the frequency of thigh/adductor injuries. Loosli & Quick (1992) found that 10 of 30 Division I swimmers had a history of or a present thigh injury. Their questionnaire indicated that the most common thigh injuries were defined as adductor magnus and/or brevis strains (Loosli & Quick, 1992). Grote et al. (2004) found that of the 296 swimmers who mainly participated in breaststroke ( $n=130$ ), individual medley ( $n=80$ ), or neither ( $n=86$ ), those that were classified as breaststroke swimmers had a greater adductor strain prevalence (6.92%) than either of the two other groups (Grote et al., 2004).

#### *Knee Injuries*

Knee injuries account for 5-28% of all swimming injuries (table 2). Four studies have looked specifically at knee injuries (Stulberg et al., 1980, Rovere & Nichols, 1985, Vizsolyl et al., 1987, & Hahn & Foldspang, 1998). One study (Fowler & Regan, 1986) identified "breaststroker's knee" as the most common reported swimming related knee injury. Clinically, "breaststroker's knee" occurs when the swimmer's knee is placed in a maximal valgus position causing a medial collateral ligament sprain (Fowler & Regan, 1986). Other injuries to the knee that were identified include patellar dislocation, general joint effusion, meniscus injuries, and medial synovitis (Fowler & Regan, 1986).

Stulberg et al. (1980) found that of 23 breaststroke swimmers surveyed, 10 identified a history of knee injuries relating to swimming. Further examination found 18 swimmers with tenderness over the medial facet of the patella and five of them also had pain over the medial collateral ligament (Stulberg et al., 1980). Vizsolyi et al. (1987) found that 53% of the 391 swimmers in their study had a history of knee pain and 46% of the swimmers experienced most of the pain during the first part of their kick. Rovere & Nichols (1985) found that swimmers who had more frequent knee pain had a smaller degree of internal rotation of the tibia and a smaller Q angle than those who had occasional or no knee pain (Rovere & Nichols, 1985).

#### *Ankle Injuries*

Ankle and foot injuries account for 5.7-32.5% of all injuries sustained in competitive swimming (table 2). Ankle and foot injuries in competitive swimmers are believed to be caused by the repetitive kicking motions (Kennedy et al., 1978). The most common injuries to the ankle and foot are inflammation of the extensor retinaculum and underlying extensor muscle tendons of the distal ankle (Kennedy et al., 1978). The



literature search did not reveal any studies that looked specifically at the nature and incidence of ankle injuries in competitive swimming.

### *Back Injuries*

Back injuries account for 11-37% (see table 2) of all injuries sustained as a result of participating in competitive swimming. Two studies look specifically at back injuries (see table 3). Back injuries range from minor to major injuries. Minor back injuries such as strains and spasms may force the swimmer to adjust their practice regimen by reducing their yardage and/or practicing with a completely different stroke. Major back injuries, such as spondylolysis and spondylolisthesis can significantly compromise the swimmer's ability to practice or compete and may also require corrective surgery (Kammer et al., 1999). Soler et al. (2000) found the prevalence rate of spondylolysis to be 10.23% among 176 swimmers. This is almost twice the prevalence rate of the general population which is 6.0% (Verra et al., 2009). The literature search did not reveal any studies that looked at the incidence of back injuries in competitive swimming.

### *Environmental Location*

There is a lack of research reporting on the environmental location of competitive swimming injuries. Swimming injuries not only occur in the swimming pool but in dry land training and other associated venues as well. Richardson (1999) found that of the 886 injuries reported, 42% occurred in the water, 22% occurred on the pool deck, 7% occurred outside the pool, 6% in the locker room, 5% in the bleachers, and 3% off the blocks. McFarland and Wasik (1996) found that of the 125 injuries sustained by 68 swimmers between the years of 1984 and 1991, 45% were swimming-related (both practice and competition) and 44% were related to cross-training. They also found that injury rates related to cross-training were very similar to injury rates obtained in

swimming (1.07 injuries per 1000 exposures compared to 1.05 injuries per 1000 exposures, respectively).

### When Does Injury Occur?

#### *Injury Onset*

It has been reported that the majority of swimming injuries are classified as overuse injuries (McMaster, 1996). However there is no research that reports on the relative proportions of overuse and acute injuries.

#### *Chronology*

There is very little research that investigates the timing of swimming-related injuries (e.g. timing of practice or competition, time of season, etc). Richardson (1999) found that 54% of 886 injuries occurred during competition and 32% occurred during practice (Richardson, 1999). McFarland and Wasik (1996) found that the most common injury occurring during cross-training were leg injuries, occurring 24% of the time. As for specific injuries, most swimmers (83%) stated that the shoulder pain was more bothersome during the first and middle parts of the season (Richardson et al., 1980).

### What is the Outcome?

#### *Time Loss*

Richardson et al. (1980) found that of the 58 swimmers, who complained of shoulder pain during the physician-based examination, 43 swimmers had to reduce their daily swimming yardage and 21 were forced to stop training all together. Grote et al., (2004) found that swimmers with thigh injuries missed on average 7-12 practices each season depending on their stroke preference. They also found that breaststroke swimmers were more likely to miss practice because of adductor pain (42.7%) and missed an average of 11.5 practices a season (Grote et al., 2004).

The South Australian Branch of Sports Medicine found that 75% of the total injuries sustained by 352 national swimmers were classified as minor injuries that did not restrict the swimmer from participating in competitions and practices, and 12.5% were considered major injuries requiring the swimmer to leave the competition and not finish (Grimmer et al., 1996).

Finally, Stocker et al. (1995) found that 47% of 532 collegiate swimmers and 48% of 395 master swimmers had a history of shoulder pain that lasted three or more weeks and that it was severe enough to force the swimmer to change his/her swimming routine or stop swimming altogether.

#### *Clinical Outcome*

Stoker et al. (1995) gave 532 collegiate swimmers and 395 master swimmers questionnaires to determine prevalence of shoulder pain. The results showed that collegiate swimmers (55%) were more likely to seek medical attention about their shoulder pain than master swimmers (39%). The results from this study suggest that the prevalence rate of shoulder pain does not change as the swimmer gets older and that shoulder pain can similarly affect both groups ability to swim (Stoker et al., 1995). However, this study did not account for any collegiate or master swimmers who dropped out of participating because of an injury (i.e. study of survivors only).

The literature search did not reveal any studies that reported information on catastrophic injuries, residual effects of injuries, recurrent injuries, or injuries that force the competitive swimmer to drop out of participation.

What are the Risk Factors?

#### *Intrinsic*

To date the only intrinsic risk factor that has been examined has been gender. Sallis et al. (2001) found that female swimmers were more likely to sustain an injury than male swimmers (47.08% compared to 12.37%,  $p < 0.0001$ ). The study also reported gender differences in specific injuries related to anatomical location. Female swimmers were more likely to sustain injuries to the shoulder (21.05% vs. 6.55%,  $p < 0.01$ ) and knee (5.85% vs. 1.45%,  $p < 0.01$ ) compared to their male counterparts. Both factors were statistically tested using Fisher's exact test in SPSS. A short-coming of this study, however, was that it did not use exposure-based injury rates as a basis for testing risk factors nor did it account for other risk factors that may help explain differences. Other than this study, the literature search did not reveal any studies that tested the relationship between intrinsic risk factors and the incidence of injuries in competitive swimming. Some additional intrinsic risk factors of interest may include: injury history, a positive musculoskeletal assessment, and percentage of body fat.

#### *Extrinsic*

The literature search did not reveal any studies that tested the relationship between extrinsic factors and swimming injuries. Extrinsic risk factors of interest may include swimming classification (high school or club swimmers), yardage, years of experience in competitive swimming and coaching qualifications. Equipment that may relate to increased risk of injury includes the use of hand paddles, kick boards, and flippers.

