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Generalized Joint Hypermobility and Its Relationship to Injury Patterns Among NCAA Lacrosse Players

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Objective: To prospectively observe and compare injury patterns between hypermobile and nonhypermobile NCAA athletes.

Design and Setting: Athletes were screened for generalized joint hypermobility before the 1995 lacrosse season. Injuries were recorded through the end of the postseason and compared in hypermobile and nonhypermobile athletes.

Subjects: A total of 310 male and female volunteers from 17 lacrosse teams participated in the study.

Measurements: Hypermobility was evaluated with the technique of Carter and Wilkinson (as modified by Beighton and colleagues), which uses 9 joint measurements to assess global joint mobility. For an athlete to be considered hypermobile, 5/9 of these measurements must have been positive. Next, certified athletic trainers prospectively recorded injuries and hours of practice and game participation on a standard form. After the season, all data forms were returned to us for analysis. Significance was set at $P = .05$, and χ^2 and independent t tests were used to compare injuries between groups.

Results: Twenty of 147 men (13.6%) and 54 of 163 women (33.1%) were hypermobile, yielding an overall hypermobility prevalence of 23.8%. One hundred athletes sustained 134 injuries. There were no significant differences in overall injury rate among hypermobile (2.29/1000 hours) compared with nonhypermobile (3.54/1000 hours) athletes. Nonhypermobile athletes suffered contact injuries at a higher rate (1.38/1000 hours) than hypermobile athletes (0.52/1000 hours). Hypermobile athletes showed an increased rate of ankle injuries, and nonhypermobile athletes showed a trend toward an increased rate of strains. Multiple approaches to analysis of the data revealed no other significant findings.

Conclusions: There was no difference in overall injury rates between hypermobile and nonhypermobile athletes in this sample. This finding is somewhat surprising in light of significant evidence that hypermobility appears to be a factor in joint complaints among nonathletes. Additional research is needed to clearly determine whether a relationship exists between hypermobility and injury rates among athletes.

Key Words: athletic injury surveillance, laxity, injury risk, rheumatology

Joint hypermobility is a well-recognized characteristic of collagen disorders such as Marfan syndrome and Ehlers-Danlos syndrome.[1,2] However, joint hypermobility also exists in the absence of rheumatic disease[3–12] and is often referred to as "double jointedness" by the lay public. This subject has been the topic of many studies, with research beginning in earnest in the early 1960s. Since that time, relationships have been found among global joint hypermobility and a wide array of physical maladies, including insidious arthralgia, premature osteoarthritis, and fibromyalgia. Based on such research and discussion in the rheumatologic and pediatric literature, current wisdom among rheumatologists and pediatricians suggests that hypermobile individuals should avoid strenuous physical activity because of a possible increased risk of athletic injury.[3–8,13–27]

However, many hypermobile individuals are currently participating in athletic programs and activities.[28–33] And, while the morbidity of hypermobility appears well supported by studies of nonathletes, studies of athletes are relatively limited.[15,30,33–38] Further, the conclusions of these limited studies are split with regard to whether hypermobile individuals actually run a higher risk of athletic injury. For example, Kujala et al[36] and Hopper et al[38] found no relationship between hypermobility and back pain or between hypermobility and injuries, respectively, in athletic populations. Acasuso-Diaz et al[3] and Klemp et al,[33,35] however, have found a relationship between hypermobility and injuries among soldiers and ballet dancers. Differences in methodology, common in hypermobility studies, also create problems in combining and comparing existing studies.

It is important to recognize and confirm any conditions that might predispose athletes to injury. The purpose of our study was to prospectively observe injury patterns among hypermobile and nonhypermobile athletes over one athletic season.

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METHODS

Two members of the research team (RHL and LCD) traveled to all participating schools to screen athletes and to train data collectors.

