History of Shoulder Instability and Subsequent Injury During Four Years of Follow-up

A Survival Analysis

Kenneth L. Cameron, PhD, MPH, ATC, Sally B. Mountcastle, PhD, Bradley J. Nelson, MD, Colonel (Ret) Thomas M. DeBerardino, MD, Michele L. Duffey, MS, Lieutenant Colonel Steven J. Svoboda, MD, and Lieutenant Colonel Brett D. Owens, MD

Investigation performed at the Department of Orthopedic Surgery, Keller Army Hospital, West Point, New York, the Sports Medicine & Shoulder Division, Department of Orthopaedic Surgery, University of Minnesota, Minneapolis, Minnesota, the Department of Orthopaedic Surgery, University of Connecticut Health Center, Farmington, Connecticut, and the Department of Kinesiology, Pennsylvania State University, University Park, Pennsylvania

Background: Little is known about the risk factors for glenohumeral joint instability. We hypothesized that a prior history of instability would be a significant risk factor for subsequent injury.

Methods: We conducted a prospective cohort study over a four-year period within a high-risk group of young athletes to address the research hypothesis. Subjects were freshmen entering the U.S. Military Academy in June of 2006. Part of the baseline assessment included documenting a prior history of glenohumeral instability on entry into the study. All subjects were followed for subsequent glenohumeral joint instability events until graduation in May of 2010. The primary outcome of interest in this study was time to glenohumeral instability event during the follow-up period. We examined injury outcomes, looking for any instability, anterior instability, and posterior instability events. Cox proportional-hazards regression models were used to analyze the data.

Results: Among the 714 subjects, eight shoulders were excluded from the analyses due to prior surgical stabilization, leaving 1420 shoulders, of which 126 had a self-reported prior history of instability. There were forty-six (thirty-nine anterior and seven posterior) acute instability events documented in the cohort during the follow-up period. Subjects with a prior history of instability were over five times ($p < 0.001$) more likely to sustain an acute (anterior or posterior) instability event during the follow-up period. Subjects with a history of instability were also 5.6 times ($p < 0.001$) more likely to experience a subsequent anterior instability event and 4.6 times ($p = 0.068$) more likely to experience a posterior instability event during follow-up. Similar results were observed in multivariable models after controlling for the influence of demographic and baseline physical examination findings.

Conclusions: Despite meeting the rigorous physical induction standards for military service, subjects with a prior history of glenohumeral joint instability were approximately five times more likely to experience a subsequent instability event, regardless of direction, within this high-risk athletic population.

Level of Evidence: Prognostic Level I. See Instructions for Authors for a complete description of levels of evidence.

Traumatic injuries leading to glenohumeral joint instability are endemic in young athletes[1-3] and physically active populations[2,4]. These injuries occur at a younger age, with higher rates of recurrence, and with shorter intervals between initial injury and recurrent instability events among athletes[5]. Shoulder instability events also result in a substantial time loss from participation and training[1,2] and often require surgical stabilization for optimal outcomes[6,7]. The long-term

Disclosure: One or more of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of an aspect of this work. In addition, one or more of the authors, or his or her institution, has had a financial relationship, in the thirty-six months prior to submission of this work, with an entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. No author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete **Disclosures of Potential Conflicts of Interest** submitted by authors are always provided with the online version of the article.

Disclaimer: The views and opinions expressed in this manuscript are those of the authors and do not reflect the official policy of the Department of the Army, the Department of Defense, or the United States Government.

burden of shoulder instability is also substantial and often leads to recurrent instability[8] and glenohumeral osteoarthritis[9]. Ogawa et al.[10] reported that nearly one-third of shoulders examined with use of computed tomography (CT) prior to initial shoulder stabilization had signs of osteoarthritis, with the number of prior instability events being associated with degenerative changes. Despite the impact and long-term burden of shoulder instability events, we still know little about the prospective risk factors associated with these injuries[3].

A self-reported history of prior injury has recently been examined as a prospective risk factor for subsequent injury[11-14]. A study examining the incidence of injuries among high-school athletes reported that self-reported history of prior injury was the second most important risk factor for subsequent injury[12]. Subjects with a history of shoulder injury were nine times more likely to experience a subsequent shoulder injury during the follow-up period; however, the authors did not specifically limit their injury outcome to shoulder instability events[12]. Despite high rates of recurrent instability following initial instability events, no studies to our knowledge have prospectively examined whether a self-reported history of prior injury is associated with the subsequent risk of acute shoulder instability events.

The purpose of this study was to examine the association between self-reported history of shoulder instability and the subsequent risk of acute traumatic instability events during four years of follow-up among students entering the United States Military Academy (USMA) at West Point, while controlling for the influence of baseline physical examination findings and other potential confounding variables. Our research hypothesis was that a self-reported history of glenohumeral instability would be associated with the subsequent likelihood of acute traumatic instability events.