#### What are the Inciting Events?

Since swimming is such a highly repetitive sport, it is no surprise that the majority of the injuries occurring in swimming are classified as overuse injuries. The high prevalence of shoulder pain is symptomatic of the excessive wear and tear that the

shoulder complex must endure during swimming. On average, each shoulder goes through more than one million revolutions during each competitive season (Johnson, 2003). Elbow injuries are similar since they are also caused by repetitive motions, in particular the high elbow position during the pull phase of the butterfly, breast, and free style strokes. Research has demonstrated that swimmers who experience these elbow injuries have been known to compensate by dropping their elbow into the water which places more pressure on the shoulder, and makes the swimmer more susceptible to shoulder pain and inflammation (Fowler & Regan, 1986).

Lower extremity injuries occur in swimmers because of the repetitive leg motions generated by forceful kicks they complete in order to propel themselves forward in the water (Richardson, 1987). When the kick is performed multiple times during a practice or competition, an excessive valgus force begins to affect the medial collateral ligament (MCL) of the knee and an inflammatory response occurs causing pain and discomfort.

Ankle injuries are caused by the extreme plantarflexion of the ankle during each kick cycle, stretching the tendons and retinaculum beyond their normal limits (Kennedy et al., 1978).

#### Future Research

The need for future research in the area of injuries in competitive swimming arises from the gaps in the current research. These are as follows:

- Overall injury occurrence: (not specific anatomical locations) especially research that identifies overall injury rates that relate to time exposures (# of injuries per 1000 hours swimming or AEs). In addition, a more in-depth look at the timing of these injuries should also be included in research on overall injury rates.

- The lack of prospective designed studies: the majority of past research is retrospective in nature and dependent on questionnaires (i.e. subject to recall bias).
- Prevalence of pain and how it relates to injury occurrence: research in this area would also help in gathering further information about injury onset as it relates to swimming injuries.
- Injury outcomes: including time loss associated with injury, the clinical outcomes of injuries (includes information of catastrophic injuries, residual effects of injuries, recurrent injuries, dropping out of participation due to injury), and economic cost associated with injury.
- Studying risk factors associated with injuries is important because if a risk factor has been shown to relate to increased risk of injury steps can be taken to reduce or eliminate this risk factor. Examples of possible intrinsic risk factors include injury history, a positive musculoskeletal assessment, gender, and percentage of body fat. Examples of extrinsic risk factors include swimming classification (high school or club swimmers), yardage, and years in competitive swimming.

## CHAPTER III

### METHOD

#### Participants

In this study all participants were swimmers for the University of North Dakota Division I swimming team. Consent was obtained from each participant in writing, giving his/her approval to participate in the study and for access to their medical files from the UND Athletic Training Room. This sample is considered a sample of convenience. The number of participants is based on the number of swimmers who agreed to participate and maintained participation through out the entire study.

#### Study Design

As shown in Figure 1, the study was prospective cohort in nature. Baseline data, which consists of demographic information and injury history was gathered on the participants prior to the start of the competitive season. Afterward, the participants were monitored forward in time for the duration of the regular swimming season (6 months) to determine the nature and incidence of injuries. Injury was defined as one that (1) occurred as a result of participation in organized swimming practice or competition, (2) resulted in restriction of the student athlete's participation or performance and/or (3) required the student athlete to seek medical attention by a Certified Athletic Trainer or team physician. Following injury surveillance, data were analyzed to determine incidence rate and distribution of injuries. Additionally, incidence rate was used as a basis for analyzing risk factors.

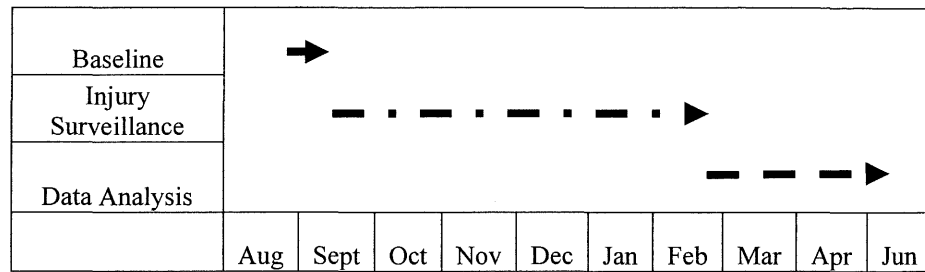


Figure One. Timeline for Prospective Study

## Instruments and Procedures

### *Pre-season*

Approval to conduct this study was obtained from the University of North Dakota Institutional Review Board. Each participant signed a consent form (Appendix A) that outlines the requirements of the study and a Health Insurance Portability and Accountability Act (HIPAA) form (Appendix B) that allowed the researcher to look into participant’s medical records in the UND Athletic Training Room. On September 8, 2009 baseline data were collected from each participant including basic demographic information such as age, gender, swimming experience, competitive level, past training regimen, and past injury history. For the majority of the swimmers (those that were with UND during the 2007-2008 season) information pertaining to past injury history was supplemented using their medical records from the UND Athletic Training Room. This injury surveillance portion of the study began the first day the UND swim team started regular season practice (September 9, 2008).

### *Pre-participation Examination*

Before any swimmer was able to start practicing, he/she was required to complete a pre-participation exam with the UND athletic training staff. This exam included a brief medical history questionnaire, anthropometric measurements (height and weight), a brief



musculoskeletal assessment, and a section to be completed by the team physician. This form varied slightly for returning swimmers versus new (freshman) swimmers. This variation shortened the musculoskeletal assessment and physician section for the returning swimmers. The information from pre-participation exams was used to assist in identifying any previous injuries that affected the swimmers.

#### *Medical History Questionnaire*

Swimmers were asked to complete a medical history questionnaire (Appendix C) which was dispensed to each individual swimmer during a 30-minute meeting held by the researcher. This questionnaire prompted the swimmers to provide information about their swimming experience and about the injuries that they incurred during the past twelve months. Information provided in this questionnaire was be used in the study to help determine whether previous injury was a risk factor for new injury.

#### *Competitive Season*

##### *Injury data*

An injury report form was designed (Appendix D) to record all injuries that the swimmer identified throughout the course of the study. This form is a modification of the form used by the NCAA Injury Surveillance System, and was modified to record swimming-related injuries. The injury report form is intended to provide an in-depth look at the injury including anatomical location, injury onset, injury mechanism, type of injury, timing of injury, and time lost from injury.

Injury incidence information was obtained as follows: (1) each week the researcher asked the Certified Athletic Trainer assigned to swimming if there were any new injuries, (2) the researcher attended practice once a week to see if there were any new injuries that were affecting the swimmers and to see how past injuries were

progressing, and (3) the swimming coach was contacted weekly and asked about swimmers who had not been practicing or had limited practice due to an injury. If the researcher was informed of any new injuries an injury report form was filled out. If the swimmer was unavailable at practice the researcher emailed the swimmer immediately after practice to enable completion of the injury report form.

#### *Exposure data*

In addition to collecting information about injury incidence the researcher also collected data that pertained to the swimmers' exposure time. The swimmers were asked to complete a weekly training log to track their attendance, time spent training, and yardage. The weekly training log was distributed to the swimmers through a packet given to them at the beginning of the study. However, there were several compliance issues which arose throughout the study. As a result, exposure data including attendance records, daily yardage, and length of practices (in hours) were obtained from the head coach.

#### Data Analysis

The study concluded at the end of the regular competitive season. When the study was finished the researcher made sure that all the injury and exposure data forms were completed for each swimmer. Once all data forms were completed, data from the entire study was entered into an Excel spread sheet to assist in transferring the data into a statistical package. Once the data were entered, various measures of central tendency were calculated and recorded into table format. In addition, both descriptive and analytical analyses were performed.