Hypermobility Assessment

A total of 310 (147 males, age = 20 ± 2 years; 163 females, age = 20 ± 4 years) volunteers from 17 NCAA lacrosse teams were screened for hypermobility using the method developed by Carter and Wilkinson[18] and modified by Beighton et al.[6] The cohort included all members of the participating teams. This method, validated by Bird et al,[39] examines the ability to hyperextend knees and elbows beyond 10°, to passively extend the fingers so they are parallel to the forearm, to passively abduct the thumb so that it touches the forearm, and to forward flex the trunk so that the palms easily touch the floor, and it employs a 0 to 9 scoring scheme (Figure 1). A goniometer was used to measure knee and elbow hyperextension. We also employed an "injury allowance," whereby athletes who screened positive for only one side of a bilateral test, but had a history of significant injury (eg, anterior cruciate ligament tear or reconstruction) to the contralateral joint, were given an injury allowance point. The same certified athletic trainer (RHL) was involved in screening all the athletes. Athletes who scored 5 or higher were considered hypermobile.

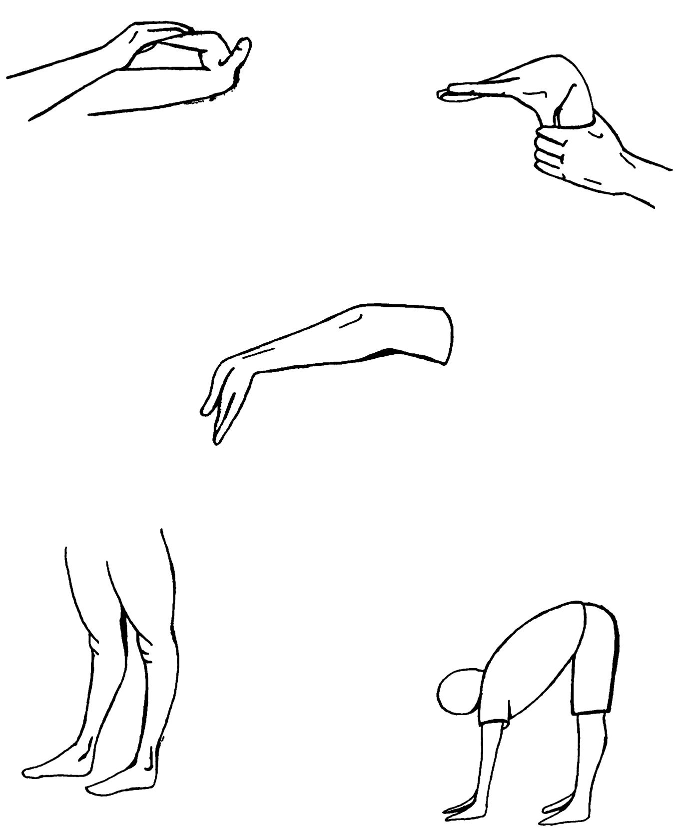

Figure 1. Motion required for positive hypermobility screening tests. Reprinted with permission from *Archives of Pediatrics and Adolescent Medicine*, (1997;151:989–992). Copyright 1997, American Medical Association.

Injury Surveillance

Certified athletic trainers at each participating school were recruited to prospectively record injury data. One researcher (RHL) met individually with each data collector to review data collection forms and procedure. The certified athletic trainers prospectively recorded on a standard form injuries and time lost from participation during the 1995 season, including preseason and postseason play. For this study, only injuries that required the athlete to miss at least one practice or game were considered. Time missed was counted until athletes returned to full participation. Information obtained about all injuries included body part, mechanism of injury, activity at the time of injury, diagnosis, referral to physician, surgical intervention, and practices, games, and classes missed because of the injury. To account for exposure differences, athletic trainers also recorded hours of practice and game participation for their team(s), and injuries were expressed per 1000 hours of exposure.

Statistical Analysis

An independent *t* test was used to determine differences in injury rate between hypermobile and nonhypermobile athletes, while χ^2 analyses were used to assess independence in all other variables. Analyses were performed using SPSS for Windows (version 6.01, SPSS Inc, Chicago, IL).

RESULTS

At the end of the 1995 season, data were forwarded to the research team by all participating schools. Figure 2 shows the injuries reported per team.