Materials and Methods

Design and Setting

We conducted a prospective cohort study over a four-year period within a high-risk group of young athletes to address the research hypothesis. Subjects were freshmen entering the USMA in June of 2006. Part of the baseline assessment included documenting a prior history of instability. All subjects were followed for subsequent glenohumeral joint instability events until graduation from the USMA in May of 2010. The primary outcome of interest in this study was time to glenohumeral instability event during the follow-up period from June 26, 2006, through May 22, 2010. We examined injury outcomes for any instability, anterior instability, and posterior instability events. During the follow-up period, all members of the cohort were required to participate in physical education courses, competitive sports, and military training activities. A detailed description of these requirements has been presented previously[15], as were data regarding the high risk for shoulder instability events associated with these requirements[2]. Our institutional review board reviewed and approved this study prior to initiation.

Subjects

All 1311 members of the entering freshman class of 2010 at the USMA were solicited to enroll in this study and 80% (1050) agreed to participate and provided informed consent. Of these 1050 subjects, complete baseline data were obtained for 714 subjects who composed the final cohort. Only subjects who completed all baseline visits for data collection were included in the final cohort. Subjects with a history of prior surgical stabilization for glenohumeral instability were excluded from the analyses. Of the 714 subjects, 630 (88%) were males and eighty-four (12%) were females, which is consistent with the general population at the USMA[16]. All subjects were deemed healthy and medically fit for military service prior to admission to the academy through the Department of Defense Medical Evaluation Review Board. In addition, there were few physical examination findings associated with shoulder instability noted at baseline within this cohort[17].

Injury Definitions and Surveillance

All cadets receive their medical care through the closed health-care system at the USMA, and all injuries are evaluated through its associated sports medicine and orthopaedic clinics[15]. As a result, all shoulder instability injuries are evaluated by the orthopaedic surgeons at Keller Army Hospital[15]. All acute shoulder instability events that occurred during the follow-up period between the enrollment date on June 26, 2006, and the administrative end of the study on May 22, 2010, were classified, according to the criteria described by Owens et al.[18], as complete dislocations if a manual reduction was required and subluxation events if no reduction was performed. Instability events were classified as anterior in direction on the basis of a documented anterior dislocation event or by evaluation of history, physical examination, imaging, and findings at surgery (if performed). Posterior events were classified in a similar fashion. In addition, all injured subjects completed an injury questionnaire at the time of injury to help further classify the nature and mechanism of the injury. All incident cases that occurred during the follow-up period were reviewed by a single, sports-medicine fellowship-trained orthopaedic surgeon (B.D.O.) who was blinded to the baseline status and history of each subject with shoulder instability.

We conducted active surveillance within the study cohort during the follow-up period to identify all acute shoulder-instability events. Because all cadets are required to participate in athletics, these injuries are documented in multiple electronic databases that were used for injury surveillance. Because of the closed health-care system at our institution and the available injury surveillance resources, our ability to detect any injuries during the follow-up period was excellent.

Covariate Definitions

A self-reported history of glenohumeral joint instability prior to enrollment was the primary risk factor of interest for instability events during the follow-up period in the current study. History of glenohumeral joint instability was identified through a baseline questionnaire that was administered to all subjects in their first week at the academy[16]. Two items were specifically used to identify prior glenohumeral joint instability: (1) Have you ever dislocated (needed to be put back into place) either shoulder? (2) Have you ever had a shoulder subluxation (shifts out of place—but does not need to be put back in position)? Additional items related to the type of instability event, side injured, arm dominance, and mechanism of injury, as well as demographic information (e.g., sex and race) were also included in the baseline questionnaire.

A baseline physical examination that was focused on shoulder instability was also performed bilaterally on all subjects upon entry into the cohort, the details of which have been described previously[17]. Briefly, the examination consisted of a load-shift (anterior, posterior, inferior) maneuver, anterior apprehension test, relocation test, sulcus-sign test, and assessments of scapular dyskinesis and ligamentous laxity. None of the subjects had multidirectional instability at the time of the baseline physical examination. Because these baseline physical examination findings have been associated with a self-reported history of shoulder instability[16,17], we wanted to control for these factors in our analysis to determine if a self-reported history of instability was associated with the likelihood of sustaining a subsequent instability event during the follow-up period in our cohort.

