Risk Factors for Volleyball-Related Shoulder Pain and Dysfunction

Jonathan C. Reeser, MD, PhD, Elizabeth A. Joy, MD, MPH, Christina A. Porucznik, PhD, MSPH, Richard L. Berg, MS, Ethan B. Colliver, DO, Stuart E. Willick, MD

Objective: To identify risk factors for volleyball-related shoulder pain and dysfunction.
Design: Cross-sectional, observational.
Setting: National championship sporting event.
Participants: Competitors at the 2006 National Intramural & Recreational Sports Association Collegiate Club Volleyball Championship competition were invited to volunteer for the study. A total of 422 athletes returned questionnaires, of whom 276 also underwent a structured physical examination.
Assessment of Risk Factors: Study participants provided information on any history of volleyball-related shoulder pain or dysfunction. The simple shoulder test (SST) and a visual analog scale permitted subjects to quantify the extent of their perceived functional limitation. Subjects also were invited to undergo a physical examination in which dynamic scapular positioning, glenohumeral range of motion, shoulder girdle strength, and core stability were assessed.
Main Outcome Measurements: Standard statistical methods of comparison and tests of association were used to identify risk factors for shoulder pain among participating volleyball athletes.
Results: Approximately 60% of participants reported a history of shoulder problems. Attackers and "jump" servers were more likely to have shoulder problems than setters, defensive specialists, and "float" servers. Nearly half of the athletes who reported shoulder problems perceived some associated functional limitation, with female athletes providing lower SST scores than male athletes (9.0 versus 10.1, $P = .001$). Athletes reporting shoulder pain and dysfunction were more likely to have SICK scapula scores of 3 or greater ($P = .010$). Participants who demonstrated core instability also had greater SICK scapula scores (3.9 versus 2.9, $P = .038$), and were more likely to report a history of shoulder problems ($\chi^2 = 8.83$, $P = .032$). Although the authors observed a significant mean left-right difference of 8.9° in available glenohumeral internal rotation among participating athletes, this deficit was not associated with shoulder problems. However, there was an association between asymmetric coracoid tightness /pectoral shortening and shoulder pain ($P = .030$), as well as for restricted shoulder flexion in the sagittal plane and shoulder problems ($P = .015$).
Conclusions: Although most risk factors for volleyball-related shoulder problems are similar to those identified for other overhead sports, there appear to be additional volleyball-specific risk factors that may reflect the biomechanical demands of the sport. An understanding of modifiable risk factors is critical to providing optimal care for overuse injuries and may facilitate future efforts to prevent shoulder problems among volleyball athletes.
PM R 2010;2:27-36

INTRODUCTION

Although volleyball is generally regarded as a safe sport, those who participate in it are nevertheless at risk for certain types of injuries that reflect both the design and demands of the discipline. For example, most of the skills performed by volleyball players, including spiking, setting, serving, and blocking, require the athlete to repeatedly contact the ball with

J.C.R. Office of Research Integrity and Protections, Marshfield Clinic Research Foundation, 1000 North Oak Ave., Marshfield, WI 54449. Address correspondence to: J.C.R.; e-mail: reeser.jonathan@marshfieldclinic.org
Disclosure: nothing to disclose

E.A.J. University of Utah, Salt Lake City, UT
Disclosure: nothing to disclose

C.A.P. University of Utah, Salt Lake City, UT
Disclosure: nothing to disclose

R.L.B. Biomedical Informatics Research Center, Marshfield Clinic Research Foundation, Marshfield, WI
Disclosure: nothing to disclose

E.B.C. University of Utah, Salt Lake City, UT
Disclosure: nothing to disclose

S.E.W. University of Utah, Salt Lake City, UT
Disclosure: nothing to disclose

Disclosure Key can be found on the Table of Contents andat www.pmrjournal.org

Submitted for publication March 18, 2009; accepted November 22.

the upper limbs in an overhead position. Consequently, volleyball athletes frequently experience shoulder pain and dysfunction [1,2].

Shoulder problems have been estimated to account for between 8% and 20% of all volleyball-related injuries [3]. Data collected prospectively by the National Collegiate Athletic Association Injury Surveillance System (NCAAISS) during a period of 16 years indicate that shoulder problems are among the leading causes of time lost from training and competition among female volleyball players [4]. With an acute time-loss injury rate of 0.65 injuries per 1000 athletic exposures, the shoulder ranks third behind the ankle and the knee as the most frequently injured body part among these athletes. The NCAAISS data reveal that time-loss shoulder injuries are evenly divided between training (0.33 per 1000 athletic exposures) and competition (0.32 per 1000 athletic exposures). However, the NCAAISS data almost certainly underestimate the true prevalence of shoulder pain and dysfunction among female collegiate volleyball athletes because most volleyball-related shoulder pathology (eg, impingement, rotator cuff tendinopathy, atraumatic glenohumeral instability, suprascapular neuropathy) is caused by overuse rather than acute overload [1-3,5-9].

Although the prevalence of volleyball-related shoulder problems is not known with any degree of precision, a season-long prospective study of volleyball injuries conducted by Verhagen et al [2] makes it clear that impairment of the shoulder girdle can result in significant disability. These authors reported that shoulder injuries resulted in the longest duration of time lost from training or competition of any injured body part (mean = 6.2 weeks). Additional evidence of the functional impact of shoulder injuries comes from Wang and Cochrane [7], who followed 59 first-division male English volleyball players during the course of 2 seasons and reported that 23 had to discontinue training as the result of shoulder pain.