Prevalence and Features of Hypermobility

The Table outlines demographic data about our subjects. The injury allowance alone did not cause any athletes to be

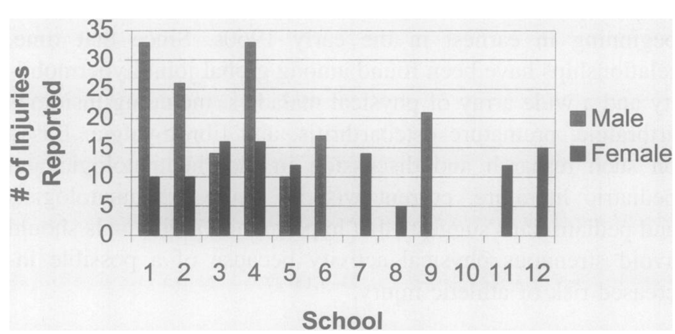

Figure 2. Frequency of injuries by institution. Schools 1–5 had both men's and women's teams participating in the study, schools 6 and 9 had only men participating, and schools 7, 8, and 10–12 had only women participating.

Description of Sample

Sex	Subjects (number)	Mean Age (y)	Mean Height (cm)	Mean Weight (kg)	Hypermobility Prevalence (% of N)
Male	147	20 ± 2*	179.07	81.19	13.6
Female	163	20 ± 4	166.12	59.87	33.1

* Mean ± standard deviation.

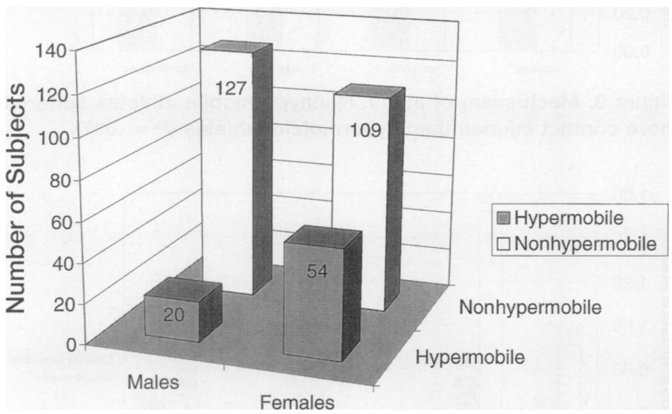

Figure 3. Frequency of hypermobility by sex. Significantly more females ($P < .001$) met the 5/9 criteria to be considered hypermobile.

considered hypermobile; therefore, it was not a significant factor in the rate of hypermobility. The prevalence of generalized joint hypermobility was 23.9% (74/310): 33.1% (54/163) of females ($P < .001$) and 13.6% (20/147) of males (Figures 3–5).

Injury Surveillance

One hundred athletes sustained 134 injuries. Males suffered injuries at a rate of 4.67 per 1000 player-hours of exposure and females at a rate of 1.76 per 1000 hours ($P < .001$) (Figure 6A). Mechanism of injury was dependent on sex ($P < .05$), with contact injuries more common in males and spontaneous (unknown cause) injuries more common in

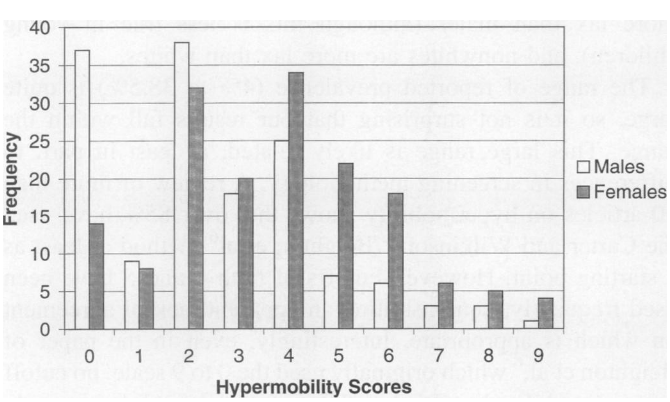

Figure 4. Frequency of screening scores by sex. Most males scored 4/9 or less, while female scores are better distributed. Only 22/310 (7%) subjects scored 7, 8, or 9.

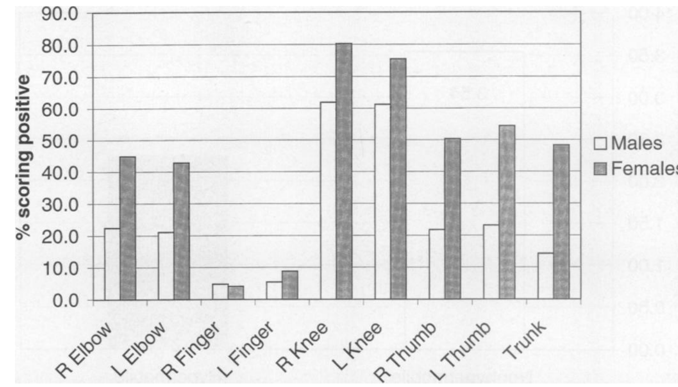

Figure 5. Frequency of positive findings by joint and sex. Knee hyperextension beyond 10° was common in both sexes, while upper extremity hypermobility was more common among female subjects.

