Incidence of Joint Hypermobility Syndrome in a Military Population

Impact of Gender and Race

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Abstract

Background Joint hypermobility syndrome is defined by abnormal laxity in multiple joints in association with symptomatic joint pain. Previous studies in small populations suggest a predominance of female gender and nonwhite race among those diagnosed with hypermobility syndrome.

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Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research. This work was performed at the Department of Surgery, William Beaumont Army Medical Center, El Paso, TX, USA, the Center for Data and Statistics, United States Military Academy, West Point, NY, USA, and at the Department of Orthopaedic Surgery, University of Colorado-Denver, Denver, CO, USA.

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Questions/purposes We investigated the epidemiology of joint hypermobility in a large military population, presuming this syndrome would be less prevalent in this specialized population but that demographic analysis would reveal risk factors for this rare condition.

Methods We queried the Defense Medical Epidemiology Database by race, gender, military service, and age for the years 1998 to 2007 using the International Classification of Diseases, 9th Revision code 728.5 (hypermobility syndrome).

Results We identified 790 individuals coded for joint hypermobility syndrome among a population at risk of 13,779,234 person-years for a raw incidence rate of 0.06 per 1000 person-years. Females had a higher incidence rate for joint hypermobility syndrome compared with males. Racial stratification showed service members of white race had higher rates of joint hypermobility syndrome compared with service members categorized as black and “other.”

Conclusions In a large, established military database it appears joint hypermobility syndrome is a rare condition within the young, active population we studied and female gender is the most important risk factor.

Level of Evidence Level II, prognostic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Joint hypermobility is often described as an extreme variation of joint laxity within the normal spectrum of human joint mobility. The metric often used to assess individuals suspected of being hypermobile is a modification of the original score reported by Beighton et al. [3, 4], which expands the original work of Carter and Wilkinson [9]. The

five criteria of this score are (1) passive extension of the fifth fingers beyond 90°; (2) passive apposition of the thumbs to the flexor aspects of the forearms; (3) passive elbow hyperextension beyond 10°; (4) passive knee hyperextension beyond 10°; and (5) forward trunk flexion with the knees fully extended and palms of the hands resting on the floor. Beighton et al. modified the original scoring system so that each hypermobile joint is given one point with one additional point for positive trunk flexion for a total score of 9 [4]. Most authors consider a score of 4 of 9 to be consistent with a diagnosis of hypermobility [4, 7, 23, 27, 28, 36, 38]. Some authors use 5 of 9 as the basis of hypermobility, because they believe a score of 4 may not represent hypermobility beyond an average person's normal range of motion [12, 13, 33].

Joint hypermobility with associated musculoskeletal symptoms such as arthritis [14], internal joint derangements [21], and myalgias is characterized as joint hypermobility syndrome (JHS). Grahame et al. [17] revised the criteria for the diagnosis of JHS to include the presence of two of the major criteria, one major and two minor criteria or four minor criteria (Table 1). Two minor criteria are sufficient when there is an unequivocally affected first-degree relative. BJHS is excluded by presence of Marfan or Ehlers-Danlos syndromes (other than the EDS hypermobility type—formerly EDS III) as defined by the De Paepe et al. 1996 [11] and the Beighton et al. 1997 [5] criteria, respectively. Criteria major 1 and minor 1 are mutually exclusive, as are major 2 and minor 2. Recent studies

consider JHS as a diagnosis of exclusion, because it should be differentiated from systemic connective tissue disorders such as Marfan's syndrome, Ehlers-Danlos syndrome, and osteogenesis imperfecta [16].

Current literature may underestimate the prevalence of JHS since patients may not seek medical care given the often mild and self-limiting nature of their symptoms [23]. However, JHS is associated with multiple medical conditions and can influence function. Recent studies have associated hypermobility with recurrent sprains and dislocations, arthralgias [2], premature osteoarthritis [23], mitral valve prolapse [8, 43], and chronic fatigue syndrome [28]. Patients with hypermobility often need specific multidisciplinary rehabilitation after injuries because of reduced power and stamina of striated muscle in addition to pain and impaired proprioception [18, 19, 27]. The identification of risk factors for JHS may be helpful to implement preventive measures against injury for athletes and individuals with physically demanding jobs. Women reportedly have a higher prevalence of JHS than men [6, 13, 15, 24]. In addition, JHS incidence has been seen to decrease with increasing age [15]. In considering racial/ethnic variance of JHS, two studies suggest an increased incidence of joint hyperextensibility of Indians and Africans compared with the European white population [20, 35].

We therefore determined (1) the incidence of JHS in a highly active, multiracial and diverse population as seen in the US military; (2) whether there would be a higher incidence of JHS in female or black soldiers; (3) whether the incidence would vary by age.

Table 1. The Brighton revised diagnostic criteria for benign joint hypermobility syndrome (BJHS)—from Grahame et al. [17]. (Table adapted and reprinted with permission from Grahame R, Bird HA, Child A. The revised (Brighton 1998) criteria for the diagnosis of benign joint hypermobility syndrome (BJHS). *J Rheumatol.* 2000;27:1777–1779.)