#### *Descriptive Data Analysis*

A descriptive analysis of data was ran to determine the rate and nature of injuries that affected the swimmers during an entire season (6 months). Two injury rates were calculated: (1) by dividing the total number of injuries sustained by the total number of hours trained, then multiplying this figure by 1000. This approach yielded an injury rate per 1000 hours exposure, and (2) by dividing the total number of injuries sustained by the total number of athletic exposures, then multiplying this figure by 1000. This approach yielded an injury rate per 1000 athletic exposures. In addition information on injury distribution (e.g. location, type) was calculated in terms of numbers and relative percentage of injuries. The *frequencies* and *compute variable* procedures in SPSS 16 (SPSS Inc: Chicago, IL) were used to determine the number, percentage, rate of injuries, and 95% confidence intervals.

#### *Rick Factor Analysis*

A Poisson regression model was fitted using generalized estimating equations (GEE) to estimate incidence rate ratios (IRR, 95% CI). The swimmer's individual injury rates were used as outcome variables. Predictor variables included gender, previous injury to same anatomical location, previous injury at other sites, and years swimming competitively. Each of these predictors was entered separately in an unadjusted model to estimate injury rate ratios (IRR's) for each risk factor. In addition, the risk factors were also entered into an adjusted model to compare risk factors to each other. All risk factors were included in the adjusted model because of the small sample size and few risk factors. The Poisson regression procedures in statistical package R (R Development Core Team: Auckland, New Zealand) was used to compute the IRR's in both the unadjusted and adjusted analysis.

## CHAPTER IV

### RESULTS

#### Descriptive Results

##### *Demographic Information*

Baseline data collection began on September 8, 2008, following a preseason practice. At that time forty-three swimmers were asked to participate in this study. Those interested in participating were asked to complete a participant information form and medical history questionnaire that asked about any swim-related injuries sustained during the past 12 months. Table four summarizes the participant's demographic information. Of the thirty-four swimmers who agreed to participate, 16 were male (47.1%) and 18 female (52.9%), with an overall mean age of 19.47 years ( $SD = 1.461$  years). There were 17 freshman (50% of the total participants), 6 sophomores (17.6%), 6 juniors (17.6%), and 5 seniors (14.7%). Nine swimmers decided not to participate in this study, of which 6 were female swimmers and 3 were male swimmers. In addition, five of the 9 were seniors in college and four were freshman.

Additional demographic information obtained included the age that participants started swimming competitively, how many years they had been swimming, and how many competitions they had completed in during the past twelve months. As shown in table 4 the mean age started swimming was slightly higher in male swimmers ( $M = 8.75$  yrs) than in female swimmers ( $M = 8.22$  yrs). But the total number of years swimming was slightly higher in female swimmers ( $M = 11.11$  yrs) than male swimmers ( $M = 10.88$  yrs).

Lastly, male swimmers on average participated in more competitions during the past 12 months than their female counterparts ( $M = 12.44$  competitions compared to  $M = 11.28$  competitions).

Table 4. Comparison of Participants Demographic Information by Means\*

Variable	Male	Female	Total
Number	16	18	34
Age (years)	19.62 [18-23]	19.33 [18-22]	19.47 [18-23]
Height (inches)	72.31 (2.63)	66.39 (2.91)	69.18 (4.06)
Weight (lbs)	176.38 (16.88)	142.67 (17.78)	158.53 (24.16)
Age Started	8.75 [3-16]	8.22 [4-12]	8.47 [3-16]
Years Swimming	10.88 (4.29)	11.11 (2.59)	11 (3.44)
# of Competitions (Previous 12 months)	12.44	11.28	11.82

\*Mean values are noted with ranges in brackets and standard deviation in parentheses

### *Injury History*

In addition to the demographic information, information on medical history of swim-related injuries from the past twelve months was obtained. Seventeen of the 34 (50%) swimmers, including 7 males and 10 females, reported a total of 23 injuries in the 12 months prior to completing the questionnaire. Nine injuries were sustained by male swimmers and 14 injuries were sustained by female swimmers. A percent distribution of anatomical location of these injuries is provided in table 5. The most common anatomical locations were the shoulder, accounting for 11 (47.9%) injuries and the knee accounting for 5 (21.8%).

A percent distribution of injuries by injury type is provided in table 6. As shown, the most common type of injury sustained in the year prior to the swim season was shoulder impingement, accounting for 11 (47.8%) injuries followed by patellar tendonitis accounting for 5 injuries (21.8%).

Table 5. History of Injury  
A Percent Distribution by Anatomical Location

Location	Total N of Injuries	% of Total Injuries
Neck	1	4.3
Shoulder	11	47.9
Low Back	2	8.7
Thigh	1	4.3
Knee	5	21.8
Ankle	2	8.7
Upper Leg	1	4.3
Total	23	100

Table 6. History of Injury  
A Percent Distribution by Injury Type

Location	N of Injuries	% of injuries
Neck Strain	1	4.3
Shoulder Impingement	11	47.9
Low Back Strain	2	8.7
Femur Fracture	1	4.3
Patellar Tendonitis	5	21.8
Sprained Ankle	1	4.3
Ankle Tendonitis	1	4.3
Hamstring Strain	1	4.3
Total	23	100

### *Injury Rates*

The prospective portion of this study began on September 9, 2008, which was the first day of the regular swimming season. During the study period (9/9/09 – 2/28/09), exposure data were gathered from the following sources: practice attendance records, training logs (yardage per practice), length of training sessions, and injury report forms for injuries sustained during the study period. From these data, the researcher was able to determine number of athletic exposures (AEs) accumulated by each participant during the season, an estimated number of yards that each swimmer completed during practices

throughout the season (based on coach records), how many injuries each participant sustained, and extensive information on the nature of injuries sustained.

The exposure and injury data are summarized in Table 7. Examination of this table reveals that there were a total of 5,585 athletic exposures accumulated by the 34 swimmers. Of the 5,585 athletic exposures, practice accounted for 5,206 AEs and competitions accounted for 379 AEs. As for yardage, the participants swam a combined total of 22,346,909 yards during practice throughout the season. In addition, the participants accumulated an estimated 10,180 hours of practice time.

Table 7. Exposure and Injury Rate Data

Subjects	n	No. of Injuries	Rate			Rate		
			AE's	per 1000 AE's	95% CI (low/high)	Hours	per 1000 Hours	95% CI (low/high)
Male	16	13	2614	4.97	2.16/8.10	4752.9	2.74	1.16/4.49
Female	18	18	2971	6.06	3.17/10.22	5427.8	3.32	1.72/5.58
Overall	34	31	5585	5.55	3.73/8.18	10180.7	3.04	2.04/4.49

AEs = Athlete Exposures (One Athlete Swimming in One Practice or Competition)

As shown in Table 7, twenty of the 34 participants (58.8%) sustained a total of 31 injuries during the study period. Of the 31 injuries sustained 13 injuries were incurred by 9 male swimmers and 18 injuries were incurred by 11 female swimmers. Fourteen swimmers (41.2%) did not sustain an injury during the season, 11 swimmers (32.4%) sustained one injury, 8 swimmers (23.5%) sustained 2 injuries, and one swimmer (2.9%) sustained four injuries.

Two different injury rates were calculated. The overall injury rate for athletic exposures was 5.55 injuries per 1,000 athletic exposures. All injuries were sustained

during practice and training sessions therefore a separate injury rate for practice and competition AEs was not calculated. The overall injury rate for hours practiced was 3.04 injuries per 1,000 hours practiced. Injury rates were higher for female swimmers, both when rates were calculated with reference to AEs (6.06 vs. 4.97) and hours of practice (3.32 vs. 2.74). However the differences were not significant.

### *Injury Location*

Table 8 displays a percent comparison of injuries by anatomical location and gender. The most common locations were shoulder accounting for 12 injuries (38.7%), back for 5 injuries (16.1%), and knee for 4 injuries (12.9%). The most common anatomical location for both male and female swimmers was the shoulder, accounting for 6 injuries each. However, the second most common anatomical location for male swimmers was the back (3 injuries) whereas it was the ankle for the female swimmers (4 injuries).