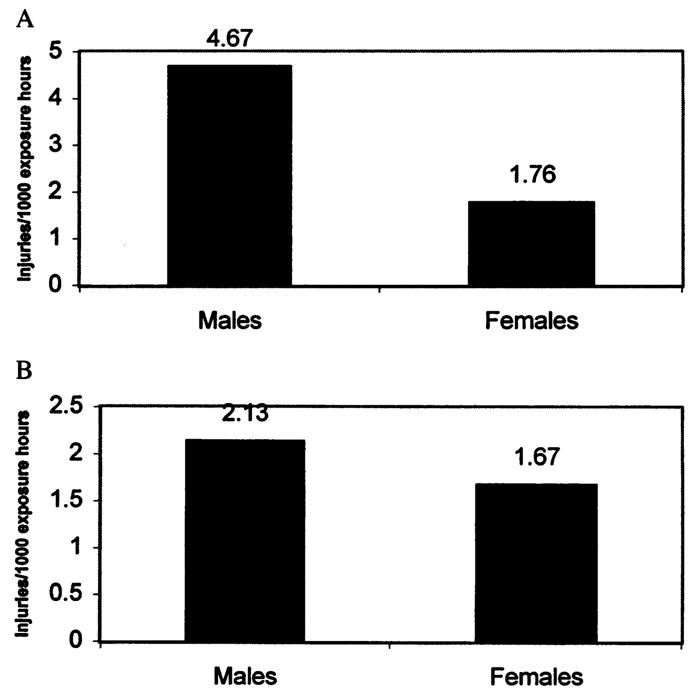

Figure 6. A, Injury rate by sex. Overall, males suffered a higher rate of injuries than females ($P < .001$). B, Noncontact injury rate by sex. Since men's lacrosse is a contact sport, contact injuries were removed for reconsideration of injury rate by sex. There was no significant difference in injury rate after contact injuries were purged.

females. Analysis of the data, with contact injuries excluded, brings these figures significantly closer, with males at 2.13 injuries per 1000 hours and females at 1.67 per 1000 hours ($t_{308} = 1.05$, $P = .293$; 2-tailed for independent samples) (Figure 6B). The knee was the most common site of injury in males at 15.2% (14/92) of injuries, while the thigh was most often injured in females, representing 28.6% (12/42) of injuries. The thigh was also the most common site of injury overall, accounting for 18.7% (25/134) of injuries, primarily strains.

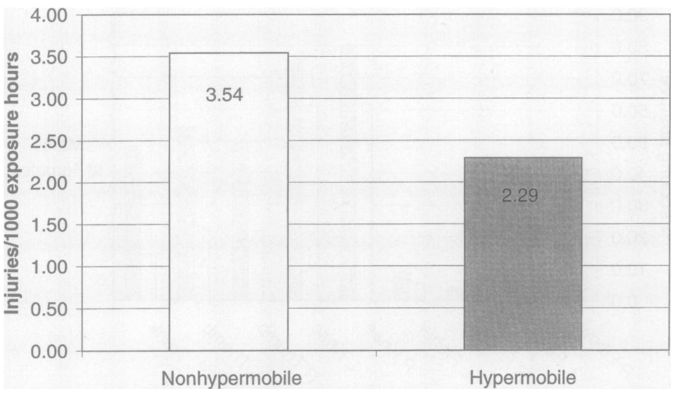

Figure 7. Injury rate by hypermobility status. Injury rate was not affected by hypermobility status (*P* = .18)