Major criteria

- (1) A Beighton score of 4/9 or greater (either currently or historically)
- (2) Arthralgia for longer than 3 months in four or more joints

Minor criteria

- (1) A Beighton score of 1, 2 or 3/9 (0, 1, 2 or 3 is aged 50+)
- (2) Arthralgia (≥ 3 months), in one to three joints or back pain (≥ 3 months), spondylosis, spondylolysis/spondyloslisthesis.
- (3) Dislocation/subluxation in more than one joint, or in one joint on more than one occasion.
- (4) Soft tissue rheumatism, at least three lesions (e.g. epicondylitis, tenosynovitis, bursitis)
- (5) Marfanoid habitus (tall, slim, span/height ratio > 1.03 , upper:lower segment ratio less than 0.89, arachnodactily (positive Steinberg/wrist signs)
- (6) Abnormal skin: striae, hyperextensibility, thin skin, papyraceous scarring
- (7) Eye signs: drooping eyelids or myopia or antimongoloid slant
- (8) Varicose veins or hernia or uterine/rectal prolapse

Patients and Methods

The Defense Medical Epidemiology Database (DMED) is a large military database that compiles International Classification of Diseases, Ninth Revision (ICD-9) coding information for every active-duty military patient encounter. This database also maintains the total number of personnel on active duty each year and contains patient demographic and military-specific data. DMED is a frequently updated database that is able to track military service members as they move throughout the world. DMED also adjusts for active-duty personnel as they enlist into the armed forces and retire. It has been used previously to provide information on various musculoskeletal conditions [30–32, 34, 41]. DMED provides four types of data: demographic features, inpatient hospitalizations, ambulatory visits, and reportable events. The outpatient data in the DMED are a combination of the standard ambulatory data records extracted from the Ambulatory Data System, from the Composite Health Care System used in military treatment facilities worldwide, and from outsourced

(nonmilitary) outpatient healthcare facilities providing care to active-duty service members. This study received Institutional Review Board approval from William Beaumont Army Medical Center Department of Clinical Investigation.

To determine the total number of patients with hypermobility syndrome, we queried the ambulatory DMED system for the years 1998 to 2007 using the ICD-9 CM code 728.5, which is defined as “generalized joint hypermobility.” Other codes, such as those for joint instability and for various collagen vascular diseases, were not queried due to the potential for overlap and inclusion of acute injury or other comorbidity. Hypermobility syndrome is primarily an outpatient diagnosis and therefore inpatient data were excluded from this analysis. To exclude repeat coding of the same initial diagnosis, ambulatory encounters were limited to a “first occurrence.” The accuracy of this diagnosis as a first-time diagnosis is enhanced by the fact that on entry into the US military, an entry examination is performed to screen for any preexisting orthopaedic abnormalities. Although JHS itself is not a disqualifying condition, associated abnormalities such as osteoarthritis, recurrent dislocation of a major joint, or a symptomatic mitral valve prolapse would exclude an individual from initial entry into active-duty military service.

Data were analyzed and stratified by gender, race, age, rank, and military service. Race data are routinely obtained from the Defense Manpower Data Center, which compiles service members’ self-report of race with the following options: white, black, Hispanic, Alaskan Native/American Indian, Asian/Pacific Islander, and other. DMED classifies these categories into three larger groups: white, black, and other. Mixed-race individuals were classified according to self-report. The age categories used were younger than 20, 20–24, 25–29, 30–34, 35–39 and 40 years or older. The rank categories used were junior enlisted (E1–E4), senior enlisted (E5–E9), junior officers (O1–O3), and senior officers (O4–O9). The military service categories used were Army, Navy, Air Force, and Marines. Height and weight data are not reported in this database, making this information unavailable for analysis. The database was also queried for the total number of personnel on active duty

during the study time period categorizing the results by gender, race, age, rank, and service. To estimate incidence, 1 exposure year was defined as 1 year that the individual was in the United States Armed Forces.

The incidence of joint hypermobility syndrome was expressed as rate per 1000 person-years. We used multivariate Poisson regression to estimate the rate of hypermobility per 1000 person-years by gender, race, and age (unadjusted rates). Additionally, using Poisson regression analysis, we computed rate ratios for gender using males as the referent category and controlling for differences in race, age, and rank between males and females (adjusted rates). Rate ratios were also calculated for race using black as the referent category and age, using 40 years or older as the referent group. All statistical analysis was performed using SAS software Version 9.1 (Cary, NC).

Results

From coding we identified 790 cases of JHS in our population at risk of 13,779,234 person-years for an overall incidence 0.057 per 1000 person-years.