Outcome Measures

The primary outcome of interest in this study was time from baseline (June 26, 2006) to a subsequent glenohumeral instability event during the follow-up period. We examined injury outcomes for any instability, anterior instability, and posterior instability events based on the injury definitions described above. Accurate follow-up time was available through the office of institutional research at the USMA and was based on dates of entry, injury, separation, and graduation. Follow-up time was measured in days during the study period from entry into the cohort on June 26, 2006, until a subject (1) sustained a subsequent glenohumeral

TABLE I Univariate and Multivariable Cox Proportional-Hazards Regression Models Evaluating the Association Between History of Glenohumeral Instability at Baseline and Acute Instability Injury During Follow-up

	Univariate			Final Multivariable Model*		
Injury Outcome	HR†	P Value	95% CI	HR†	P Value	95% CI
Any instability	5.38	0.001	2.98, 9.69	4.25	0.001	2.02, 8.93
Anterior instability	5.59	0.001	2.98, 10.49	3.77	0.002	1.64, 8.69
Posterior instability	4.60	0.068	0.89, 23.69	8.67	0.007	1.81, 41.59

*Adjusted for sex, height, weight, race, and baseline physical examination findings (total Beighton score, anterior translation, posterior translation, inferior translation, sulcus sign, and relocation sign). †For the hazard ratio (HR), those with no history of glenohumeral joint instability at baseline served as the referent group.

instability event, (2) left the USMA due to separation prior to graduation, or (3) reached the administrative end of the study at the time of graduation on May 22, 2010. Subjects sustaining an incident glenohumeral instability event during the follow-up period were censored at the time of initial diagnosis and contributed no further time to follow-up during the study period.

Statistical Analysis

We calculated standard descriptive statistics, including frequencies for categorical variables and means and standard deviations for continuous variables, within the study cohort. Using the Kruskal-Wallis test, we compared the number of years from a prior instability event until enrollment in the study at baseline between the subjects who went on to have an acute instability event and the subjects who did not. We evaluated injury outcomes for any instability event, anterior instability event, and posterior instability event separately. Initially, Kaplan-Meier survival estimates were plotted to compare the differences in the injury rates with regard to acute glenohumeral instability events between groups on the basis of self-reported history of glenohumeral instability at baseline. Univariate and multivariable Cox proportional-hazards regression models were used to estimate the time from entry into the cohort until incident glenohumeral instability event during the follow-up period, with shoulder nested within each subject as the unit of analysis. Robust standard errors were used to calculate confidence intervals (CIs) and p values to account for correlation between shoulders within each subject. Based on an examination of the proportional hazards plot, the proportional hazards assumption appeared to be adequately satisfied. Initially, we calculated hazard ratios (HRs) and 95% CIs by self-reported history of glenohumeral instability at baseline, using those with no prior history of instability as the referent category. Multivariable analytical models were also used to control for the influence of demographic and baseline physical examination findings for instability on the association between a self-reported history of glenohumeral instability at baseline and the rate of acute shoulder instability events during follow-up. The final multivariable model included history of glenohumeral joint instability, sex, height, weight, race, and baseline physical examination findings (total Beighton scale score on a scale of 0 to 9[16], anterior translation, posterior translation, inferior translation, sulcus sign, and relocation sign).

Source of Funding

This study was aided by a grant from the Orthopaedic Research and Education Foundation.

Results

Among the 714 subjects in the cohort, 630 were male (average age plus standard deviation, 18.8 ± 1.0 years; average height, 178.5 ± 7.5 cm; and average weight, 76.1 ± 12.9 kg at baseline)

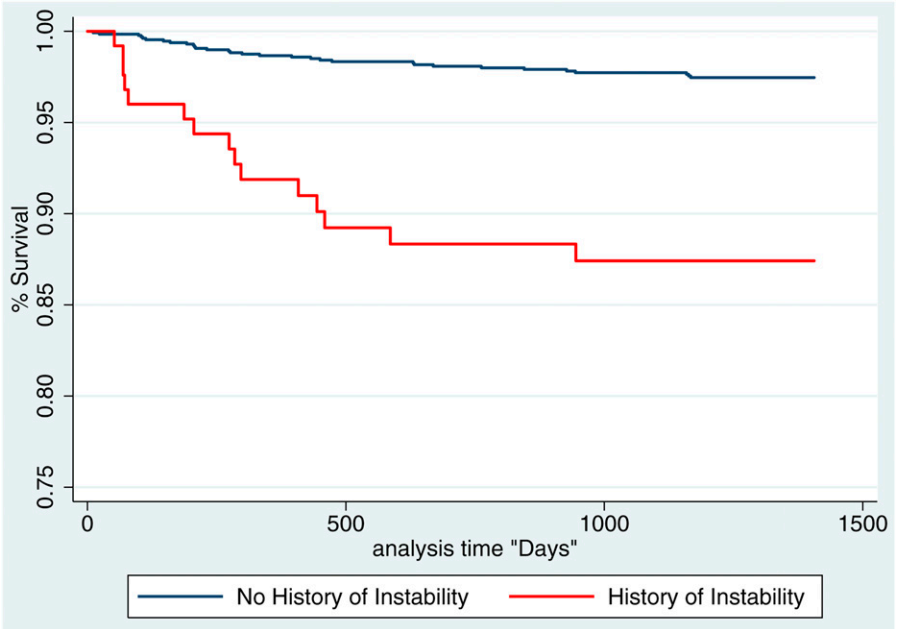

Fig. 1

Kaplan-Meier survival estimates by prior history of glenohumeral instability at baseline for any instability event during the follow-up period.