These observations underscore the need for shoulder injury prevention initiatives among volleyball athletes. Before interventions aimed at reducing the shoulder girdle injury rate can be designed, the risk factors for sport-related injury must first be identified [10]. However, present understanding of the factors that influence the epidemiology of volleyball-related shoulder problems is limited [11].

Kugler et al [12] authored one of the first accounts of the effect of chronic overuse on the mechanics of the shoulder girdle in volleyball athletes, describing asymmetric scapular positioning and restricted shoulder girdle range of motion on the dominant side in a cohort of elite volleyball players. Although dominant scapular dysfunction is now thought to be a relatively common finding in the overhead athlete, there has been little volleyball-specific follow-up to Kugler et al's important study. In most of the published work that has investigated shoulder girdle function in volleyball players, authors have focused on the potential significance of various ratios of shoulder internal and external rotational isokinetic strength [13-17]. In general, these studies suggest that asymmetric strength ratios (ie, strength imbalances) are associated with a history of shoulder injury among adult volleyball players.

Table 1. *Components of the physical examination*

Inspection and palpation; identification of landmarks
Assessment of scapulohumeral rhythm
Scapular slide measurement
Infera/lateral scapular displacement/scapular abduction measurements
Assessment for impingement
Assessment of shoulder flexion in the sagittal plane
Assessment of coracoid tightness/pectoral shortening
Measurement of glenohumeral range of motion (passive external and internal rotation)
Assessment of anterior capsular laxity (apprehension test)
Assessment of isometric shoulder internal and external rotation strength (against manual resistance)
Assessment of balance during single leg stance and squat (screen for core instability)

The goal of this study was to characterize the risk factors for volleyball-related shoulder problems by identifying historical features and easily assessed physical attributes that are associated with shoulder pain and dysfunction among volleyball players. It is the authors' hope that these findings will enable sports medicine practitioners to better identify the volleyball athlete at risk for shoulder problems while informing future research on the prevention of volleyball-related shoulder injuries.

METHODS

The research protocol was approved by both the National Intramural and Recreational Sports Association (NIRSA) and the Marshfield Clinic Research Foundation Institutional Review Board. Volunteer subjects were recruited from among the participants in the 2006 NIRSA Volleyball Championships. Questionnaires requesting demographic information and details on any history of shoulder pain or related functional limitation during the preceding competitive season were distributed to each team as part of the on-site registration process. These part 1 questionnaires incorporated the simple shoulder test (SST), a well-validated 12-item index of shoulder function (scored 0-12) in which greater scores indicate better function [18]. Subjects who returned completed part 1 questionnaires were invited to undergo an optional physical examination, the components of which are listed in Table 1. The examination was designed to evaluate the shoulder girdles bilaterally, with particular emphasis on scapular function (Figures 1–4) [19-23]. A screening assessment of core stability (Figure 5) also was conducted by use of a technique described by Kibler et al [22].

Those athletes who participated in the physical examination portion of the study were asked to also complete a brief

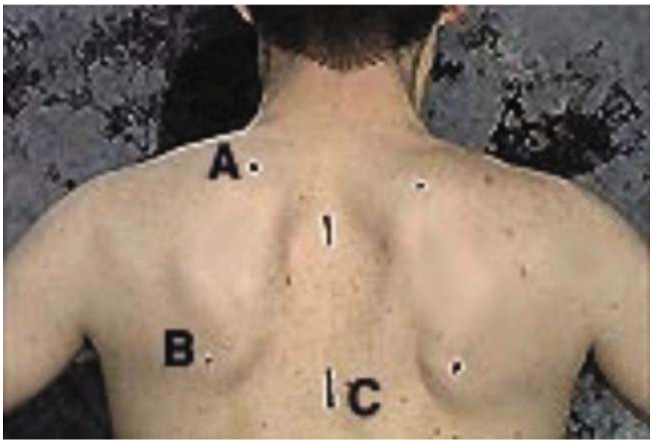

Figure 1. Landmarks identified to permit measurement of various indices of scapular positioning included the intersection of the medial border and the spine of the scapula (A), the inferior scapular angle (B), and the spinous processes of the interscapular thoracic vertebral bodies (C).

secondary (part 2) questionnaire that included a 100-mm visual analog scale assessment of their degree of functional limitation attributable to shoulder problems (VAS-FL), ranging from no restriction (0) to extremely limited (100). Examiners, who were recruited from the University of Utah Departments of Physical Medicine & Rehabilitation and

Figure 2. Infera, defined as the vertical distance between the intersection of the medial scapular border and the scapular spine on the right versus the left, is one measure of scapular asymmetry. The examiner first locates the more superiorly positioned landmark (in this case on the athlete's left) and then, by using a level to extend that position to the contralateral side, measures of the difference between the 2 landmarks in the coronal plane (the distance between the inferior edge of the level and the landmark, identified by the arrow).

Figure 3. In this study, an asymmetry of anterior shoulder positioning in the transverse (axial) plane was interpreted as an indication of coracoid tightness/pectoral shortening (after Burkhart et al (20)). A carpenter's level, positioned across the chest at the level of the coracoid, facilitated detection of any gross asymmetry. In this case the athlete's right shoulder girdle (R) is noticeably more anterior compared with the left (L).

Physical Therapy, were blinded to the athlete's responses to either of the questionnaires. In an effort to maximize consistency and standardization of the examinations, each examiner was required to view a tutorial video demonstrating how each test should be performed and how to obtain the requested measurements.