Table 8. A Percent Comparison by Anatomical Location

Location	Overall		Males		Females	
	N	%	N	%	N	%
Neck	1	3.2	0	0	1	5.6
Shoulder	12	38.7	6	46.2	6	33.3
Back	5	16.1	3	23.0	2	11.1
Knee	4	12.9	1	7.7	3	16.7
Ankle	4	12.9	0	0	4	22.2
Upper Leg	3	9.7	1	7.7	2	11.1
Groin	2	6.5	2	15.4	0	0
Total	31	100	13	100	18	100

### *Injury Type*

A percent comparison of the specific type of injury sustained by the participants in this study is shown in table 9. Injury type is defined as the exact injury that the



participant was diagnosed as having by the Certified Athletic Trainer or team physician. The most common injury type was shoulder impingement which accounted for 6 injuries (19.4%). Shoulder impingement/bicipital tendonitis was the second most common injury type. This injury type was sustained by 5 participants and accounted for 16.1% of the total injuries. Another common injury type was ankle tendonitis. This injury type was found in 4 swimmers and accounted for 12.8% of all the injuries.

Table 9. A Percent Comparison by Injury Type

Injury Type	Overall		Males		Females	
	N	%	N	%	N	%
Tendonitis	18	58	6	46.2	12	66.6
Shoulder Impingement	6	19.4	4	30.8	2	11.1
Bicipital Tendonitis	1	3.2	1	7.7	0	0
Bicipital Tendonitis & Impingement	5	16.1	1	7.7	4	22.2
Patellar Tendonitis	2	6.5	0	0	2	11.1
Ankle Tendonitis	4	12.8	0	0	4	22.2
Strain	11	35.5	6	46.1	5	27.8
Back Strain	5	16.1	3	23.0	2	11.1
Neck Strain	1	3.2	0	0	1	5.6
Hamstring Strain	3	9.7	1	7.7	2	11.1
Groin Strain	2	6.5	2	15.4	0	0
Sprain	2	6.5	1	7.7	1	5.6
LCL Sprain	2	6.5	1	7.7	1	5.6
Total	31	100	13	100	18	100

Table 9 also shows a percent comparison of injury type by gender. The most common injury type for male swimmers was shoulder impingement, which accounted 4 of the 13 injuries (30.8%). Back strains were the second most common injury type in male swimmers, which accounted for 3 of the 13 injuries (23.1%). As for female swimmers, the most common injury types were ankle tendonitis and the combination of shoulder impingement and bicipital tendonitis, each accounting for 4 of the 18 injuries

(22.2%). These were followed closely by shoulder impingement, patellar tendonitis, back strain, and hamstring strain, each accounting for 2 injuries (11.1%).

### *Injury Onset*

Injury onset is typically divided into two main categories: acute and overuse injuries. Acute injuries are classified as those that occur suddenly without prior pain or discomfort (i.e. MCL sprain) and overuse injuries are those that occur as a result of repetitive motion and/or impact on the particular area and usually occur with gradual increase in pain and discomfort (i.e. bicepital tendonitis). It is thought that because of swimming's highly repetitive nature, more overuse injuries will be sustained than acute injuries. As shown in Table 10, overuse injuries occurred more frequently, accounting for 18 of the 31 injuries (58.1%). Acute injuries accounted for 13 injuries (41.9%). Of the 13 injuries sustained by male swimmers, acute onset injuries were more common, 7 injuries (53.8%), compared to overuse injuries, 6 injuries (46.2%). In female swimmers overuse onset, with 12 injuries (66.7%) was twice as frequent as acute onset, with 6 injuries (33.3%).

Table 10. A Percent Comparison of Injury Onset

Injury Onset	Overall		Males		Females	
	N	%	N	%	N	%
Acute	13	41.9	7	53.8	6	33.3
Overuse	18	58.1	6	46.2	12	66.7
Total	31	100	13	100	18	100

Further analysis shows that all 12 shoulder injuries (66.7% of all overuse injuries) were classified as overuse injuries, making it the most common anatomical location for overuse injuries. As for acute injuries the back was the most common anatomical location with 5 injuries (38.5%). In addition, the most common overuse injury was shoulder

impingement, 6 injuries (33.3%). Back muscle strains (5 injuries [38.5%]) were the most common acute injury.

### *Injury Classification*

Injury classification was used to differentiate if the injury was a new injury or if the swimmer had previously experienced a similar injury. The three categories that were used to classify an injury were: (1) new injury, (2) recurrence of injury from previous swim season, and (3) recurrence of injury from the current season. For the purpose of this study, recurrence of injury was defined an injury that occurs to the same body part and is the same injury type as one that had previous occurred. However, in many cases a re-injury is more severe than the first injury.

The most common injury classification was new injury, accounting for 19 injuries (61.3%). Of those injuries 7 were sustained by male swimmers and 12 by female swimmers. The second most common injury classification was recurrence of injury from previous season, accounting for 10 injuries (32.2%). Lastly two injuries (6.5%) were classified as a repeat injury from the current season.

### *Mechanism of Injury*

During the study period there were three distinctive injury mechanisms: (1) repetitive motion, (2) weight lifting, and (3) dry-land training, such as running and agility. However, an additional category (no specific reason) was added for those injuries where the swimmer was unable to identify a specific injury mechanism. Table 11 displays a percent comparison of mechanism of injury. Overall, the most common mechanism was repetitive motion which accounted for 19 of the 31 injuries (61.3%) sustained during the season. In addition, repetitive motion was the most common mechanism for both male (10 injuries) and female (9 injuries) swimmers.

Table 11. A Percent Comparison of Mechanism of Injury (MOI)

MOI	Overall		Males		Females	
	N	%	N	%	N	%
No Specific Reason	5	16.1	2	15.4	3	16.7
Repetitive Motion	19	61.3	10	76.9	9	50.0
Weight Lifting	3	9.7	1	7.7	2	11.1
Dry-land Training	4	12.9	0	0	4	22.2
Total	31	100	13	100	18	100

*Time Loss*

For this study, time loss was calculated based on the number of practices that the swimmer either missed completely or did not participate in fully because of an injury. The time loss was divided into three main categories: less than 7 days, 7-21 days, and more than 21 days. Table 12 shows a percent comparison of time loss associated to injuries. The most common time loss category was less than 7 days, which accounted for 18 injuries (58.1%). Of those 18 injuries, 8 occurred to male swimmers (61.5% of all male injuries) and 10 occurred to female swimmers (55.6% of all female injuries).

Table 12. A Percent Comparison of Time Loss

Time Loss	Overall		Males		Females	
	N	%	N	%	N	%
Less than 7 Days	18	58.1	8	61.5	10	55.6
7 to 21 Days	6	19.3	3	23.1	3	16.6
More than 21 Days	7	22.6	2	15.4	5	27.8
Total	31	100	13	100	18	100

Further analysis shows that the back and ankle, each accounting for 4 injuries (22.2%) are the most common injury locations for the time category of less than 7 days. These are followed by the shoulder and knee, accounting for 3 injuries each (16.7%). In the more than 21 days time loss category, the shoulder was the most common injury location accounting for 6 injuries (85.7%).

As for injury type, ankle tendonitis and back strain were the most common injury type for the less than 7 days time loss category. As for the second category (7-21 days), shoulder impingement was the most common injury type, accounting for 2 of the 6 injuries (33.3%). Additionally, the two most common injury types for the more than 21 days lost were shoulder impingement and the combination of bicepital tendonitis and shoulder impingement, each accounting for 3 of the 7 injuries (42.9%). Lastly, both overuse (8 injuries (44.4%)) and acute injuries (10 injuries (76.9%)) were more frequently related to fewer than 7 days of time loss than the other two categories.

