Journal of Athletic Training 2010;45(3):253–258

www.nata.org/jat

Association of Generalized Joint Hypermobility With a History of Glenohumeral Joint Instability

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Context: Little is known about the relationship among sex, generalized joint hypermobility, and glenohumeral joint instability.

Objective: To examine the relationship among sex, generalized joint hypermobility scores, and a history of glenohumeral joint instability within a young, physically active cohort and to describe the incidence of generalized joint hypermobility within this population.

Design: Cross-sectional cohort study.

Setting: United States Military Academy at West Point, New York.

Patients or Other Participants: Of the 1311 members of the entering freshman class of 2010, 1050 (80%) agreed to participate.

Main Outcome Measure(s): Generalized joint hypermobility was assessed using the Beighton Scale. A history of glenohumeral joint instability was identified via a baseline questionnaire.

Results: Most participants (78%) had no signs of generalized joint hypermobility. Only 11 volunteers (1.5%) had Beighton Scale scores of 4 or greater. Logistic regression analysis revealed a relationship between generalized joint hypermobility and a history of glenohumeral joint instability ($P = .023$). When sex and race were controlled, those with a total Beighton Scale score of ≥2 were nearly 2.5 times as likely (odds ratio = 2.48, 95% confidence interval = 1.19, 5.20, $P = .016$) to have reported a history of glenohumeral joint instability. A relationship was observed between sex and nearly all individual Beighton Scale items. Although women had higher total Beighton Scale scores than men, sex ($P = .658$) and race ($P = .410$) were not related to a history of glenohumeral joint instability when other variables in the model were controlled.

Conclusions: In these participants, generalized joint hypermobility and a history of glenohumeral joint instability were associated.

Key Words: military athletes, sex differences, joint injuries, shoulder injuries

Key Points

- When the influences of sex and race were controlled, a relationship was observed between generalized joint hypermobility and a history of glenohumeral joint instability.
- Participants with a history of glenohumeral joint instability had higher total Beighton Scale scores than did participants with no such history.
- Participants with a Beighton Scale score of 2 or greater were nearly 2.5 times more likely to have experienced an episode of glenohumeral joint instability than were participants with lower scores when sex and race were held constant.

Individuals with generalized joint hypermobility may be at increased risk of sport-related injuries.[1,2] Generalized joint hypermobility has been proposed as a risk factor for injuries to the ankle, knee, and shoulder joints.[3–5] Although the relationship between generalized joint hypermobility and injury to the ligamentous structures in the ankle[1,3] and knee[5,6] joints has been examined, less is known about the effect on glenohumeral joint instability.[4,7] Several authors[4,7] have suggested that generalized joint hypermobility may be related to glenohumeral joint instability,[8–13] but this relationship has not been adequately investigated.

Generalized joint hypermobility is implicated in multidirectional glenohumeral instability, yet its relationship with traumatic shoulder instability has not been established. In addition, several reports[1,4,14–18] have shown a relationship between sex and generalized joint hypermobility. Signs of generalized joint hypermobility are more commonly observed in females than in males. This relationship has been demonstrated in elementary,[14] high school,[15,16] and college students[1,17,18] and in populations with various demographic characteristics. The relationship between sex and generalized joint hypermobility has also been observed among adolescent[15] and collegiate athletes.[1] Despite the substantial amount of evidence supporting the relationship between sex and generalized joint hypermobility, it is unclear whether increased generalized joint hypermobility among females is related to an increased risk for glenohumeral joint instability.[19]

The purpose of our study was to examine the relationship among sex, race, generalized joint hypermobility scores, and a history of glenohumeral joint instability in a young, physically active cohort. A secondary objective was to describe the patterns of generalized joint hypermobility within this population.

Table 1. Beighton Scale Items and Criteria for a Positive Sign

Beighton Scale Item	Highest Possible Score[a]	Criteria for a Positive Sign
Passive hyperextension of the fifth finger	2	>90°
Passive thumb opposition to the forearm	2	Thumb touches forearm
Elbow hyperextension	2	>10°
Knee hyperextension	2	>10°
Standing trunk flexion with knees fully extended	1	Both palms flat on floor

[a] Each item is scored bilaterally, except for standing trunk flexion.