TABLE II Univariate Cox Proportional-Hazards Regression Models Evaluating the Association Between Dislocation and Subluxation History at Baseline and Acute Instability Injury During Follow-up

	History of Dislocation			History of Subluxation		
Injury Outcome	HR*	P Value	95% CI	HR*	P Value	95% CI
Any instability	5.47	0.001	2.48, 12.08	3.63	0.001	1.78, 7.39
Anterior instability	5.57	0.001	2.35, 13.20	3.87	0.001	1.83, 8.20
Posterior instability	5.35	0.113	0.67, 42.59	2.54	0.391	0.30, 21.45

*For the hazard ratio (HR), those with no history of glenohumeral joint instability at baseline served as the referent group.

and eighty-four were female (average age, 18.7 ± 0.9 years; average height, 165.4 ± 7.0 cm; and average weight, 63.2 ± 9.1 kg at baseline). Baseline data were available for 1428 shoulders (n = 714 subjects). Eight shoulders were excluded from the analyses due to prior surgical stabilization for glenohumeral instability, leaving 1420 shoulders, of which 118 had a self-reported history of instability. Of the 118 with a self-reported history of instability at baseline, twenty-eight reported a history of dislocation, seventy-six reported a history of subluxation, and fourteen reported a history of both dislocation and subluxation. There were forty-six (thirty-nine anterior and seven posterior) acute instability events documented in the cohort during the follow-up period, and surgery was subsequently performed in thirty-one (67.4%) of the forty-six shoulders. Overall, the cumulative incidence of any acute glenohumeral instability event during follow-up was 12.7% (fifteen of 118; 95% CI: 7.1%, 21.0%) among shoulders that had a self-reported history of instability at baseline, as compared with 2.4% (thirty-one of 1302; 95% CI: 1.6%, 3.4%) in shoulders with no self-reported history of glenohumeral instability at baseline. Among those with a self-reported history of instability at baseline, there was no significant difference in the number of years from the time of prior injury to the time of enrollment in the study cohort (p = 0.945). The median time from previous instability injury to enrollment was one year (interquartile range [IQR] = 1.5 years) for both the group that experienced acute instability events during the follow-up period and the group that did not. Demographic data by history of instability at baseline are presented in the Appendix.

Univariate Cox proportional-hazards analyses revealed that subjects with a self-reported history of glenohumeral instability at baseline were more than five times more likely to sustain an acute (anterior or posterior) instability event during the follow-up period (Table I). Kaplan-Meier survival estimates for the rate of any instability event during follow-up by group are presented in Figure 1. Subjects with a history of instability at baseline were also 5.6 times more likely to experience an acute anterior instability event (Fig. 2) and 4.6 times more likely to experience an acute posterior instability event (Fig. 3) during follow-up. Results were similar when a history of dislocation and a history of subluxation at baseline were examined independently; however, the magnitude of the hazard ratios was greater for those with a prior dislocation (Table II).

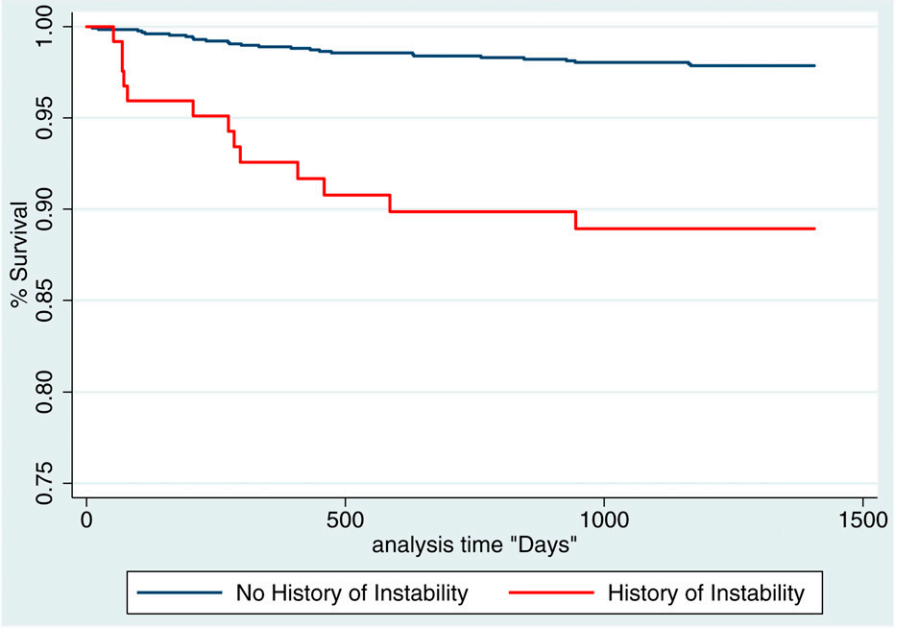

Fig. 2
Kaplan-Meier survival estimates by prior history of glenohumeral instability at baseline for anterior instability events during the follow-up period.