Standard descriptive statistics were used to describe the data collected, including the observed prevalence of shoulder problems among the participants. Statistical methods for comparisons and tests of association included χ^2 analyses for

Figure 4. Passive glenohumeral range of motion was measured goniometrically with the athlete in a supine position to better stabilize the scapula. The upper limb was positioned either in internal rotation at the shoulder (as in the figure) until the scapula began to elevate off the examination table or in external rotation until the scapula or lower back began to elevate off the table.

Figure 5. The athlete's ability to maintain his or her balance while standing on one leg (A) and while attempting to perform a single-leg squat (B) was used as an index of core stability. Postural instability/sway, "corkscrewing," and outright loss of balance were all considered indicative of core weakness/dyscontrol.

categorical variables, the Wilcoxon and Kruskal–Wallis nonparametric tests for continuous variables, and the Spearman rank correlation coefficient. A P value of $\leq .05$ was taken as an indication of statistical significance.

RESULTS

Injury Epidemiology

Two thousand three hundred fifty-two athletes (1452 men, 900 women) participated in the NIRSA collegiate club championships. The study authors collected 422 completed part 1 questionnaires during the 3-day tournament, an 18% overall participation rate. Of the 286 male respondents, 57% had ever experienced a shoulder problem, whereas 44% had experienced a shoulder problem during the current season. Sixty percent of the 136 female respondents had ever experienced a shoulder problem, whereas 42% reported a shoulder problem during the current season (Table 2). Ninety-three percent of respondents were right hand dominant, and the right shoulder was symptomatic in 92% of those who had ever experienced a shoulder problem. Sixty-six percent of athletes who reported shoulder problems during the current season attributed their symptoms to a recurrent volleyball-related injury, but only 25% could recall a specific instance when their symptoms began. Athletes with a history of shoulder problems were, on average, older than those who denied shoulder problems (21.8 years versus 20.5 years, Wilcoxon P value $< .001$).

The position assignments of the respondents were representative of the standard player positions that constitute a typical volleyball lineup, (setter 11.4%, middle blocker 30.6%, opposite 15.9%, outside hitter 35.3%, libero/defensive specialist 11.4%). Those athletes who functioned as attackers (eg, outside hitters, middle blockers, and opposites) reported shoulder pain during the current season more often than setters and liberos (64% versus 49%, $\chi^2 = 5.73$, $P = .017$, estimated relative risk 1.3). Service style also was associated with a history of shoulder problems. Athletes who used the more traditional float serve were less likely to have ever experienced shoulder problems (57%) when compared to jump servers (67%) or to those who reported "other" service styles, such as a "top spin" serve (79%; $\chi^2 = 7.01$, $P = .030$, estimated relative risk 0.82).

Functional Consequences

Nearly half (46%) of the athletes who reported shoulder problems believed that their symptoms interfered with their ability to play volleyball. Female athletes with shoulder problems scored lower on the SST than did male athletes (women 9.0 versus men 10.1, Wilcoxon $P = .001$), and they were more likely than male athletes to seek medical attention for their complaints (35% versus 21%, respectively, Fisher exact test $P = .025$). Fifty-five percent (n = 152) of the 276 athletes who agreed to undergo the physical examination reported experiencing shoulder problems at some point during the current season. Twenty-eight of the 152 (18%) did not have significant shoulder discomfort or functional limitation at the time they completed the survey, whereas 78

Table 2. *Demographic variables and prevalence data*

Variable	Men	Women	Total
Participants	286	136	422
Mean age of participants, years	21.5	20.9	21.3
Mean years of volleyball played	7.1	9.1	7.8
Mean number of practices/week	1.9	2.9	2.2
Athletes who have ever had shoulder problems, n (%)	163 (57)	82 (60)	245 (58)
Athletes with shoulder problems this season, n (%)	125 (44)	57 (42)	182 (43)
Athletes whose sport performance was adversely affected by shoulder problems, n (%)	56 (45)	27 (47)	83 (46)
Mean SST score among athletes with SP	10.1*	9.0*	9.8

SP = shoulder problems; SST = simple shoulder test.
*Significantly different, $P = .001$.

(51%) reported "minimal volleyball-related discomfort," and 38 (25%) complained of "frequent pain while serving or spiking." From the subgroup of athletes with shoulder problems who were examined, 24% reported pain only after competing, whereas 43% experienced pain while competing.

Those with shoulder pain during the current volleyball season reported a mean VAS-FL score of 22.3 compared with a mean VAS-FL score of 11.9 for those who did not experience significant shoulder pain during the current season (Wilcoxon $P < .001$). Forty (23%) of the athletes reporting shoulder problems during the current season lost time from training or competition as the result of their shoulder injury; 25 respondents took 7 or fewer days to recover, whereas 9 missed up to a month, and 6 missed more than a month as the result of their injury. Those who experienced the greatest time lost also reported the highest mean VAS-FL scores (Kruskal–Wallis $P < .001$) and the lowest mean SST scores (Kruskal-Wallis $P = .001$).

Findings on Physical Examination

One hundred eighty-six male and 90 female athletes (a combined 65% of the responding cohort) were examined. The examination included aspects of inspection, as well as functional testing. Virtually half of the examination cohort was thought to demonstrate a head-forward posture, whereas 47% of the cohort (51% of men versus 38% of women) demonstrated rounded shoulders (Fisher exact test $P = .040$). Male athletes were more likely than female athletes to have a unilaterally "dropped scapula" (36% versus 19%, Fisher exact test $P = .007$). Periscapular atrophy was observed in 39 subjects (14% of those who underwent examination) and was more common among male than female athletes (18% versus 7%, Fisher exact test $P = .016$). However, in the final analysis neither atrophy nor any of the other static inspection variables (with the exception of coracoid tightness/pectoral shortening; discussed later) was found to have a significant statistical association with self-reported shoulder pain or dysfunction.