METHODS

Design and Setting

We initiated a prospective cohort study to identify modifiable and nonmodifiable risk factors for glenohumeral joint instability in a young, healthy, and physically active population. This project represents the cross-sectional analysis of a subset of the baseline data from a broader longitudinal cohort study. The institutional review board at our institution reviewed and approved this study before it began.

Participants

All 1311 members of the entering freshman class of 2010 at the United States Military Academy at West Point, New York, were solicited to enroll in this study, and 80% of the class (1050) agreed to participate and provided informed consent. Of those who agreed to participate, only those with complete data were included in the analysis (n = 714: 630 men [88%] and 84 women [12%]). These percentages are consistent with the general population at this institution, which annually enrolls a freshman class of approximately 85% men and 15% women.

Among the men, the average age was 18.8 ± 1.0 years, height was 178.5 ± 7.5 cm, and mass was 76.1 ± 12.9 kg. Among the women, the average age was 18.7 ± 0.9 years, height was 165.4 ± 7.0 cm, and mass was 63.2 ± 9.1 kg. All participants were deemed healthy and medically fit for military service through the Department of Defense Medical Evaluation Review System before admission to the Academy. As a result, those with connective tissue disorders such as Marfan syndrome, osteogenesis imperfecta, and Ehlers-Danlos syndrome would have been disqualified from military service and were, therefore, excluded from this cohort.

Outcome Measures

Generalized Joint Hypermobility. We used the Beighton Scale to assess generalized joint hypermobility in all volunteers.[20,21] Originally described by Carter and Wilkinson[22] and subsequently modified by Beighton and Horan[20] and Beighton et al,[21] the scale includes 9 items (Table 1; each item is scored bilaterally except for standing trunk flexion) and is scored on an ordinal scale from 0 to 9, with a higher score representing greater generalized joint hypermobility. For each item, a negative sign is scored as 0 and a positive sign as 1. All clinical measurements were performed by the same sports medicine fellowship-trained orthopaedic surgeon (B.D.O.), who was blinded to the baseline questionnaire data.

The Beighton Scale has emerged as a major diagnostic criterion for benign joint hypermobility syndrome.[23,24] Authors have documented the psychometric properties of the Beighton Scale, with reliability estimates of 0.74 to 0.84,[23] 0.79 to 0.93,[25] 0.44 to 1.00,[26] and 0.65 to 0.81.[27]

Although several cutoff criteria have been used in the literature, no criterion for identifying generalized joint hypermobility with the Beighton Scale has been universally accepted.[23,28] For the purpose of this study, we established the cutoff criterion at the 95th percentile to represent increased generalized joint hypermobility. This corresponded with a total Beighton Scale score of 2 or greater.

History of Glenohumeral Joint Instability. A primary outcome measure of this study was a history of glenohumeral joint instability before arrival at our institution. *Glenohumeral joint instability* was defined as a traumatic event in which the humeral head was displaced from the glenoid cavity. Glenohumeral joint instability events were identified through a baseline questionnaire that was administered to all participants in their first week at the Academy. Two items were specifically used to identify previous glenohumeral joint instability: (1) *Have you ever dislocated (needed to be put back into place) either shoulder?* and (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, injured arm dominance, and mechanism of injury were also included in the baseline questionnaire.

Statistical Analysis

The relationship between generalized joint hypermobility and a history of glenohumeral joint instability was evaluated using multivariable logistic regression analysis while controlling for the influence of sex and race as covariates. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated by history of glenohumeral joint instability, using those with no history of instability as the reference group. Because data for the total Beighton Scale scores were not normally distributed, we conducted the Mann-Whitney *U* test to identify differences in total Beighton Scale scores by sex and history of glenohumeral joint instability. Frequencies were calculated for each individual Beighton Scale item and the total Beighton Scale score for both men and women. The relationship between sex and score for each Beighton Scale item was assessed using the χ^2 test. We calculated ORs and 95% CIs for sex using men as the reference group. Data analysis was performed with SPSS (version 11.5; SPSS Inc, Chicago, IL).