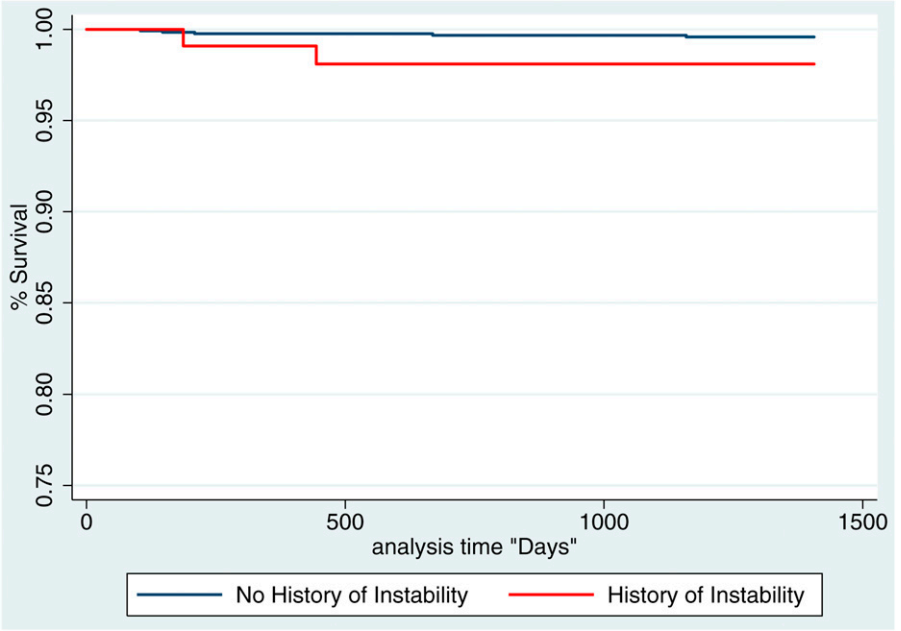

Fig. 3
Kaplan-Meier survival estimates by prior history of glenohumeral instability at baseline for posterior instability events during the follow-up period.

Similar results were observed in multivariable models for the relative hazard of each glenohumeral instability injury outcome during the follow-up period (Table I). After adjusting for the influence of demographic and baseline physical examination findings, subjects with a self-reported history of glenohumeral instability at baseline were 4.3 times more likely to experience an acute instability (anterior or posterior) event during the follow-up period. The multivariable results for acute anterior instability events during the follow-up period were similar to those observed for any instability event. After adjusting for the other variables in the model, subjects with a prior history of shoulder instability at baseline were nearly four times more likely to experience an acute anterior instability event during the follow-up period. Self-reported history of glenohumeral instability at baseline was also associated with the relative hazard of sustaining an acute posterior instability event during the follow-up period, after controlling for the other variables in the model. Those with a self-reported history of glenohumeral instability at baseline were nearly nine times more likely to sustain an acute posterior instability event during the follow-up period, after adjustment.

Discussion

We conducted a prospective cohort study to determine if a self-reported history of glenohumeral joint instability at baseline was associated with the rate of subsequent injury during four years of follow-up in a young and active population previously determined to be at high risk for shoulder instability[2]. Subjects with a history of glenohumeral joint instability were much more likely to experience an acute instability event during the follow-up period, regardless of the direction of instability, in both univariate and multivariable models.

Based on an examination of the Kaplan-Meier survival curves, those with a history of glenohumeral joint instability at baseline experienced higher rates of acute instability events earlier in the follow-up period, with most experiencing a subsequent instability event within the first two years of follow-up. These findings are very similar to those reported by Robinson et al.[19] who also noted that 87% of recurrent instability events, in their cohort of patients who were managed nonoperatively, occurred within the first two years following primary anterior dislocation. They also reported that age and sex were associated with the subsequent risk of instability in their cohort. In contrast, sex was not associated with the risk of acute instability events during the follow-up period, in either univariate or multivariable analyses, in the current study. Furthermore, because age was relatively homogeneous within our population, we were unable to adequately evaluate the association between age and the subsequent risk of glenohumeral instability. The survival rates among those with a self-reported history of instability in the current study and the time to subsequent injury are also comparable with those previously reported in a prospective cohort study examining the results of nonoperative treatment following acute anterior shoulder dislocation and the time to subsequent surgical intervention[20]. The same study also reported no differences in time to subsequent surgical intervention by sex, which is comparable with our findings for time to subsequent injury.