Analysis of the injury data by hypermobility status (Figure 7) showed no significant difference in injury rate between hypermobile (2.29/1000 hours) and nonhypermobile (3.54/1000 hours, t_{308} = 1.37, P = 0.18; 2-tailed for independent samples) athletes. There was no difference in injury severity as judged by time missed: of the 134 injuries in 100 athletes, 44% (59) resulted in the athlete's missing a week or more of practices or games (Figure 8). Further, there was no significant finding in activity at the time of injury (89% occurred during sport) or referral to physician (27% of injuries referred). There was also no significant difference in the occurrence of sprains, fractures, bursitis, or cartilage injuries. An exhaustive analysis of the data set from many perspectives revealed only 2 statistically significant findings. Hypermobile athletes showed an increased rate of ankle injuries: 26.1% (6/23), compared with only 9% (10/111) of injuries to nonhypermobile athletes ($P < .05$). Nonhypermobile athletes had a higher rate of contact injuries (1.38/1000) than hypermobile athletes (0.52/1000, P = .037) (Figure 9). Nonhypermobile athletes showed a trend toward an increased rate of strains: 40.5% (45/111) of injuries to nonhypermobile athletes versus 30.4% (7/23) to hypermobile athletes (P = .051) (Figure 10).

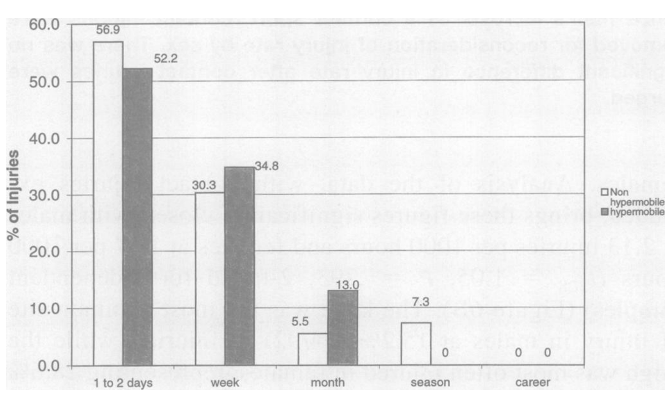

Figure 8. Injuries resulting in time loss. Note the relatively even distribution of time lost by hypermobile and nonhypermobile athletes.

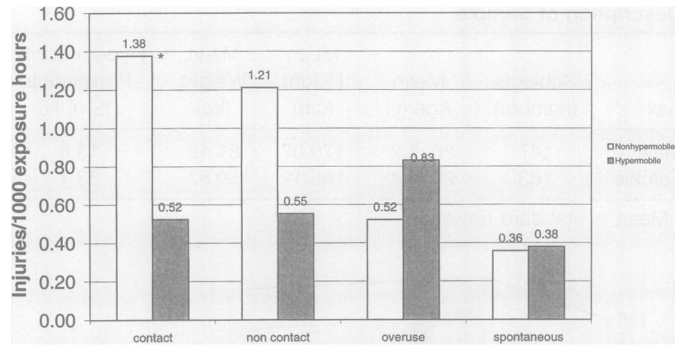

Figure 9. Mechanism of injury. Nonhypermobile athletes suffered more contact injuries than hypermobile athletes (*P* = .037).

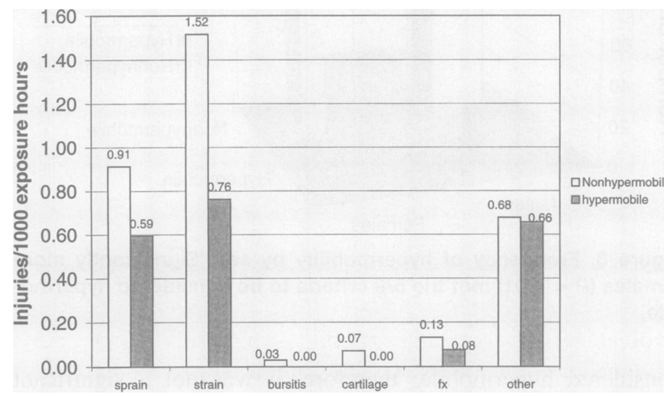

Figure 10. Diagnosis by hypermobility status. Strains and sprains were the most common types of injury. Nonhypermobile athletes suffered more strains, but this finding was not statistically significant (*P* = .051)

DISCUSSION

Prevalence and Features of Hypermobility

A review of the literature reveals that researchers have screened more than 10000 people for hypermobility,* including school children, college students, factory workers, rheumatology clinic patients, people of different ethnic backgrounds, and athletes. In general, laxity decreases with age, females are more lax than males (although this is less true in young children), and nonwhites are more lax than whites.