RESULTS

The racial breakdown of our 714-person cohort was as follows: 554 (78%) were white, 33 (5%) were African American, 28 (4%) were Asian, 57 (8%) were Hispanic, and

Table 2. Demographic Data by Sex for Participants Reporting a History of Glenohumeral Joint Instability

Characteristic	Men (n = 630) n (%)	Women (n = 84) n (%)	Total (n = 714) n (%)
Type of instability event			
Dislocation	25 (28.4)	1 (8.3)	26 (26)
Subluxation	53 (60.2)	9 (75.0)	62 (62)
Dislocation and subluxation	10 (11.4)	2 (16.7)	12 (12)
Total	88 (88.0)	12 (12.0)	100 (100)
Injured side			
Right	42 (47.7)	6 (50.0)	48 (48)
Left	30 (34.1)	1 (8.3)	31 (31)
Bilateral	16 (18.2)	5 (41.7)	21 (21)
Total	88 (88.0)	12 (12.0)	100 (100)
Injured arm and dominance			
Injured dominant arm	43 (48.9)	6 (50.0)	49 (49)
Injured nondominant arm	28 (31.8)	1 (8.3)	29 (29)
Injured both arms	16 (18.2)	5 (41.7)	21 (21)
No dominance reported	1 (1.1)	0 (0.0)	1 (1)
Total	88 (88.0)	12 (12.0)	100 (100)
Mechanism of injury			
Contact	42 (47.7)	4 (33.3)	46 (46)
Noncontact	11 (12.5)	4 (33.3)	15 (15)
Unknown	35 (39.8)	4 (33.3)	39 (39)
Total	88 (88.0)	12 (12.0)	100 (100)

37 (5%) were of other races. A total of 100 participants reported a history of glenohumeral joint instability, with 614 reporting no such history. Self-reported demographic information for those with a history of instability is presented in Table 2.

Participants with a history of glenohumeral joint instability had higher total Beighton Scale scores than did those with no prior history of instability (Table 3). Furthermore, when the influences of sex and race were controlled, a significant correlation was noted between a history of glenohumeral joint instability and a total Beighton Scale score of 2 or greater ($\chi^2_1 = 5.16$, $P = .023$) (Table 4). Participants with a total Beighton Scale score of 2 or greater were nearly 2.5 times as likely (OR = 2.48, 95% CI = 1.19, 5.20, $P = .016$) to have reported a history of glenohumeral joint instability. This trend of increased joint mobility and a history of glenohumeral joint instability was observed in both men and women. Sex ($\chi^2_1 = 0.196$, $P = .658$) and race ($\chi^2_1 = 0.714$, $P = .410$) were not related to a history of glenohumeral joint instability within this cohort when we controlled for the influence of the other variables in the statistical model.

The observed frequencies for each individual Beighton Scale item by sex are presented in Table 5. The most common sign of generalized joint hypermobility in both men and women was standing trunk flexion with knees fully extended, which was observed in 14.1% of the men and nearly half (46.4%) of the women. Knee and elbow hyperextension were the next most commonly observed signs in this cohort for both men and women. A significant relationship was demonstrated between the score for each individual Beighton Scale item and sex, except for 90° or greater extension at the metacarpophalangeal joint in the fifth finger bilaterally (Table 5). In general, higher frequencies for each individual Beighton Scale item were observed in women than in men. The estimated ORs between men and women and 95% CI for each item ranged from 2.30 to 7.83; all were significant, except extension at the metacarpophalangeal joint in the fifth finger bilaterally (Table 5).

Most participants had no positive signs of generalized joint hypermobility. Only 11 (5 men, 6 women) had Beighton Scale scores of 4 or greater. Because this represented only 1.5% of our cohort, no significant differences were discernible, given this small number. The mean Beighton Scale score was 0.34 and the median was 0, with a range of 0 to 7. Overall, 78.4% of the volunteers in this cohort had a score of 0 for the total Beighton Scale. When examined by sex, 82.4% of the men and 48.8% of the women had a score of 0. A total Beighton Scale score of 2 or greater placed individuals at or above the 95th percentile in this cohort. Frequencies for the total Beighton Scale score by sex and for the entire cohort combined are presented in Table 6. Higher total Beighton Scale scores were observed among women when compared with men ($P < .001$) (Table 7).