Several prospective studies have reported that a history of prior injury is an important independent risk factor for subsequent injury[11-14]. Van Mechelen et al.[11] reported that athletes with a history of injury at baseline, as compared with those with no prior history, were nearly 9.5 times more likely to experience a subsequent injury during follow-up and that a prior history of injury was the most important risk factor associated with subsequent injury. Similarly, Knowles et al.[12], in a prospective study of injury incidence among high school athletes, reported that a history of injury at baseline was one of the most important risk factors

associated with the subsequent risk of injury. To our knowledge, the study by Knowles et al.[12] is also the only prospective study to specifically examine shoulder injuries. Within that study cohort, subjects with a self-reported history of shoulder injury were nine times more likely to experience a subsequent shoulder injury during the follow-up period; however, the authors did not specifically limit their injury outcome or history to shoulder instability events[12]. In contrast with the current study, while the authors controlled for many potentially confounding variables in their analyses they did not account for baseline physical examination findings consistent with shoulder instability.

Hovelius et al.[21] reported that 57% of the patients with primary anterior shoulder dislocation who were managed nonoperatively in their prospective cohort experienced subsequent dislocations during long-term follow-up. Similarly, Robinson et al.[19] reported that 56% of the patients with primary anterior shoulder dislocation who were managed nonoperatively in their prospective cohort experienced subsequent dislocation within two years following the initial injury; however, this value increased to 67% after five years of follow-up. In contrast, Sachs et al.[20] reported that only 33% of the acute traumatic anterior dislocations initially managed conservatively in their prospective cohort experienced at least one subsequent dislocation during an average of four years of follow-up. A primary limitation of these studies is that the investigators were unable to compare their results to a similar group of patients who had no history of glenohumeral joint instability at baseline. Another important limitation was the relative heterogeneity in age and activity level within the study populations. These studies also failed to report transient luxation events (subluxations).

Although high rates of recurrent instability have been well documented following initial glenohumeral joint dislocation[19,21] injuries, no studies to our knowledge have prospectively examined the subsequent risk of acute shoulder instability injuries in a group of patients with a history of shoulder instability who were treated nonoperatively in comparison with a group with no history of shoulder instability. In the current study, we examined the relative hazard for acute glenohumeral instability events during a four-year follow-up period in a large cohort with relatively homogeneous age and physical activity requirements. Subjects with a self-reported history of glenohumeral joint instability and no history of surgical stabilization were approximately four to nine times more likely to experience a subsequent instability event (regardless of direction) after controlling for the influence of baseline demographic and physical examination findings consistent with shoulder instability. Despite the increased hazard of recurrent instability in our study population, the cumulative incidence of acute instability during the follow-up period was only 12.7% in those with a history of instability at baseline. This is likely due to the select nature of our cohort, which was medically screened for admission to our institution, and the fact that few subjects had any abnormal physical examination findings consistent with instability at baseline[17].

The findings of the current study, as well as those of previous studies[2,12], confirm the importance of the primary prevention of shoulder instability injuries in young athletic populations. In addition to having high rates of recurrent instability, those with a history of instability are also at increased risk of having serious damage to the joint capsule[22], subsequent glenohumeral osteoarthritis[9,10,23], and increased mortality rates[24]. In a recent study, it was reported that 31.2% of shoulders examined with CT prior to initial shoulder stabilization had signs of osteoarthritis, with the number of prior instability events being associated with degenerative changes[10]. Glenohumeral instability injuries may also lead to socioeconomic impacts, including career limitations, increased medical costs, and potential loss of income. Although the orthopaedic and sports-medicine communities have made appreciable advances in the identification of modifiable risk factors associated with anterior cruciate ligament injuries in the knee and in the development of injury-prevention programs to address these risk factors, comparable progress in the area of shoulder instability has yet to be realized. To prevent shoulder instability injuries, we need to prospectively identify the modifiable risk factors associated with these injuries so that we can develop interventions to target these factors[25].

As with any investigation, the current study has important limitations. We relied on a self-reported history to document previous glenohumeral instability events, which raises the potential of recall bias. However, previous studies have demonstrated similar results for a self-reported history of injury as a risk factor for subsequent injury[12,13]. Furthermore, because only 714 of the 1050 subjects who consented were able to complete all baseline data collection visits, we cannot rule out the potential influence of selection bias in our cohort. However, those who did not complete all baseline data collection visits were similar to the 714 who did, based on the demographic data presented in the Appendix. Although we enrolled 714 subjects, only forty-six acute glenohumeral instability events were observed during the follow-up period, and this likely influenced the precision of our hazard ratio estimates. Finally, because there were very few subjects with a prior history of glenohumeral instability that required surgical stabilization prior to enrollment, we were unable to compare those treated nonoperatively and those treated surgically in the current study.