#### Risk Factor Data Analysis

Risk factors of interest in this study included gender, years swimming competitively, a history of injury to any body part, and a history of injury to the same body part that was injured in the study. These risk factors were analyzed in both an unadjusted (risk factors analyzed alone) and adjusted (risk factors analyzed with others) Poisson regression model that was fitted using general estimating equations to estimate incidence rate ratios. Any risk factors that had a *p*-value of  $< .02$  were considered statistically significant.

Table 13 shows both the unadjusted and adjusted results of the regression and identifies the injury rate ratio per 1000 hours training for each risk factor. History of any injury and history to a specific body part were found to be statistically significant. Having a history of any injury was associated with nearly four times increase in injury rate (IRR= 3.79, 95% CI= 1.59, 9.05) than not having a history of injury, before adjusting for the other factors. This number decreases (IRR= 2.86, 95% CI= 1.23, 6.64) after adjustment for other factors. As for swimmers with a history of injury to the same specific body part the unadjusted injury rate was almost two and half times higher (IRR= 2.42, 95% CI=

1.73, 3.40) than for those that did not have a history. When this risk factor is adjusted to account for the other risk factors, swimmers with a specific history of injury had more than one and half times the risk (IRR=1.67, 95% CI= 1.21, 2.31) of injury than those that did not have this history.

Both gender and number of years competing in swimming were found to be statistically non-significant predictors of injuries. However, male swimmers were found to be less likely to sustain an injury than female swimmers in both the unadjusted (IRR= 0.69, 95% CI= 0.34, 1.42) and adjusted (IRR= 0.78, 95% CI= 0.49, 1.23) models. However, these differences were not tested statistically.

As for injury rate ratios per 1000 AEs, Table 14 shows both the unadjusted and adjusted analysis of the risk factors. Similar to the rates per 1000 hours, history of any injury significantly increased the swimmer's rate of injury more than three and a half times (IRR= 3.64, 95% CI= 1.51, 8.73) in the unadjusted model and more than two and a half times (IRR= 2.74, 95% CI= 1.18, 6.37) after adjusting for the other risk factors. In addition, history of injury to the same specific body part was found to have almost a two and a half times increase (IRR= 2.46, 95% CI= 1.75, 3.46) in the unadjusted estimate and almost a twofold increase in the adjusted model (IRR= 1.75, 95% CI= 1.25, 2.45).

Once again, both gender and years competing were not found to be significant predictors. Like the previous model, male swimmers still had a lower injury rate than female swimmers in both the unadjusted and adjusted model (IRR= 0.72, 95% CI= 0.35, 1.48). However, these differences were not tested statistically.

Table 13. Risk Factors Analysis of Injury Rate Ratios (IRRs) per 1000 Hours

Risk Factor	Unadjusted			Adjusted		
	IRRs	95% CI	P Value	IRRs	95% CI	P Value
Gender			0.3188			0.2815
Female	Reference			Reference		
Male	0.96	0.34, 1.42		0.78	0.49, 1.23	
Year Swimming	1.08	0.96, 1.21	0.2051	1.04	0.99, 1.09	0.1568
Any History of Injury			0.0028			0.0147
No	Reference			Reference		
Yes	3.79	1.59, 9.05		2.86	1.23, 6.64	
Specific History of Injury			<0.0001			0.0020
No	Reference			Reference		
Yes	2.42	1.73, 3.40		1.67	1.21, 2.31	

Table 14. Risk Factors Analysis of Injury Rate Ratios (IRRs) per 1000 AE's

Risk Factor	Unadjusted			Adjusted		
	IRRs	95% CI	P Value	IRRs	95% CI	P Value
Gender			0.3706			0.3721
Female	Reference			Reference		
Male	0.72	0.35, 1.48		0.81	0.50, 1.29	
Year Swimming	1.07	0.95, 1.20	0.2752	1.03	0.98, 1.08	0.2834
Any History of Injury			0.0039			0.0188
No	Reference			Reference		
Yes	3.64	1.51, 8.73		2.74	1.18, 6.37	
Specific History of Injury			<0.0001			0.0012
No	Reference			Reference		
Yes	2.46	1.75, 3.46		1.75	1.25, 2.45	



## CHAPTER V

### DISCUSSION

#### Descriptive Analysis

##### *Injury Rate*

Table 15 shows a comparison between this study and the previously published studies about swimming-related injuries. To date, there is only one published study that reported the rate of injuries per 1000 athletic exposures (AEs). McFarland & Wasik, 1996 computed retrospectively an injury rate of 1.05 injuries per 1000 AEs. However, in this study the researcher was able to compute prospectively a much higher injury rate of 5.55 injuries per 1000 AEs. The high rate reported in this study may reflect the prospective nature of follow up and the use of a Certified Athletic Trainer to collect data. No previously published studies have reported injury rate as a function of time exposure (per 1000 hours). However, this study reported an injury rate of 3.04 injuries per 1000 hours.

As for injury rates by gender, this study found that female swimmers had higher injury rates than males swimmers for both reported injury rates, AEs and hours (6.06 vs. 4.97 and 3.32 vs. 2.74 respectfully). However, these differences were not tested statistically. Similarly, Sallis et al. (2001) reported that overall female swimmers had a significantly higher injury rate per 100 athletes than male swimmers (47.08 vs. 12.37).

In addition to swimming related research, there have been several studies that looked at the injury rate in other collegiate "overhead" sports with similar reported injuries. These sports include baseball, softball, and volleyball. Table 16 shows a

Table 15. Overall Injury Rates in Competitive Swimming

Authors	Year	Study Design	Method	Gender	Level	N of Swimmers	N of Injuries	Rate per 100 Athletes*	Rate per 1000 AEs	Rate per 1000 Hours
Kennedy et al.	1978	R	S		O	35	43	122.9		
		R	Q		NS	2496	261	10.5		
Mutoh et al.	1988	R	Q	10F 9M	E/N	19	37	194.7		
Bak et al.	1989	R	Q		NS	268	100	37.3		
Lanese et al.	1990	P	IR	21F 36M	C	57	29	50.9		
Grimmer et al.	1996	R	Q	193F 159M	N	352	16	4.5		
McFarland & Wasik	1996	L	S	68F	C	68	56	82.4	1.05	
Richardson	1999	R	S		A	1500	886	59.1		
THIS STUDY	2009	P	IR	16M 18F	C	34	31	91.2	5.55	3.04

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A=Age Group Swimmers  
 C=Collegiate Swimmers  
 E=Elite Swimmers  
 M=Masters Swimmers  
 N=National Swimmers  
 O=Olympic Swimmers  
 NS=Not Specified

Study Design R=Retrospective P=Prospective L= Longitudinal  
 Methods Q=Questionnaire S=Survey IR=Injury Report E=Examination

\* This number was manually calculated from the data

comparison of injury rates in these sports and the injury rate from this study. All three similar sports reported higher injury rates than this study. Both baseball and softball had the highest injury rates which may be because both baseball and softball average about 42 games a season where swimming only averages about 11 competitions a season. As for volleyball, the injury rate was still slightly higher than that of swimming however, similar injuries, such as tendonitis and back strains were observed in both volleyball and swimming. Other previous research compared injury rates per 100 athletes by gender in basketball, track, swimming, soccer, tennis, water polo, and cross country. They reported that overall, female athletes had a higher injury rate than male athletes (52.45 vs. 47.68) (Sallis et al., 2001). Basketball was found to have the highest overall injury rate per 100 athletes for both male (126.94) and female (112.04) athletes (Sallis et al., 2001).