More than half (60%) of the participants who were examined were thought to demonstrate abnormal scapular mechanics on at least one side. Seventy-three (26%) of the examination group were determined to have type 1 scapular dyskinesis as defined by Burkhart et al [19,20], whereas 56 (20%) demonstrated evidence of type 2 dyskinesis and 29 (11%) were thought to exhibit type 3 scapular dyskinesis. The authors also measured the extent of dynamic scapular malposition by use of the scapular slide technique [21]. They observed a prevailing lateralization of the dominant scapula that was detectable in all 3 testing positions (signed ranks test, $P < .001$). However, it was only in the third position of the scapular slide (ie, with the upper limbs abducted 90° and in maximal voluntary internal rotation at the shoulder) that the data revealed a significant association between the extent of scapular lateral displacement (as measured by the mean difference of the distance from the midline to the medial scapular border) among those with and those without a history of shoulder problems during the current season (Table 3).

Table 3. *Lateral scapular displacement (as measured by the scapular slide technique) in athletes with and without a history of shoulder pain*

	Pain History (With vs Without)	
	Difference of the Means (cm)	
Test Position	Right	Left
I (arms at side)	0.3	0.4
II (hands on hips)	0.3	0.2
III (90° - max IR)	0.8*	0.7†

*$P = .012$; †$P = .009$.

Other indices of scapular positioning that were measured included infera (the vertical distance between the medial scapular border at the intersection with the scapular spine on the right versus the left; Figure 2), lateral scapular displacement (a static measure of relative scapular lateralization which compares the distance from the intersection of the scapular spine and the medial scapular border to the adjacent spinous process, right versus left), and scapular abduction (a measure of the side to side difference in the degree of scapular rotation, measuring and comparing the angle created by the medial scapular border and a vertical plumb line, right versus left) [21]. None of these measures was able to independently discriminate between those with and those without a history of shoulder pain during the present season, or ever. However, the authors did discover an association between coracoid tightness/pectoral shortening (present in 63% of those examined; Figure 3) and shoulder pain (Fisher exact test $P = .030$), and they also documented a statistically significant association between restriction of pure flexion of the upper limb in the sagittal plane and a history of shoulder problems (Wilcoxon $P = .015$).

Athletes were screened for evidence of functional anterior impingement, as well as anterior glenohumeral instability. Twenty-nine percent of the athletes examined reported anterior shoulder pain when they elevated the upper limb in the scapular plane. Those athletes with a history of shoulder pain were more likely to demonstrate impingement than those without complaints of shoulder pain (39% versus 11%, $\chi^2 = 20.99$, $P < .001$). Of those with signs of impingement, 73% had their symptoms relieved by the scapular assistance test. In addition, 80 of the 276 athletes who were examined (29%) demonstrated evidence of apprehension at the extreme of passive glenohumeral external rotation in at least one shoulder. Of these, 66 (82.5%) experienced some relief from their apprehension by the relocation test. The athlete's response to

Table 4. *Components and derivation of the SICK scapula score, after Burkhart et al (20)*

Subjective Pain History	Objective Pain History	Scapular Position	0 cm	1 cm	2 cm	3 cm
Coracoid, Y/N	Coracoid ,Y/N	Infera	0	1	2	3
AC joint, Y/N	AC joint, Y/N	Lateral protraction	0	1	2	3
Periscapular, Y/N	Superior medial angle, Y/N	Scapular abduction	0	1	2	3
Proximal lateral arm, Y/N	Impingement, Y/N					
Radicular symptoms, Y/N	Scapular assistance test, Y/N					
	TOS symptoms, Y/N					

The SICK scapula score is derived from summating responses to questions regarding the existence of subjective symptoms at the areas indicated (1 point for each yes), the existence of tenderness or a positive response to the tests listed in the objective areas (1 point for each yes), and a numerical score based upon the magnitude of the measures of scapular malposition. The maximum score is 20.

AC = acromioclavicular joint; SICK = **S**capular malposition, **I**nferior medial border prominence, **C**oracoid pain and malposition, and dys**K**inesis of scapular movement; TOS = thoracic outlet syndrome.

the apprehension test and the relocation test was not associated with his/her complaints of shoulder problems.

The relative loss of available glenohumeral internal rotation in the dominant shoulder of the overhead athlete (compared with the nondominant shoulder) has been termed the glenohumeral internal rotation deficit (GIRD) [24]. The range of motion data revealed a significant reduction in available passive glenohumeral internal rotation on the right (dominant) side compared to the left (nondominant) side, with a mean left–right difference in available glenohumeral internal rotation of 8.9° (signed ranks test, $P < .001$; Figure 4). On average, passive internal rotation on the right measured 46.1° versus a mean of 55° on the left, (t-statistic = 4.51, $P <. 001$). The authors also detected a nonsignificant increase in available passive external glenohumeral rotation on the right side (89° right versus 87° left). Taken together, the total available glenohumeral range of motion on the right was not statistically different from that on the left.

In the study population, the authors were unable to detect an association between the degree of GIRD and self-reported shoulder problems, either during the current season or ever. Similarly, there was no association between the degree of GIRD measured and the position played (although attackers did have a slightly greater mean deficit of dominant glenohumeral internal rotation than did nonattackers, the difference did not reach statistical significance).