DISCUSSION

Several authors[7–13] have speculated on a relationship between generalized joint hypermobility and glenohumeral joint instability; however, this relationship has not been examined empirically. Warner et al[12] observed generalized joint hypermobility in 25% of normal control participants and 22% of those with glenohumeral joint instability but did not examine the relationship between glenohumeral joint instability and measures of generalized joint hypermobility. Cooper and Brems[9] reported that 29 of 38 surgical patients (76%) with multidirectional glenohumeral joint instability demonstrated generalized joint hypermobility, but as in the study by Warner et al,[12] the relationship between these variables was not examined. In a cohort of 178 athletes, McFarland et al[7] reported a difference in generalized joint hypermobility between participants with a grade I sulcus sign and those with a grade II sulcus sign, yet the authors failed to provide enough data to evaluate the nature of this difference. Furthermore, it is not clear if the authors attempted to examine the difference in generalized

Table 3. Mann-Whitney *U* Test Analysis of Differences in Total Beighton Scale Score Between Groups Based on History of Shoulder Instability

History of Instability?	n	Total Beighton Score		*U* Value	Z Value	*P* Value[a]
		Mean Rank	Sum of Ranks			
No	614	351.71	215 949.00	27 144.00	−2.59	<.009
Yes	100	393.06	39 306.00			

[a] Two-tailed test of significance.

Table 4. Logistic Regression Analysis of History of Shoulder Instability as a Function of Beighton Scale Score, Controlling for Sex and Race

Variable	B	Standard Error	χ^2	*df*	*P* Value	Odds Ratio[a]	95% Confidence Interval	*P* Value
Sex	0.154	0.353	0.196	1	<.658	1.17	0.58–2.33	<.662
Race	0.082	0.100	0.714	1	<.398	1.09	0.89–1.32	<.410
Beighton Scale score ≥2	0.910	0.377	5.159	1	<.023	2.48	1.19–5.20	<.016

[a] No history of shoulder instability was the referent group for comparisons.

Table 5. Frequency and Prevalence for Each Beighton Scale Item by Sex

	Men (n = 630)		Women (n = 84)					
	Yes	No	Yes	No			Odds	95% Confidence
Beighton Scale Items	n (%)	n (%)	n (%)	n (%)	χ^2	*P* Value	Ratio	Interval
>90° Fifth finger metacarpophalangeal joint extension								
Dominant side	10 (1.6)	620 (98.4)	3 (3.6)	81 (96.4)	1.63	.201	2.30	0.62–8.52
Nondominant side	9 (1.4)	621 (98.6)	3 (3.6)	81 (96.4)	2.06	.151	2.56	0.68–9.63
Thumb to forearm opposition								
Dominant side	4 (0.6)	626 (99.4)	4 (4.8)	80 (95.2)	11.39	.001	7.83	1.92–31.90
Nondominant side	4 (0.6)	626 (99.4)	4 (4.8)	80 (95.2)	11.39	.001	7.83	1.92–31.90
>10° Elbow hyperextension								
Dominant side	13 (2.1)	617 (97.9)	7 (8.3)	77 (91.7)	10.70	.001	4.32	1.67–11.14
Nondominant side	11 (1.7)	619 (98.3)	7 (8.3)	77 (91.7)	13.09	.001	5.12	1.93–13.59
>10° Knee hyperextension								
Dominant side	12 (1.9)	618 (98.1)	6 (7.1)	78 (92.9)	8.28	.004	3.96	1.45–10.85
Nondominant side	12 (1.9)	618 (98.1)	6 (7.1)	78 (92.9)	8.28	.004	3.96	1.45–10.85
Both palms flat on floor	89 (14.1)	541 (85.9)	39 (46.4)	45 (53.6)	52.56	.001	5.27	3.25–8.55

joint hypermobility between individuals with a grade I sulcus sign and those with a grade III sign.[7] Because McFarland et al[7] studied healthy, asymptomatic athletes, it was not possible to examine the relationship between generalized joint hypermobility and glenohumeral joint instability.