#### *Injury Location*

Table 17 shows the percent comparison by anatomical location for previous published studies and this study. Like similar studies (Kennedy et al., 1978, Grimmer et al., 1996 & McFarland & Wasik, 1996), this study identified the shoulder as the most common anatomical location for injuries. In addition, the percentage of shoulder injuries sustained in this study was within the range of percentages that the other studies observed (3-55% were shoulder injuries). This study found that 38.7% of all injuries sustained in the swimming season were to the shoulder. This high percentage of shoulder injuries would be expected because of the highly repetitive motion that the shoulder experiences during a swimming season. In addition, this study found that female swimmers had a higher percentage of shoulder injuries (46.2%) compared to male swimmers (33.3%). However this difference was not tested statistically. Similar findings were reported by

Table 16. A Comparison of Injury Rates in Other Collegiate Sports

Author	Year	Sport	Injury Rate Per 1000 AE's
Dick et al.	2007	Baseball	7.4
Marshall et al.	2007	Softball	7.3
Agel et al.	2007	Volleyball	6.2
THIS STUDY	2009	Swimming	5.55

Table 17. A Percent Distribution of Injuries by Anatomical Location

Authors	Year	Study Design	N of Athletes	N of Injuries	Head/ Neck	Shoulder	Arm/ Hand	Thigh/ Adductor	Knee	Ankle/ Foot	Back	Other
Kennedy et al.	1978	R	35	43		37			28	19		16
		R	2496	261		31			26.8	32.5		9.7
Mutoh et al.	1988	R	19	37	3	31.3	3		20	5.6	37.1	
Grimmer et al.	1996	R	352	16		47	5.8	5.8	23.5		17.4	0.5
McFarland & Wasik	1996	L	68	56	7	55	4	5	11		18	
Richardson	1999	R	1500	886	26	3	18		5	32	3	13
THIS STUDY	2009	P	34	31	3.2	38.7		6.5	12.9	12.9	16.1	9.7

Study Design: R=Retrospective P=Prospective L= Longitudinal

Sallis et al. (2001) who found that female swimmers had a significantly higher shoulder injury rate (per 100 athletes) than male swimmers (21.05 vs. 6.55).

Other studies reported the highest percentage of injuries involved the back (Mutoh et al., 1988) and ankle (Richardson, 1999). Although these locations were not found to have the highest percentages in this study, each anatomical location was within the ranges that the previous research observed. In this study, 12.9% of all injuries involved the ankle which could be due to the forceful kicking motion during swimming. The percentage of back injuries sustained by the participants of this study was (16.1%) and interestingly only two of the 5 back injuries occurred during weight lifting activities. Back injuries in swimming are relatively common because of the high stress placed on the back during the breathing phases of specific strokes (such as the breaststroke, backstroke, and freestyle) and during flip-turns.

This study reports only 12.9% of the injuries sustained in the season were related to the knee. This finding was unexpected because the majority of the previously published studies found much higher percentage of knee injuries (20-28% of injuries). It would be expected to find higher proportion of knee injuries because of the chronic stress placed on the knee during kicking, especially with breaststroke. However the majority of swimmers at the collegiate level may perform preventative measures to reduce the occurrence of knee pain during the season.

#### *Injury Type*

This study showed that the most common injury type associated with swimming was tendonitis. In total, eighteen of the 31 injuries were classified as tendonitis. The most common form of tendonitis was shoulder impingement, which is a specific form of tendonitis that affects the rotator cuff tendons within the shoulder. Previous research has

identified “swimmers shoulder” as a common injury affecting competitive swimmers (Johnson et al., 1987). “Swimmers shoulder” is defined as an impingement syndrome that affects either the supraspinatus muscle tendon, biceps brachii tendon or both (Johnson et al., 1987). This particular diagnosis was not specifically used in this study; however, similar injuries were identified as being problematic. These included shoulder impingement, bicipital tendonitis, and the combination of shoulder impingement and bicipital tendonitis. Previous research states that the higher incidence of tendonitis in the shoulder complex compared to other locations demonstrates the intense stress that is placed on the shoulder during swimming. (Ciullo & Stevens, 1989)

Another area affected by tendonitis was the ankle which accounted for 4 of the 18 tendonitis injuries. Past research has identified inflammation of the extensor retinaculum and underlying extensor muscle tendons of the distal ankle as the most common injury type related to the ankle (Kennedy et al., 1978). Similarly, another study reported that tendonitis most commonly occurs to the extensor tendons because of the swimmers excessive stretching of the anterior compartment of the lower leg in hopes of achieving greater ankle flexibility (Johnson, Sim, & Scott, 1987) Although no specific tendon was identified within this study, tendons that assist in the plantarflexion and dorsiflexion of the ankle are most commonly affected by this type of injury.

In this study, female swimmer incurred a higher percentage of tendonitis type injuries than male swimmers (66.6% vs. 46.2%). However, this apparent difference was not tested statistically. Currently there is no additional swimming related research that looks specifically at gender and injury type.

Strains, accounting for 11 of the 31 injuries, were the next most common injury type in this study. Locations for these strains included the back, neck, hamstring, and

groin. According to previous research, back strains are common in swimming and should be monitored to make sure that the swimmer doesn't have a more serious injury such as spondylolysis and spondylolisthesis (Kammer et al., 1999). No swimmer in this study sustained either; however, two swimmers complained regularly of intense back pain that forced them to reduce their swimming and seek the advice of a team physician. In addition, another study found an increase in strains of the lumbar fascia in lower back in swimmers. That study identified a lack of lumbar flexibility as the main cause of this increase in back strains (Richardson, 1999)

As for hamstring and groin strains, these can be associated with the kicking forces that are produced by swimmers. Previous research reported that these strains account for 5% of all injuries sustained in competitive swimming (McFarland & Wasik, 1996 & Grimmer et al., 1996). Another study (Grote et al., 2004) found that swimmers who compete regularly in breaststroke events had a higher percentage of groin strains (42.7%) than any other swimmer. This study was not able to separate the swimmers by stroke but based on information from the participants those affected by groin strains did compete regularly in breaststroke events. No studies were found that looked specifically at hamstring strains.

#### *Injury Onset*

To date, there has been minimal research conducted on the different types of injury onset and their relation to swimming injuries. Previous researchers (McMaster, 1999) have only speculated that the majority of swimming related injuries are overuse in nature. This study was able to reinforce this by finding that the majority of the injuries sustained in the season were overuse injuries. However, the percentage of overuse injuries was not far above that of the percentage of acute injuries (58.1% of injuries were

overuse and 41.9% were acute). Perhaps different from other studies, the acute injuries sustained in this study were not necessarily the typical traumatic acute injuries such as broken bones. In this study, acute injuries included muscle strains and sprains. These were classified as acute injuries because of the sudden onset of pain. However, some injuries such as strains may be classified as acute because of the sudden onset of pain but may actually be overuse in nature because of the slow progression of trauma to the muscle from the repetitive motions in swimming.

#### *Time Loss*

Time loss associated with an injury can vary based on several different factors including the severity of the injury, the athlete's compliance to treatment, the athlete's perception of pain, and the overall healing process. For instance, one may think that an overuse shoulder injury may require a swimmer to sit out of practice longer than a sprained ankle. Previous research has reported that the majority of injuries affecting swimmers were minor with very little to no time loss (Grimmer et al., 1996). This study reported that 18 of the 31 injuries required less than 7 days time loss. Within this category, the most common anatomical locations were the back and ankles with 4 injuries each followed by shoulder and knee with 3 injuries and lastly the hamstring and groin with 2 injuries each. A high number of injuries within this category may demonstrate the swimmer's drive to train and compete within the sport they are so passionate about.

As for the more than 21 days time loss, Stocker et al. (1995), reported that swimmers experiencing shoulder pain were more likely to sit out for extended periods of time (3 weeks or more) than those that did not experience shoulder pain. Similarly, in this study it was reported that overuse shoulder injuries were associated with the highest amount of time loss. This high amount of time loss could be because of the highly



repetitive nature of swimming or the difficulty treating inflammation within the shoulder because of its anatomical structure. An excessive amount of time loss (21 days or more) is very problematic because it adversely affects the swimmers training and performance in the swimming season.