Manual assessment of isometric shoulder motor function revealed a total of 46 athletes (17%) with imbalanced right versus left shoulder external rotational strength. Imbalanced internal rotational motor function was detected less often (n = 16, 6%). Imbalanced isometric motor function of the shoulder external or internal rotators was associated with self-reported volleyball related shoulder problems during the current season leading up to the championship event (χ^2 = 19.9, $P < .001$, estimated relative risk 1.8).

The SICK scapula score (**S**capular malposition, **I**nferior medial border prominence, **C**oracoid pain and malposition, and dys**K**inesis of scapular movement), a composite numerical measure of the extent of scapular malposition and related symptoms and signs originally developed by Morgan [20], was calculated from the measurements obtained during the exam using the scoring algorithm detailed in Table 4. This index was found to correlate significantly with the degree of self-reported pain and impairment caused by shoulder problems (as reflected by the VAS-FL and SST scores, Spearman correlation coefficient $r = -0.351/P < .001$ and $r = 0.39/P < .001$, respectively). Greater SICK scapula scores, particularly scores ≥3, were associated with an increased likelihood of shoulder problems in the current season (Mantel–Haenzel $\chi^2 = 6.61$, $P = .010$; Table 5); however, the SICK scapula score did not correlate with the degree of GIRD.

Functional neuromuscular trunk control (core stability) was assessed by having each athlete alternately stand/balance on either his or her right or left leg (Figure 5) [22]. Athletes were subsequently asked to perform a single-leg knee bend on each side. Seventy percent of athletes performed single-leg stance without difficulty, but only 38% of the athletes were able to perform a single-leg squat without any postural instability (eg, postural sway, corkscrewing, or outright loss of balance) on either side. Those who had difficulty with the single-leg stance were more likely to have ever experienced

Table 5. *SICK scapula score vs shoulder pain during the current season*

	Shoulder Problems This Season	
SICK Scapula Score	No	Yes
0	24	11
1	31	16
2	24	26
3	19	28
4	12	17
5	9	8
6	5	14
7+	6	19

Scores ≥3 (shaded area) were more likely to be associated with a history of shoulder problems during the current season.

SICK = **S**capular malposition, **I**nferior medial border prominence, **C**oracoid pain and malposition, and dys**K**inesis of scapular movement.

Mantel–Haenzel $\chi^2 = 6.6095$, $P = .010$.

shoulder problems (χ^2 = 8.83, P = .032, estimated relative risk 1.2). Furthermore, those who exhibited postural instability on single-leg stance had greater mean SICK scapula scores compared to those who demonstrated no deficits of core stability (3.9 versus 2.9, respectively, Kruskal-Wallis P = .038).

DISCUSSION

To effectively prevent or treat volleyball-related shoulder problems, particularly those caused by overuse, the individual athlete's modifiable risk factors for injury must be identified and addressed. Unfortunately, understanding of the factors contributing to volleyball-related shoulder problems is limited by a paucity of research. The authors undertook this investigation with a goal of improving the understanding of the risk factors for shoulder pain and dysfunction among volleyball athletes. They speculated that volleyball would share several risk factors for shoulder injury with other overhead sports, including the volume of overhead activity, degree of GIRD, scapular dyskinesis, posterior shoulder weakness, and a history of previous injury along the kinetic chain [25].

These data suggest that shoulder problems are common among competitive college-aged volleyball players. The limited response rate prevents one from accurately measuring the true prevalence of shoulder problems in this population. However, because the authors intentionally did not restrict themselves to only collecting data on time-loss injuries, this dataset may more accurately capture the experience of (and thus the risk factors inherent to) the athlete with shoulder pain and/or dysfunction caused by chronic overuse, particularly when compared with studies or databases that are limited to time-loss injuries.

In that regard, (limitations of participation and recall bias notwithstanding) these data suggest that shoulder problems that did not result in time loss outnumbered time-loss shoulder injuries by a ratio of 3:1. Furthermore, shoulder problems represent a considerable source of discomfort and functional limitation to the affected athletes. The impact of shoulder pain on the study cohort is reflected not only in the SST and VAS-FL scores reported by participants with a history of shoulder problems, but also by the relatively high percentage of volleyball players who reported seeking medical attention for their symptoms. Of those with a shoulder problem during the current season, 28% sought medical attention whereas 37% reported the use of antiinflammatory medication at least weekly for their shoulder problem [26]. Although there does not appear to be a significant gender difference in the prevalence of shoulder problems, female participants with shoulder problems reported lower overall shoulder function and sought medical care more frequently than did male participants with shoulder problems.

The authors identified 3 historical factors associated with a history of shoulder problems: age, position played, and service style. Interestingly, although "years of participation" was not associated with shoulder problems, this variable was inversely correlated with the SST score (Spearman correlation coefficient r = 0.248, P = .003). The fact that those athletes who were required to attack the volleyball or who used an aggressive service style were more likely to have experienced shoulder problems points to the importance of repetitive overhead loading in placing athletes at risk for shoulder problems.

Spiking, along with its service correlate, the jump serve, is perhaps the most dramatic skill in volleyball. It has been estimated that an elite volleyball player, practicing and competing 16 to 20 hours per week, may perform as many as 40,000 spikes in one season [12]. This figure may well underestimate the actual number of repetitions performed throughout the year by the modern elite volleyball athlete. The volume of loading inherent in that much overhead activity (much like the baseball pitch or the tennis serve) places enormous demands on the shoulder girdle. Athletic shoulder function is dependent upon the precise action of the rotator cuff and the muscles that stabilize the scapula. These muscles must be well conditioned and their actions precisely coordinated to ensure pain-free shoulder function. Unfortunately, through repetition and the sheer volume of training, the musculoskeletal structures of the shoulder girdle may become overloaded and fatigued, thereby increasing the risk of injury [27,28]. It is therefore not surprising that attackers should report a greater frequency of shoulder problems than setters or defensive specialists.