In contrast, Lintner et al[29] observed no relationship between shoulder-specific clinical laxity measures and knee or elbow hyperextension or thumb-to-forearm distance in a small cohort of asymptomatic National Collegiate Athletic Association Division I collegiate athletes. As was the case with McFarland et al,[7] Lintner et al investigated healthy athletes with asymptomatic shoulders. As a result, the relationship between generalized joint hypermobility and glenohumeral joint instability could not be examined.

Table 6. Distribution of Total Beighton Scale Scores by Sex and for the Entire Cohort Combined

Total Beighton Score	Men (n = 630) n (%)	Women (n = 84) n (%)	Combined (n = 714) n (%)
0	519 (82.4)	41 (48.8)	560 (78.4)
1	82 (13.0	30 (35.7)	112 (15.7)
2	16 (2.5)	3 (3.6)	19 (2.7)
3	8 (1.3	4 (4.8)	12 (1.7)
4	2 (0.3)	1 (1.2)	3 (0.4)
5	1 (0.2)	3 (3.6)	4 (0.6
6	1 (0.2)	0 (0.0)	1 (0.1)
7	1 (0.2	2 (2.4)	3 (0.4)
8	0 (0.0)	0 (0.0)	0 (0.0)
9	0 (0.0)	0 (0.0)	0 (0.0)

These and other studies have been cited to support the relationship between generalized joint hypermobility and glenohumeral joint instability in the literature.[4] However, these reports more appropriately suggest a relationship between generalized joint hypermobility and glenohumeral laxity.

In the present study, we have shown a relationship between increased generalized joint hypermobility based on Beighton criteria and a history of glenohumeral joint instability. Participants with increased generalized joint hypermobility, represented by a total Beighton Scale score of 2 or greater, reported a history of glenohumeral joint instability nearly 2.5 times as often as those without increased generalized joint hypermobility. Thus, our results provide preliminary evidence to support the relationship between generalized joint hypermobility and glenohumeral joint instability when the influences of sex and race are controlled. Clinically, this investigation provides preliminary support for increased generalized joint hypermobility as a potential predisposing risk factor for glenohumeral joint instability. Therefore, measures of generalized joint hypermobility may be useful in identifying individuals at increased risk for shoulder instability, although prospective research is needed to confirm this.

Previous authors[4,14] have shown a correlation between female sex and increased incidence of generalized joint hypermobility. These results are consistent with the findings of studies examining this relationship in both athletic[1,2,15] and general[14,16–18,21] populations. In the current study, women had higher total Beighton Scale scores than men. The relationship between sex and generalized joint hypermobility was also observed for each

Table 7. Mann-Whitney *U* Test Analysis of Differences in Total Beighton Scale Score Between Groups Based on Sex

		Total Beighton Score				
Sex	n	Mean Rank	Sum of Ranks	*U* Value	Z Value	*P* Value
Male	630	343.12	216 167.00	17 402.00	−7.12	<.001
Female	84	465.33	39 088.00			

individual Beighton Scale item except for hyperextension of the metacarpophalangeal joint of the fifth finger bilaterally. When we examined the individual Beighton Scale items, women were 2.3 to 7.8 times more likely than men to have a single positive sign for generalized joint hypermobility.