Despite the limitations noted above, we performed a large prospective cohort study to determine if a self-reported history of glenohumeral joint instability at baseline was associated with a subsequent risk of injury during four years of follow-up in a population at high risk of sustaining shoulder instability. Because of the prospective nature of this study, we were able to control for the influence of baseline demographic and physical examination findings for glenohumeral instability during our analyses. Due to the closed health-care system at our institution, we were able to capture all subsequent glenohumeral instability events within the study cohort during the follow-up period.

Conclusions

Despite meeting the rigorous physical induction standards for military service, subjects with a prior history of glenohumeral joint instability were over five times more likely to experience an acute glenohumeral instability (anterior or posterior) event, within the high-risk athletic population studied. Results were similar

when anterior and posterior instability injuries that occurred during follow-up were examined independently, and after controlling for the influence of baseline demographic and physical examination findings for glenohumeral instability. The results of the current study emphasize that a self-reported history of glenohumeral instability is an important independent risk factor for subsequent shoulder instability injury, regardless of the direction of the instability.

Appendix

eA A table showing demographic data and instability outcome according to history of instability at baseline is available with the online version of this article as a data supplement at jbjs.org. ■

NOTE: This project was aided by a grant from the Orthopaedic Research and Education Foundation. A study of this scope and nature would not be possible without the support and assistance of many colleagues. The authors thank Tim Kelly, ATC, and Dana Putnam, ATC, in the Department of Intercollegiate Athletics at the United States Military Academy (USMA); Dr. Craig Yunker, ATC, Karen Peck, ATC, Chris Jones, ATC, and Jason Suby, ATC, in the Department of Physical Education at the USMA; and Colonel Paul Stoneman, PT, PhD, Major William Loro, DPT, Major Mark Thelen, DPT, Lieutenant Colonel James Dauber, DPT, and Major Heath Todd, DPT, in the Keller Army Hospital Physical Therapy Department for their assistance with the logistics, baseline data collection, and injury surveillance for this project. The authors also recognize and thank the members of the USMA Graduating Class of 2010 for their participation in this study and their commitment to serve our nation.

Kenneth L. Cameron, PhD, MPH, ATC
Sally B. Mountcastle, PhD
Lieutenant Colonel Steven J. Svoboda, MD
Lieutenant Colonel Brett D. Owens, MD
Department of Orthopedic Surgery,
Keller Army Hospital,
United States Military Academy,
900 Washington Road,
West Point, NY 10996.
E-mail address for K.L. Cameron: kenneth.cameron@amedd.army.mil

Bradley J. Nelson, MD
Sports Medicine & Shoulder Division,
Department of Orthopaedic Surgery,
University of Minnesota,
2512 South 7th Street, Suite R200,
Minneapolis, MN 55454

Colonel (Ret) Thomas M. DeBerardino, MD
Department of Orthopaedic Surgery,
University of Connecticut Health Center,
MARB4, 263 Farmington Avenue,
Farmington, CT 06030

Michele L. Duffey, MS
Department of Kinesiology,
Pennsylvania State University,
271F Recreation Building,
University Park, PA 16803

References

1. Owens BD, Agel J, Mountcastle SB, Cameron KL, Nelson BJ. Incidence of glenohumeral instability in collegiate athletics. Am J Sports Med. 2009 Sep;37(9):1750-4. Epub 2009 Jun 25.

2. Owens BD, Duffey ML, Nelson BJ, DeBerardino TM, Taylor DC, Mountcastle SB. The incidence and characteristics of shoulder instability at the United States Military Academy. Am J Sports Med. 2007 Jul;35(7):1168-73.

3. Kerr ZY, Collins CL, Pommering TL, Fields SK, Comstock RD. Dislocation/separation injuries among US high school athletes in 9 selected sports: 2005-2009. Clin J Sport Med. 2011 Mar;21(2):101-8.

4. Owens BD, Dawson L, Burks R, Cameron KL. Incidence of shoulder dislocation in the United States military: demographic considerations from a high-risk population. J Bone Joint Surg Am. 2009 Apr;91(4):791-6.

5. Rhee YG, Cho NS, Cho SH. Traumatic anterior dislocation of the shoulder: factors affecting the progress of the traumatic anterior dislocation. Clin Orthop Surg. 2009 Dec;1(4):188-93. Epub 2009 Nov 25.

6. Bishop JA, Crall TS, Kocher MS. Operative versus nonoperative treatment after primary traumatic anterior glenohumeral dislocation: expected-value decision analysis. J Shoulder Elbow Surg. 2011 Oct;20(7):1087-94. Epub 2011 May 6.