In addition to historical risk factors, the authors sought to identify readily assessed physical factors that are associated with volleyball-related shoulder pain. The authors of other studies [13-17] have documented shoulder strength imbalances among volleyball athletes who complain of shoulder pain. The data in this article confirm this association. Importantly, however, rather than the use of expensive dynamometers or other equipment that may be unavailable to sports medicine practitioners, the study authors screened for strength imbalances by using manual muscle testing techniques, thereby underscoring the utility of the physical examination in screening for risk factors.

As did Kugler et al [12], the current authors also detected evidence of dominant scapular adaptation to overuse in the majority of volleyball athletes who submitted to the standardized shoulder examination. In particular, they documented widespread postural abnormalities and shoulder girdle adaptations (including coracoid tightness/pectoral shortening, GIRD and infera) that, although not all statistically associated with a history of shoulder problems, may represent functional adaptations to the imposed demands of this overhead sport [29-31].

Deficits of glenohumeral range of motion on the dominant side have been described among athletes participating in a variety of overhead sports, including baseball, tennis, and volleyball [24,32]. GIRD exceeding 20-25° has been linked with an increased risk of shoulder problems in overhead athletes [33]. Given that the mean side-to-side difference in available glenohumeral internal rotation among the current cohort of volleyball athletes was only 8.9°, it was not surprising to find that GIRD was not associated with self-reported shoulder problems in this study, either for the present season or ever. Indeed, the mean GIRD that was documented on the right (dominant) side is comparable with what has been previously documented in nonpathological shoulders of athletes competing in other overhead sports [33]. Thus, from a mechanistic standpoint, this lack of association suggests that the cumulative forces on the shoulders of these competitive collegiate volleyball players simply did not exceed the threshold necessary to precipitate more extensive reactive/adaptive changes. Testing that hypothesis would require a more definitive assessment of both the intensity and volume of the load experienced by each athlete over time.

Such a study would also permit determination of whether the relatively minor degree of GIRD measured is a consequence of the age and skill level of our sample of athletes or whether it is representative of volleyball athletes in general. Kibler et al [24] found that the degree of GIRD among a cohort of tennis players was dependent on the athlete's age and the number of years they had been competing. The fact that the study authors did not detect such an association forces them to ask whether the mobility pattern observed (ie, minor GIRD on the dominant side without a significant corresponding increase in external rotation ipsilaterally) reflects the typical extent of physiologic adaptation that occurs among volleyball athletes. Interestingly, the authors of 2 other studies [34,35] document relatively small amounts of GIRD in the dominant shoulder of volleyball athletes, suggesting that the biomechanical demands of volleyball may be decidedly different from those of other overhead sports.

Studies comparing the scapular mobility of volleyball athletes at various stages of development (eg, high school, collegiate, and elite/national team) would afford some insight into the natural history of the scapular adaptations that accrue over time in response to chronic overloading. It could be that the spike and the jump serve, both of which are performed with the volleyball athlete in an unsupported position with his or her feet off the ground, produce less posterior capsular overload than do skills such as the baseball pitch, in which the athlete remains in contact with the ground. It is interesting to note that water polo athletes apparently do not demonstrate significant GIRD either but have been found to have a significant unilateral gain in shoulder external rotation [27]. Recent data also indicate that the proximal force on and the torque generated at the shoulder by the volleyball spike and serve are lower than those generated by the baseball pitch and the tennis serve (Reeser J., et al, 2009 unpublished data), perhaps contributing to the comparatively smaller GIRD detected among the study sample of collegiate club volleyball athletes. The current authors therefore speculate that the shoulder mobility pattern observed in this study reflects a volleyball-specific pattern of physiologic adaptation to the unique demands of the sport. Clearly, further longitudinal research is indicated.

The fact that the study data did not reveal a statistical association between periscapular atrophy and shoulder problems cannot be considered surprising, given that clinically diagnosed suprascapular neuropathy is typically painless and frequently results in no discernible performance deficit [36]. It is surprising, however, that the scapular slide technique was not more sensitive in distinguishing between athletes with shoulder problems and those without. Asymmetric lateral displacement of the dominant scapula during the scapular slide test was originally thought by Kibler et al [21] to serve as a reliable indicator of clinically significant scapular dyskinesis. In the current study, the right-versus-left difference in mean scapular displacement from the midline in each testing position failed to show an association with shoulder injury history. However, the scapular slide testing did reveal significantly greater lateralization of both scapulae in the third position among volleyball athletes with a history of shoulder problems during the current season compared with those athletes without a similar history of shoulder complaints (Table 3). Whether a threshold exists for symptomatic scapular lateralization in the third position (ie, a value that might serve as a reliable predictor of shoulder dysfunction) remains to be seen.

Conversely, it was found the SICK scapula score [20] was able to discriminate between volleyball athletes with and without a history of shoulder problems. Specifically, the authors found that scores of ≥ 3 were statistically more likely to be associated with a history of shoulder problems during the current season. Furthermore, the SICK scapula score was significantly correlated with the VAS-FL score, the SST score, and measures of core instability. Therefore, it is believed that the SICK scapula score may be a potentially useful screening instrument to detect (and possibly monitor the status of) shoulder problems among volleyball athletes.