The range of reported prevalence (4% to 38.5%) is quite large, so it is not surprising that our results fall within the range. This large range is likely related, at least in part, to differences in screening methodology. A review of more than 50 articles on hypermobility shows that over 85% have used the Carter and Wilkinson[18]/Beighton et al[6] method at least as a starting point. However, cutoffs of both 4 and 5 have been used frequently, demonstrating an apparent lack of agreement on which is appropriate. Interestingly, even in the paper of Beighton et al,[6] which originally used the 0 to 9 scale, no cutoff is suggested. Further, Bird et al[39] performed a validation study

References 3–6, 11–13, 18, 22, 23, 28, 29, 33, 39–41.

of the Carter and Wilkinson[18] method without mentioning the cutoff studied, although one assumes it was the 3/5 used by Carter and Wilkinson (3/5 seems to correspond to 5/9, although with decreased quantifiability). There is little doubt that the cutoff can make a significant difference in prevalence. For example, in our study, instead of an overall prevalence of 23% using 5/9, prevalence would rise to 49% (153/310) using 4/9.

Injury Surveillance

The vast differences in rules between men's and women's lacrosse likely account for the increase in both overall and contact injury rates among males. Since men's lacrosse is a contact game, it seems likely there would be more contact injuries, and the analysis of the data with contact injuries excluded confirms this. We can conclude that male lacrosse players are more likely to be injured than female lacrosse players; however, it was not a goal of this study to make a sex comparison. Rather, we were specifically interested in injury patterns between hypermobile and nonhypermobile athletes. In particular, because some experts recommend limiting sport participation for hypermobile athletes, we were looking for an increased injury rate among hypermobile athletes.

Sutro[16] was among the first to call attention to the possible involvement of joint hypermobility in cases of recurrent, insidious joint effusions. Continued investigation confirmed the existence of a type of generalized joint laxity that was not associated with other common connective tissue anomalies, such as hyperelasticity of the skin, vessel failure, and skeletal abnormalities.[1,10,20,25,42] Because of the lack of disease, loose jointedness in otherwise healthy individuals became known as "benign" hypermobility. This tag was short-lived, however, as many researchers began reporting on musculoskeletal complaints associated with "benign" joint hypermobility.[1,10,13,19,42] In 1967, Kirk et al[10] coined the term "hypermobility syndrome" to describe cases in which joint laxity was associated with unexplained rheumatic complaints, such as recurrent joint pain and effusion, recurrent dislocations of the patella and shoulder, and early osteoarthritis. Indictments of joint hypermobility as a factor in joint complaints continue to grow. In fact, researchers have found such convincing evidence that hypermobility causes musculoskeletal problems that they frequently conclude their manuscripts with comments like the following:

> "Sports and careers that result in over stretching the joints are unsuitable for hypermobile children and teenagers and should be advised against them."[8]
>
> "The adolescent boy or girl with joint laxity or joint hypermobility must be recognized and deterred from participation in contact sports."[15]
>
> "... adolescent overindulgence in athleticism may precipitate the hypermobility syndrome."[14]
>
> "The above results can be exploited to advise relatively lax individuals to avoid physical exertion at a higher than normal rhythm."[3]

This last quotation followed the description of a study of 675 male soldiers who were screened for hypermobility before a military boot camp. Injuries were recorded during the 2-month training period, revealing a significantly higher rate of musculoskeletal lesions, particularly of the knee and ankle, among the hyperlax individuals. This study was well designed and had the advantage of being performed on a group of similar subjects with identical levels of activity during the study period. Unfortunately, the researchers' changes in the existing screening criteria make it difficult to compare their results with other studies. Further, they did not validate the new screening criteria. In particular, the criterion for knee hyperextension was decreased to 5°, and men who had scores of only 2/5 were included in the lax group. We are concerned, therefore, that individuals described as lax based on these criteria may not actually be significantly outside the realm of normal joint mobility. Methodologic changes such as these are noted throughout the hypermobility literature, and, as previously mentioned, the use of different cutoffs is especially common. Interestingly, however, even using a 4/9 cutoff with our injury data did not produce a significant difference in injury rates.