As for gender differences based on time loss, this study reported that female swimmers had a higher percentage of injuries that required more than 21 days time loss than male swimmers (27.8 vs. 15.4%). However, this apparent difference was not tested statistically. In addition, based on percentages of overall injuries male swimmers had a higher percentage (61.5%) of injuries that required less than 7 days time loss than female swimmers (55.6%). However, this apparent difference was not tested statistically. To date there has been no published swimming related studies that compared gender difference and time loss.

Other studies that looked at similar sports reported time loss as anything that required more than 10 days of time loss as the most severe category. Studies reporting injuries in baseball, softball, and volleyball found that lower extremity injuries were most commonly associated with more than 10 days time loss (Dick et al., 2007, Marshall et al., 2007, & Agel et al., 2007). However, this study reported that shoulder injuries, accounting for 9 injuries, were most commonly associated with 7 days of time loss or more.

#### Risk Factor Analysis

The risk factor analysis for this study was completed using the Poisson regression fitted using generalized estimating equations and showed that both a history of any injury and a history of injury to a specific body part significantly predicted an increase in the risk of injury per 1000 hours and per 1000 AEs. This increase is evident in the large

number of overuse injuries that the swimmers sustained during the study period. Perhaps these were old injuries that never fully healed and/or were never fully treated/rehabilitated. As for gender, although not statistically significant, this study was able to report that female swimmers had a higher injury rate than male swimmers with both injury rate categories.

To date, there has been only one study that examined risk factors associated with injuries in competitive swimming. Those authors found that female swimmers were more likely to sustain an injury than male swimmers (Sallis et al., 2001). However, the authors only calculated injury rates per 100 athletes and did not account for any time exposure. This study found similar findings in both the unadjusted and adjusted models for both injury rates per 1000 hours training and per 1000 AEs. No other studies have looked at risk factors associated to injuries in competitive swimming.

As for studies that looked at other sports, Knowles et al. (2006) reported on risk factors of injuries in football, soccer, basketball, track, baseball, softball, wrestling, and volleyball. Researchers reported that athletes with a previous injury had almost three times the injury rate in the unadjusted model and twice the injury in the adjusted model than athletes with no previous injury. As for gender, the researchers didn't look at gender differences overall however, they did break down specific sports based off gender (i.e. basketball, track, and soccer). For instance, baseball and softball players have similar injury rates in both the unadjusted (0.95 vs. 0.96) and the adjusted models (0.26 vs. 0.28) (Knowles et al., 2006).

#### Suggestions for Future Research

This is one of only two studies that reported the incidence rate of injuries that affect intercollegiate swimmers. In addition, it is the only current study that is a

prospective cohort design. Therefore, future research in this area should include the following:

- Additional prospective cohort studies that follow the swimmers forward in time over longer periods of time to record injuries as they occur.
- Studies that look at different age groups such as high school, elite, masters, Olympic, etc.
- Comparing injuries across different levels of competitive swimming.
- Studies that involve a larger number of participants such as including a larger team or including more than one team or conference.
- Studies that look at the difference in injuries that occur during practices as oppose to competitions
- Additional studies that analyze risk factors including body composition, most common stroke used, coaching qualifications, and training devices (kick boards).
- Randomized clinical trails that identify and evaluate specific preventative measures

### Conclusion

For years, injuries have been known to affect a swimmers ability to perform at the top of their abilities yet surprisingly, there is still very little research that looked at these injuries. This study was designed to add to current literature and some interesting data relating to injuries in competitive swimming was found. For instance, this study calculated an injury rate of 5.55 injuries per 1000 athletic exposures and 3.04 injuries per 1000 hours. This number is relatively similar to those that are seen in other studies and in

other sports with similar injuries. This study also identified that overuse shoulder injuries were the most problematic for swimmers followed by overuse injuries to the knees and ankles and acute back strains. Of the risk factors that were examined in this study, both history of any injury and history of injury to the same specific body part were found to be significant predictors of swimming-related injuries. This study contributed to the current literature by providing prospective data collection, injury rates in hours and AEs and significant risk factors. However, further research is still needed to examine swimming related injuries and their risk factors more closely to hopefully reduce injury occurrence to a minimum.

APPENDICES

Appendix A  
Informed Consent

**Title:** Injuries in Competitive Swimming: Incidence and Risk Factors

**Principal Investigator:** Kristin Chase, Graduate Student, Department of Physical Education, Exercise Science, & Wellness, University of North Dakota, (651) 303-0791, kristin.chase@und.nodak.edu. Student's Advisor, Dr. Dennis Caine, University of North Dakota, (701) 777-4041.

**Invitation to Participate:** You are invited to participate in a research study on injuries affecting the University of North Dakota swimmers during the 2008-2009 season.

**Statement of Research:** A person who is to participate in the research must give his or her informed consent to such participation. This consent must be based on an understanding of the nature and risks of the research. This document provides information that is important for this understanding. Research projects include only participants who choose to take part. Please take your time in making your decision as to whether you wish to participate. If you have questions at any time, please ask.

**Purpose of Research:** The purpose of this research study is to determine the nature and rate of injuries that affect competitive swimmers throughout the regular season and to determine the relationship between injuries and specific risk factors such as gender, previous years of competitive swimming, previous injuries, and yardage. This research is important because to date there has been little research that looks at the incidence of injuries in competitive swimming and the risk factors that are associated with these injuries.

**Length of the Study:** Your participation in the study will last one complete regular season of competitive swimming. You will be contacted by the researcher once a week to fill out a training log and to discuss in private any pain or injuries that you have experienced during the previous week. Depending on the extent of the pain and/or injuries, it may take anywhere from 10 to 30 minutes to complete. The study will end at the end of the regular season of UND swimming.

**What Will Happen During This Study:** For the first part of the study you will be asked to complete a medical history questionnaire that asks about injuries that you may have sustained during the past 12 months as a result of participating in swimming practices or competitions. This questionnaire will take between 10 to 20 minutes to complete.

The second part of the study will involve observing and recording any injuries that you sustain during the season. You will be contacted weekly to discuss new or persistent injuries that you may have experienced. You will be asked to fill out an injury report that asks several questions about the details of any pain or injury that you are currently experiencing (separate form for pain and injury). In addition you will also be asked to complete a weekly training log that will request information about your training regimen for the past week.

**Risks of the Study:** This study is intended to just observe and record any pain nor injuries that occur during the season, there are no foreseeable risks to the participants.

**Benefits of the Study?** You may not benefit personally from being in this study. However, we hope that, in the future, other people might benefit from this study because it will give both coaches and swimmers in-depth data on the types of injuries, the nature and incidence of injuries, and risk factors that may increase their risk of injury.

**Confidentiality:** All your data and information obtained through forms will remain confidential. Your identity will be withheld from data files, sheets, and analyses through the use of a numeric coding system. In addition, you will not be identified in any reports about this study that might be published. All data will be retained for a period of 3 years following completion of this study in a locked container in the PXW office. Any information that is obtained in connection with this study and can be identified with you will remain confidential and will be disclosed only with your written permission.

**Voluntary Participation:** Your decision whether or not to participate is completely voluntary and no penalties will result from refusal to participate. Your decision whether or not to participate will not affect your current or future relations with the University of North Dakota. If you decide to participate, you are free to discontinue participation at any time without it being held against you. To discontinue participation, tell the researcher that you do not wish to continue with this project.

**Contacts and Questions?** The researcher conducting this study is Kristin Chase, a UND graduate student in the physical education, exercise science, and wellness department. You may ask any questions you have now. If you later have questions, concerns, or complaints about the research please contact Kristin Chase at (651) 303-0791. You may also contact my thesis advisor, Dr. Dennis Caine, at (701) 777-4041

If you have questions regarding your rights as a research participant, or if you have any concerns or complaints about the research, you may contact the University of North Dakota Institutional Review Board at (701) 777-4279. Please call this number if you cannot reach research staff, or you wish to talk with someone else.