The fact that core instability was more common among athletes with shoulder problems than among those without shoulder issues is consistent with the current understanding of the importance of the kinetic chain in generating force for the execution of overhead sports skills and the role that the core plays in efficiently transmitting the force produced by the lower limbs up to the shoulder girdle (which in turn funnels it out to the distal upper limb). Whether core weakness and functional trunk instability are necessary preconditions for the development of scapular dyskinesis and shoulder dysfunction and pain in volleyball, athletes must await further prospective research, but the present data do imply a role for core dysfunction in the etiology of the various overuse conditions affecting the shoulder of the volleyball athlete. In that regard, it is important to note that the study authors used a relatively simple and quick screening assessment of functional neuromuscular trunk control; consequently, understanding of the mechanisms at play may be enhanced if future research specifically tested the individual muscle groups that work cooperatively to dynamically stabilize our core, as proposed by Arendt [37].

Study Limitations

This study has limitations. The participation rate was disappointing, and in retrospect, questionnaires should have been distributed directly to the athletes rather than reliance on the team representatives to perform that task. As noted previously, the participants who underwent the physical examination reported shoulder problems at a greater rate than did those in the larger group who returned the first questionnaire, suggesting participation bias. However, because a primary objective of the study was to identify physical attributes associated with shoulder problems, this bias was less consequential than if the sole intent had been to measure injury prevalence. Of course, there is also the possibility that those athletes with more serious injuries may not have attended this championship event, thereby potentially skewing this study's examination data in the other direction.

Because data were collected at a single point in time, by necessity the authors relied on self-report when determining volleyball-related exposures. Consequently, risk assessments evaluated associations rather than true cause-and-effect relationships. Finally, although the authors endeavored to standardize the physical examination, there was undoubtedly some variability in the way in which data were collected and recorded. For example, there were approximately 12 outliers in the glenohumeral passive range of motion data that suggested the possibility of inconsistencies in measurement technique. However, even when those outliers were removed from the dataset, there was no appreciable change in the statistical significance or interpretation of the relevant analyses. Consequently, all analyses were conducted on the full dataset without any effort to sanitize the data.

CONCLUSION

In summary, this investigation identified several risk factors for shoulder problems among volleyball players (tabulated in Table 6). Although these volleyball-related risk factors are indeed similar to those that have been identified for other overhead sports, the study data suggest that risk factors for shoulder problems exist in patterns that reflect the unique demands of each sport. The authors propose that the factors identified as associated with shoulder pain and dysfunction in volleyball athletes might facilitate early identification of those athletes at risk for shoulder problems, which in turn might permit timely introduction of appropriate injury prevention/therapeutic interventions. Specifically, the authors propose that coaches and team medical personnel may wish to periodically assess scapular function and dynamic postural control (eg, during preseason examinations as well as during season-ending exit examinations) to identify those athletes at greatest risk for shoulder dysfunction.

Table 6. *Factors associated with volleyball-related shoulder pain and dysfunction*

Factor	Type of Risk
Age	Intrinsic/unmodifiable
Coracoid tightness/pectoral shortening	Intrinsic/modifiable
Core instability	Intrinsic/modifiable
Gender	Intrinsic/unmodifiable
Imbalanced shoulder strength	Intrinsic/modifiable
Impingement	Intrinsic/modifiable
Position played	Extrinsic/modifiable
Restricted shoulder flexion	Intrinsic/modifiable
Service style	Extrinsic/modifiable
SICK scapula score ≥3	Intrinsic/modifiable

SICK = **S**capular malposition, **I**nferior medial border prominence, **C**oracoid pain and malposition, and dys**K**inesis of scapular movement.

ACKNOWLEDGMENTS

The authors are indebted to the athletes who participated in the 2006 NIRSA collegiate club volleyball championships and to Mary Callender and NIRSA for permitting us to conduct this study during the event. The Utah Sports Research Network was invaluable in facilitating the study. Richard Kenitzer of Marshfield Clinic expertly prepared both the video tutorial and the images that comprise Figures 1–5, and Alice Stargardt and Marie Fleisner of the Marshfield Clinic Research Foundation provided invaluable assistance in formatting and preparing the final manuscript.

REFERENCES

1. Bahr R, Reeser JC. Injuries among world-class professional beach volleyball players. The Fédération Internationale de Volleyball beach volleyball injury study. Am J Sports Med 2003;31:119-125.
2. Verhagen EA, Van der Beek AJ, Bouter LM, Bahr RM, Van Mechelen W. A one season prospective cohort study of volleyball injuries. Br J Sports Med 2004;38:477-481.
3. Briner WW Jr, Kacmar L. Common injuries in volleyball. Mechanisms of injury, prevention and rehabilitation. Sports Med 1997;24:65-71.
4. Agel J, Palmieri-Smith RM, Dick R, Wojtys EM, Marshall SW. Descriptive epidemiology of collegiate women's volleyball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. J Athl Train 2007;42:295-302.
5. Bahr R, Bahr IA. Incidence of acute volleyball injuries: a prospective cohort study of injury mechanisms and risk factors. Scand J Med Sci Sports 1997;7:166-171.
6. Jacobson RP, Benson CJ. Amateur volleyball attackers competing despite shoulder pain: analysis of play habits, anthropometric data, and specific pathologies. Physical Ther Sport 2001;2:112-122.
7. Wang HK, Cochrane T. A descriptive epidemiological study of shoulder injury in top level English male volleyball players. Int J Sports Med 2001:22:159-163.