Sex was not related to history of glenohumeral joint instability within this cohort when the influences of race and total Beighton Scale score were controlled, despite the observed relationship between sex and individual-item Beighton scores. Furthermore, sex was not an important factor affecting the relationship between a Beighton Scale score of 2 or greater and a history of glenohumeral joint instability. Interestingly, emerging epidemiologic data indicate that males are at greater risk for glenohumeral joint instability than females.[30–35] Thus, the increased generalized joint hypermobility commonly reported among females may not increase their risk of glenohumeral joint instability. Higher instability rates among males have been observed in both athletic[32,35] and general[30,31,33,34] populations. Conversely, the increased incidence among males may reflect a difference in activity-specific risk factors when compared with females.[35]

Although we demonstrated a relationship between measures of generalized joint hypermobility and a history of glenohumeral joint instability, the overall prevalence of participants meeting the diagnostic criteria for benign joint hypermobility syndrome was lower than previously reported in the literature. No universally accepted cutoff level has been established for generalized joint hypermobility,[23] but it is generally accepted that a total Beighton Scale score of 4 or greater is a major diagnostic criterion for benign joint hypermobility syndrome.[24] Prevalence rates for athletes meeting this level of Beighton criteria for benign joint hypermobility syndrome have been reported to be 23.9% in collegiate athletes[1] and between 12.9% and 43% in high school[15] and younger[2] athletes, respectively. In the current study, only 1.5% of the participants met the total Beighton Scale score diagnostic criterion for benign joint hypermobility syndrome, with a score of 4 or higher. Because of this finding in this young military academy population, we elected to establish the cutoff point for laxity at the 95th percentile, equivalent to a total Beighton Scale score of 2 or greater. We noted that even those with a total Beighton Scale score of 2 or greater had previously experienced glenohumeral joint instability more than twice as often as those with a lower score. As a result, it may not be necessary for athletes or others to meet the clinical criteria for benign joint hypermobility to be at increased risk for glenohumeral joint instability.

Some limitations of the current investigation should be noted. Primarily, a causal relationship between a Beighton Scale score of 2 or greater and a history of glenohumeral joint instability cannot be established based on the cross-sectional nature of our data. As we follow this cohort and prospectively document all glenohumeral joint instability events over time, it may be possible to confirm the directionality and causal nature of this relationship and whether increased generalized joint hypermobility is a predisposing risk factor for glenohumeral joint instability. Another limitation related to the cross-sectional nature of the current study is that instability events were not documented acutely or confirmed with radiographs or magnetic resonance imaging. As a result, the true nature of instability with regard to directionality and acuity could not be reliably determined. Finally, the Beighton Scale score cutoff for increased generalized joint hypermobility was set at 2 or greater. Although this represented the 95th percentile within our population, it is lower than the score of 4 or higher typically used to diagnose benign joint hypermobility syndrome.[30] Within our population, relatively few participants had scores high enough to meet the criteria for benign joint hypermobility syndrome. This may be due to selection bias in our cohort, which is subjected to intense scrutiny for medical and physical fitness for military service; however, despite this limitation, we noted a relationship between those with a total Beighton Scale score of 2 or greater and a history of glenohumeral joint instability. Confirming this relationship in other sport-specific populations is a goal for future investigations.

In summary, a relationship was observed between measures of generalized joint hypermobility and a history of glenohumeral joint instability, regardless of the influence of sex and race. Compared with participants without a history of glenohumeral joint instability, participants with such a history had higher total Beighton Scale scores, and participants with a Beighton Scale score of 2 or greater were more than twice as likely to have experienced a prior episode of glenohumeral joint instability than were those with a lower score.

ACKNOWLEDGMENTS

This project was aided by a grant from the Orthopaedic Research and Education Foundation. We thank Sally Mountcastle, PhD, for her assistance with the conception and design of this project. We also thank Tim Kelly, ATC, and Dana Putnam, ATC (Department of Intercollegiate Athletics); Craig Yunker, ATC, Karen Peck, ATC, and Jason Suby, ATC (Department of Physical Education), at the United States Military Academy; and William Loro, DPT, DSc, ATC, SCS; Mark Thelen, DPT; James Dauber, DPT; and Heath Todd, PT, in the Physical Therapy Department at the Keller Army Hospital for their assistance with the logistics, baseline data collection, and ongoing injury surveillance for this project. In addition, we recognize and thank the members of the United States Military Academy graduating class of 2010 for their participation in this study and their commitment to serve our nation. The views and opinions expressed in this manuscript are those of the author(s) and do not reflect the official policy of the Department of the Army, the Department of Defense, or the US Government.

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