Studies that have looked at athletes are few in number and also have design variations like those noted above. The most well known of the athlete studies was performed by Nicholas.[30] He developed a new screening protocol that was similar to the Carter and Wilkinson [18] standard in that it included 5 measurements to test for global joint laxity. He concluded that loose-jointed professional football players were significantly more likely to rupture their knee ligaments than tight-jointed players. The tight-jointed players were more likely to tear muscles. Kalenak and Morehouse[31] attempted to reproduce the Nicholas findings but noted an equal number of knee ligament injuries in both loose-jointed and tight-jointed college football players. In 1978, Grana and Moretz[32] used the Nicholas method to screen male and female high school basketball players but found no correlation between joint laxity and the occurrence or type of injury. Godshall[43] also was unable to correlate joint looseness with injuries in high school footballers. Again, these studies are basically well designed, although no study of the validity or reliability of the Nicholas method has been undertaken.

Research that has used the Carter and Wilkinson[18]/Beighton et al[6] method to study athletic individuals has also reached varying conclusions. Kujala et al[36] reported that joint hypermobility was not a factor in low back pain among athletes, although the cutoff used to determine hypermobility is unclear. Harner et al[44] determined that hypermobility was not a factor in bilateral anterior cruciate ligament rupture, but they used only upper extremity tests. Hopper et al[38] also found no difference comparing lower extremity injuries between hypermobile and nonhypermobile netball players. In a study of ballet dancers, however, Klemp et al[33] found a significantly higher rate of injury among dancers who scored 4/9 or higher and noted that hypermobility seems to be a liability for the professional ballet dancer.

Although we found a statistically significant increase in ankle injuries, our data generally seem to support previous research in finding no overall difference in injury rates among hypermobile and nonhypermobile athletes. Our study revealed a relatively small number of injured athletes, which may have affected our statistical analysis.

Appropriate Activity for Hypermobile Athletes

In addition to weighing injury surveillance data, we believe 2 points should be considered before recommending that hypermobile individuals avoid sports activity. First, some proprioception data suggest that athletic activity may actually be protective for hypermobile individuals. While studies by Hall et al[45] and Mallik et al[26] have found hypermobile individuals to have decreased proprioceptive ability at the knee and proximal interphalangeal joints, Barrack et al[46,47] have determined that proprioceptive and joint-stabilizing abilities are trainable. Further, the work of Barrack et al[46,47] showed athletes to have enhanced proprioceptive abilities when compared with nonathletes. This suggests that athletes might be able to avoid some injuries that nonathletes would sustain. Since other studies show strong evidence of increased joint complaints among hypermobile nonathletes and our study did not show increased joint complaints among hypermobile athletes, it is possible that athletic activity may actually be protective for hypermobile athletes. This could explain why studies of joint complaints among nonathletes strongly support the as-yet unsubstantiated notion that hypermobile athletes will suffer a higher rate of injuries.

The second item to consider when deciding appropriate activities for hypermobile individuals is the finding of Larsson et al[40,41] that the relationship of hypermobility to injuries depended on the demands placed on the hypermobile body part. Hypermobile joints withstand repetitive activity better than they withstand stabilization tasks. Larsson et al[40] use the example of a violinist in whom hypermobility of the thumb and wrist might be an asset, but who might have overuse complaints in hypermobile knees or spines secondary to prolonged standing or sitting. While the findings of Larsson et al[40,41] might keep some hypermobile individuals from certain activities, they leave the door open for many other types of activity.

CONCLUSIONS

The purpose of our study was to compare injury patterns in hypermobile and nonhypermobile athletes. Other research suggested that we might find a higher injury rate among hypermobile subjects. However, we did not find this, and generalized joint hypermobility had no apparent effect on overall injury rates in this study. Given the current information concerning athletes, we feel that more conclusive and persuasive evidence of the impact of hypermobility on athletic injury rates must be found before we could justify depriving hypermobile individuals of the many known benefits of regular, strenuous exercise. Further, if injury risk does prove to be higher, hypermobile individuals may still be better served by an effort to determine a means of protecting them from undue risk while permitting regular physical activity. Areas for future research include a large study of anterior cruciate ligament tears and patellar and shoulder dislocations in athletes to determine whether hypermobility is a factor in specific injuries. Comparing hypermobile athletes with nonhypermobile athletes, members of our study group are currently investigating proprioception.

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