**Agreement:** Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Participant's Name: \_\_\_\_\_

\_\_\_\_\_  
Signature of Participant

\_\_\_\_\_  
Date

Appendix B

**HIPAA<sup>1</sup> AUTHORIZATION TO USE AND DISCLOSE  
INDIVIDUAL HEALTH INFORMATION FOR RESEARCH PURPOSES**

---

- 1. Purpose.** As a research participant, I authorize Kristin Chase to use and disclose my individual health information for the purpose of conducting the research project entitled: Injuries in Competitive Swimming: Incidence and Risk Factors.
- 2. Individual Health Information to be Used or Disclosed.** My individual health information that may be used or disclosed to conduct this research includes: medical information that pertains to injuries that are either sustained as a result of participating in swimming or injuries that restrict or hinder your ability to participate fully in swimming practices or competitions.
- 3. Parties Who May Disclose My Individual Health Information.** The researcher may obtain my individual health information from medical files contained in the UND Athletic Training Room or from you, the participant, themselves.
- 4. Parties Who May Receive or Use My Individual Health Information.** The individual health information disclosed by parties listed in item 3 and information disclosed by me during the course of the research may be received and used by Kristin Chase.
- 5. Right to Refuse to Sign this Authorization.** I do not have to sign this Authorization. If I decide not to sign the Authorization, I may not be allowed to participate in this study or receive any research related treatment that is provided through the study. However, my decision not to sign this authorization will not affect any other treatment, payment, or enrollment in health plans or eligibility for benefits.
- 6. Right to Revoke.** I can change my mind and withdraw this authorization at any time by sending a written notice to Kristin Chase at [kristin.chase@und.nodak.edu](mailto:kristin.chase@und.nodak.edu) to inform the researcher of my decision. If I withdraw this authorization, the researcher may only use and disclose the protected health information already collected for this research study. No further health information about me will be collected by or disclosed to the researcher for this study.
- 7. Potential for Re-disclosure.** My individual health information disclosed under this authorization may be subject to re-disclosure outside the research study and no longer protected. For example, researchers in other studies could use my individual health information collected for this study without contacting me if they get approval from an Institutional Review Board (IRB) and agree to keep my information confidential.

**7A.** Also, there are other laws that may require my individual health information to be disclosed for public purposes. Examples include potential disclosures if required for

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<sup>1</sup> HIPAA is the Health Insurance Portability and Accountability Act of 1996, a federal law related to privacy of health information.



mandated reporting of abuse or neglect, judicial proceedings, health oversight activities and public health measures.

This authorization does not have an expiration date.

I am the research participant or personal representative authorized to act on behalf of the participant.

I have read this information, and I will receive a copy of this authorization form after it is signed.

\_\_\_\_\_  
Signature of research participant or research participant's personal representative

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed name of research participant or research participant's personal representative

\_\_\_\_\_  
Description of personal representative's authority to act on behalf of the research participant

Appendix C  
Medical History Questionnaire

ID Number: \_\_\_\_\_ Gender:  Male  Female Age: \_\_\_\_\_ Year: \_\_\_\_\_

Height (in): \_\_\_\_\_ Weight (lbs): \_\_\_\_\_

1. At what age did you start swimming? \_\_\_\_\_
2. How long have you been swimming competitively? \_\_\_\_\_
3. What events do you typically compete in? \_\_\_\_\_
4. During the past 12 months how many competitions have you completed in? \_\_\_\_\_

Injury Definition: an injury is musculoskeletal pain or discomfort causing a swimmer to rest from training for at least one day, to modify their training, or to seek medical aid from a physician or Certified Athletic Trainer.

If you answer "yes" to any question please explain further in the space provided after each question. Please include: type of injury, location of injury, severity of injury (mild, severe, season ending), length of time injury affected swimming (i.e. how long did you sit out or modify your swimming), and what type of treatment you received for this injury.

Please answer the following question which relate to injury based on THE PAST 12 MONTHS:

Yes  No 5. Have you experienced one or more injuries during practice or competitions?

\_\_\_\_\_  
\_\_\_\_\_

Yes  No 6. Has any injury required you to modify your swimming routine?

\_\_\_\_\_  
\_\_\_\_\_

Yes  No 7. Have you experienced any musculoskeletal pain or discomfort which "bothered you", but did not cause you to miss practice or to see a physician or Certified Athletic Trainer?

\_\_\_\_\_  
\_\_\_\_\_

Yes  No 8. Has any injury required you to sit out of a practice or competitions?

---

---

Yes  No 9. Has any injury been so severe that you saw a physician or athletic trainer?

---

Yes  No 10. Have you had any problems with pain or swelling in muscles, tendons, bones, or joints?

If "Yes", Circle which: Head / Neck / Shoulder / Upper Arm / Elbow /  
Forearm / Hand Chest / Upper Back / Lower Back / Hip / Thigh / Knee /  
Calf/Shin / Ankle / Foot/Toes

---

---

Yes  No 11. Have you had a shoulder injury that disabled you for a week or longer?

---

---

Yes  No 12. Does your shoulder routinely or occasionally dislocate or subluxate?

---

---

Yes  No 13. Do you have recurring shoulder pain that makes swimming difficult?

---

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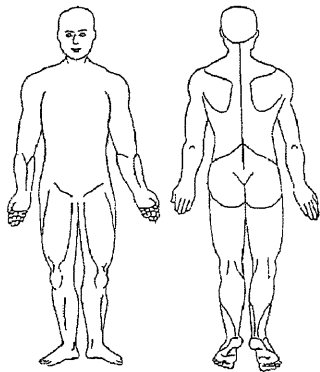
**APPENDIX D  
Injury Report Form**

**ID Number:** \_\_\_\_\_ **Gender:**  Male  Female **Age:** \_\_\_\_\_ **Year:** \_\_\_\_\_ **Date:** \_\_\_\_\_

**Date of Injury Onset**

\_\_\_\_ / \_\_\_\_ / \_\_\_\_

**Body Area Injured (mark with X)**



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**List injured body part(s) (right or left)**

\_\_\_\_\_  
\_\_\_\_\_

**Explain exactly how the injury occurred**

\_\_\_\_\_  
\_\_\_\_\_

**Is this injury**

- New injury
- Recurrence of old injury
- Repeat of injury from current season

**Injury occurred during**

- Preseason
- Regular season
- Post Season

**Injury occurred in**

- Practice
  - Warm up
  - First Half
  - Second Half
  - Cool Down
- Competition
  - Warm-up
  - During race
  - Cool-down
- Weight lifting
- Other \_\_\_\_\_

**Where did this injury occur?**

- In Water
- Locker Room
- Deck
- On Blocks
- Bleachers
- Gym
- Other \_\_\_\_\_

**Did the injury occur with a specific skill?**

- Yes
- No

**If 'yes' explain:** \_\_\_\_\_  
\_\_\_\_\_

**Mechanism of Injury**

- No Specific Reason
- Repetitive Motion
- Contact with other swimmer
- Contact with walls of pool
- Contact with bottom of pool
- Other pool related mechanism

**Explain:** \_\_\_\_\_  
 Other training related mechanism

- Weight training

**Explain:** \_\_\_\_\_  
 Dry land training

**Explain:** \_\_\_\_\_

**As a result of this injury did you immediately modify your training/competition?**

- Unable to complete competition
- Modified competition

**Explain:** \_\_\_\_\_

- Unable to complete practice
- Modified practice

- Decreased yardage
- Decreased time
- Eliminate offending stroke
- Omitted skill

**Explain:** \_\_\_\_\_

**How long did this injury keep the swimmer from participating in practice/competition?**

- 1-2 days
- 10 or more days
- 3-6 days
- Season ending
- 7-9 days
- Red shirt

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