8. Watkins J, Green BN. Volleyball injuries: A survey of injuries of Scottish National League male players. Br J Sports Med 1992;26:135-137.
9. Meister K. Injuries to the shoulder in the throwing athlete. Part one: Biomechanics/pathophysiology/classification of injury. Am J Sports Med 2000;28:265-275.
10. Bahr R, Holme I. Risk factors for sports injuries—a methodological approach. Br J Sports Med 2003;37:384-392.
11. Reeser JC, Verhagen E, Briner WW, Askeland TI, Bahr R. Strategies for the prevention of volleyball related injuries. Br J Sports Med 2006;40:594-600.
12. Kugler A, Krüger-Franke M, Reininger S, Trouillier HH, Rosemeyer B. Muscular imbalance and shoulder pain in volleyball attackers. Br J Sports Med 1996;30:256-259.
13. Alfredson H, Pietilä T, Lorentzon R. Concentric and eccentric shoulder and elbow muscle strength in female volleyball players and non-active females. Scand J Med Sci Sports 1998;8:265-270.
14. Stickley CD, Hetzler RK, Freemyer BG, Kimura IF. Isokinetic peak torque ratios and shoulder injury history in adolescent female volleyball athletes. J Athl Train 2008;43:571-577.
15. Wang HK, Cochrane T. Mobility impairment, muscle imbalance, muscle weakness, scapular asymmetry and shoulder injury in elite volleyball athletes. J Sports Med Phys Fitness 2001;41:403-410.
16. Wang HK, Juang LG, Lin JJ, Wang TG, Jan MH. Isokinetic performance and shoulder mobility in Taiwanese elite junior volleyball players. Isokinet Exerc Sci 2004;12:135-141.
17. Wang HK, Macfarlane A, Cochrane T. Isokinetic performance and shoulder mobility in elite volleyball athletes from the United Kingdom. Br J Sports Med 2000;34:39-43.
18. Placzek JD, Lukens SC, Badalanmenti S, et al. Shoulder outcome measures: a comparison of 6 functional tests. Am J Sports Med 2004; 32:1270-1277.
19. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology. Part I: Pathoanatomy and biomechanics. Arthroscopy 2003;19:404-420.
20. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology. Part III: The SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. Arthroscopy 2003;19:641-661.
21. Kibler WB. The role of the scapula in athletic shoulder function. Am J Sports Med 1998;26:325-337.
22. Kibler WB, Press J, Sciascia A. The role of core stability in athletic function. Sports Med 2006;36:189-198.
23. Meister K. Injuries to the shoulder in the throwing athlete. Part two: Evaluation/treatment. Am J Sports Med 2000;28:587-601.
24. Kibler WB, Chandler TJ, Livingston BP, Roetert EP. Shoulder range of motion in elite tennis players. Effect of age and years of tournament play. Am J Sports Med 1996;24:279-285.
25. American College of Sports Medicine. Selected issues in injury and illness prevention and the team physician: A consensus statement. Med Sci Sports Exerc 2007;39:2058-2068.
26. Witvrouw E, Cools A, Lysens R, et al. Suprascapular neuropathy in volleyball players. Br J Sports Med 2000;34:174-180.
27. Borsa PA, Laudner KG, Sauers EL. Mobility and stability adaptations in the shoulder of the overhead athlete: A theoretical and evidence-based perspective. Sports Med 2008;38:17-36.
28. Burkhart SS, Morgan CD, Kibler WB. Shoulder injuries in overhead athletes. The "dead arm" revisited. Clin Sports Med 2000;19:125-158.
29. Kibler WB, Chandler TJ, Pace BK. Principles of rehabilitation after chronic tendon injuries. Clin Sports Med 1992;11:661-671.
30. Myers JB, Laudner KG, Pasquale MR, Bradley JP, Lephart SM. Scapular position and orientation in throwing athletes. Am J Sports Med 2005; 33:263-271.
31. Oyama S, Myers JB, Wassinger CA, Daniel Ricci R, Lephart SM. Asymmetric resting scapular posture in healthy overhead athletes. J Athl Train 2008;43:565-570.
32. Ellenbecker TS, Roetert EP, Bailie DS, Davies GJ, Brown SW. Glenohumeral joint total rotation range of motion in elite tennis players and baseball pitchers. Med Sci Sports Exerc 2002;34:2052-2056.
33. Myers JB, Laudner KG, Pasquale MR, Bradley JP, Lephart SM. Glenohumeral range of motion deficits and posterior shoulder tightness in throwers with pathologic internal impingement. Am J Sports Med 2006;34:385-391.
34. Baltaci G, Tunay VB. Isokinetic performance at diagonal pattern and shoulder mobility in elite overhead athletes. Scand J Med Sci Sports 2004;14:231-238.
35. Forthomme B, Croisier JL, Ciccarone G, Crielaard JM, Cloes M. Factors correlated with volleyball spike velocity. Am J Sports Med 2005;33: 1513-1519.
36. Ferretti A, De Carli A, Fontana M. Injury of the suprascapular nerve at the spinoglenoid notch. The natural history of infraspinatus atrophy in volleyball players. Am J Sports Med 1998;26:759-763.
37. Arendt EA. Core strengthening. Inst Course Lect 2007; 56:379-384.

This CME activity is designated for 1.0 AMA PRA Category 1 Credit™ and can be completed online at me.aapmr.org. Log on to www.me.aapmr.org, go to Lifelong Learning (CME) and select Journal-based CME from the drop down menu. This activity is FREE to AAPM&R members and $25 for non-members.