7. Handoll HH, Almaiyah MA, Rangan A. Surgical versus non-surgical treatment for acute anterior shoulder dislocation. Cochrane Database Syst Rev. 2004;(1):CD004325.

8. Wheeler JH, Ryan JB, Arciero RA, Molinari RN. Arthroscopic versus nonoperative treatment of acute shoulder dislocations in young athletes. Arthroscopy. 1989;5(3):213-7.

9. Brophy RH, Marx RG. Osteoarthritis following shoulder instability. Clin Sports Med. 2005 Jan;24(1):47-56.

10. Ogawa K, Yoshida A, Ikegami H. Osteoarthritis in shoulders with traumatic anterior instability: preoperative survey using radiography and computed tomography. J Shoulder Elbow Surg. 2006 Jan-Feb;15(1):23-9.

11. Van Mechelen W, Twisk J, Molendijk A, Blom B, Snel J, Kemper HC. Subject-related risk factors for sports injuries: a 1-yr prospective study in young adults. Med Sci Sports Exerc. 1996 Sep;28(9):1171-9.

12. Knowles SB, Marshall SW, Bowling JM, Loomis D, Millikan R, Yang J, Weaver NL, Kalsbeek W, Mueller FO. A prospective study of injury incidence among North Carolina high school athletes. Am J Epidemiol. 2006 Dec 15;164(12):1209-21. Epub 2006 Sep 29.

13. Kucera KL, Marshall SW, Kirkendall DT, Marchak PM, Garrett WE Jr. Injury history as a risk factor for incident injury in youth soccer. Br J Sports Med. 2005 Jul;39(7):462.

14. Hägglund M, Waldén M, Ekstrand J. Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. Br J Sports Med. 2006 Sep;40(9):767-72. Epub 2006 Jul 19.

15. Mountcastle SB, Posner M, Kragh JF Jr, Taylor DC. Gender differences in anterior cruciate ligament injury vary with activity: epidemiology of anterior cruciate ligament injuries in a young, athletic population. Am J Sports Med. 2007 Oct;35(10):1635-42. Epub 2007 May 22.

16. Cameron KL, Duffey ML, DeBerardino TM, Stoneman PD, Jones CJ, Owens BD. Association of generalized joint hypermobility with a history of glenohumeral joint instability. J Athl Train. 2010 May-Jun;45(3):253-8.

17. Owens BD, Duffey ML, Deberardino TM, Cameron KL. Physical examination findings in young athletes correlate with history of shoulder instability. Orthopedics. 2011 Jun;34(6):460. doi: 10.3928/01477447-20110427-21.

18. Owens BD, Nelson BJ, Duffey ML, Mountcastle SB, Taylor DC, Cameron KL, Campbell S, DeBerardino TM. Pathoanatomy of first-time, traumatic, anterior glenohumeral subluxation events. J Bone Joint Surg Am. 2010 Jul 7;92(7):1605-11.

19. Robinson CM, Howes J, Murdoch H, Will E, Graham C. Functional outcome and risk of recurrent instability after primary traumatic anterior shoulder dislocation in young patients. J Bone Joint Surg Am. 2006 Nov;88(11):2326-36.

20. Sachs RA, Lin D, Stone ML, Paxton E, Kuney M. Can the need for future surgery for acute traumatic anterior shoulder dislocation be predicted? J Bone Joint Surg Am. 2007 Aug;89(8):1665-74.

21. Hovelius L, Olofsson A, Sandström B, Augustini BG, Krantz L, Fredin H, Tillander B, Skoglund U, Salomonsson B, Nowak J, Sennerby U. Nonoperative treatment of primary anterior shoulder dislocation in patients forty years of age and younger. a prospective twenty-five-year follow-up. J Bone Joint Surg Am. 2008 May;90(5):945-52.

22. Habermeyer P, Gleyze P, Rickert M. Evolution of lesions of the labrum-ligament complex in posttraumatic anterior shoulder instability: a prospective study. J Shoulder Elbow Surg. 1999 Jan-Feb;8(1):66-74.

23. Hovelius L, Saeboe M. Neer Award 2008: Arthropathy after primary anterior shoulder dislocation–223 shoulders prospectively followed up for twenty-five years. J Shoulder Elbow Surg. 2009 May-Jun;18(3):339-47. Epub 2009 Feb 28.

24. Hovelius L, Nilsson JA, Nordqvist A. Increased mortality after anterior shoulder dislocation: 255 patients aged 12-40 years followed for 25 years. Acta Orthop. 2007 Dec;78(6):822-6.

25. Cameron KL. Commentary: Time for a paradigm shift in conceptualizing risk factors in sports injury research. J Athl Train. 2010 Jan-Feb;45(1):58-60.