Females, when compared with males, had an increased ($p < 0.0001$) adjusted incidence rate ratio for JHS of 3.72 (95% confidence interval [CI], 3.21–4.32) (Table 2). The unadjusted incidence rate of joint hypermobility syndrome was 0.15 per 1000 person-years among females and 0.04 per 1000 person-years among males. The adjusted incidence rate ratio was 1.44 (95% CI, 1.19–1.75) for white service members and 1.34 (95% CI, 1.03–1.73) for personnel categorized as “other,” higher ($p = 0.0006$) than hypermobility syndrome in black service members (Table 3). The unadjusted incidence rate for JHS was 0.06 among whites, 0.05 among blacks, and 0.06 among others per 1000 person-years.

We found no differences based on the age of our military personnel with age groups ranging from younger than 20 years to 40 years or older. Within our population, the incidence rate for JHS remained similar for all age subgroups (Table 4).

Table 2. Unadjusted and adjusted incidence rate ratio (IRR) of joint hypermobility syndrome among members of the U.S. military, 1998–2006, by sex

Sex	Observed		Unadjusted		Adjusted [†]	
	Hypermobility diagnoses	Person years	Rate*	Rate ratio (95% CI) [#]	Rate*	Rate ratio (95% CI) [#]
Male	487	11,772,376	0.04	N/A	0.03	N/A
Female	303	2,006,858	0.15	3.65 (3.16, 4.21)	0.12	3.72 (3.21, 4.32)

* Incidence rate is per 1000 person-years; [#]male is referent category; [†]adjusted for age, service, rank and race. N/A = not applicable because this category was used as referent.

Table 3. Unadjusted and adjusted incidence rate ratio (IRR) of joint hypermobility syndrome among members of the U.S. military, 1998–2006, by race

Race	Observed		Unadjusted		Adjusted [†]	
	Hypermobility diagnoses	Person years	Rate*	Rate ratio (95% CI) [#]	Rate*	Rate ratio (95% CI) [#]
White	554	9,453,628	0.06	1.13 (0.94, 1.37)	0.07	1.44 (1.19, 1.75)
Black	137	2,650,285	0.05	N/A	0.05	N/A
Other	99	1,675,321	0.06	1.14 (0.88, 1.48)	0.07	1.34 (1.03, 1.73)

* Incidence rate is per 1000 person-years; [#]black is referent category; [†]adjusted for age, service, rank and sex. N/A = not applicable because this category was used as referent.

Table 4. Unadjusted and adjusted incidence rate ratio (IRR) of joint hypermobility syndrome among members of the U.S. military, 1998–2006, by age

Age (years)	Observed		Unadjusted		Adjusted [†]	
	Hypermobility diagnoses	Person years	Rate*	Rate ratio (95% CI) [#]	Rate*	Rate ratio (95% CI) [#]
< 20	65	1,120,952	0.06	1.14 (0.81, 1.60)	0.05	0.71 (0.47, 1.07)
20–24	261	4,524,305	0.06	1.13 (0.87, 1.48)	0.05	0.76 (0.54, 1.07)
25–29	177	2,854,204	0.06	1.22 (0.93, 1.61)	0.07	0.98 (0.71, 1.34)
30–34	119	2,046,511	0.06	1.14 (0.85, 1.53)	0.07	1.06 (0.77, 1.45)
35–39	97	1,836,710	0.05	1.04 (0.76, 1.41)	0.07	1.02 (0.74, 1.39)
≥ 40	71	1,396,552	0.05	N/A	0.07	N/A

* Incidence rate is per 1000 person-years; [#] ≥ 40 is referent category; [†]adjusted for race, service, rank and sex. N/A = not applicable because this category was used as referent.

Discussion

The purpose of this study was to evaluate the incidence of joint hypermobility within the military and provide descriptive epidemiology about the identified focus population, using a large database of medical encounters. Based on the limited literature about the epidemiology of JHS, we presumed female, black, and younger soldiers would show the highest incidence in the analysis.

The limitations of this study include first the specialized population of military personnel as the population at risk. The military population is screened for medical problems, particularly musculoskeletal issues as these affect military readiness. While this provides the advantage of close surveillance within a closed health care system and potential improved diagnosis of disease including joint laxity issues, the disadvantage is that screening or self-selection bias may exclude patients with more severe disease. The findings in this population may thus not be generalizable to the civilian population, but may provide valuable information for military planners and for musculoskeletal researchers. Second, we used a database with dependence on the accuracy of the coding of each clinical encounter. A recent analysis of a diagnosis-related group (DRG) database showed a diagnostic coding error rate of 11.4% [10]. Another study in Spain showed an overall coding error rate

of 3%, and asserted that primary care physicians could achieve a high rate of quality with database reporting [29]. While we are unable to specify the diagnostic criteria for joint hypermobility syndrome used by primary care providers in the military, the literature provides evidence that the diagnostic coding error rate is relatively low. Thus, these data and subsequent analysis should not be impacted by a presumed small coding error rate. Third, correlative data such as history of previous ligament injuries, physical examination findings, and standardized laxity testing, as well as athletic and military activities, are not available within this database but would be useful in the interpretation of our results. However, the comprehensive data captured from each medical encounter in a large population, with demographic information and standardized diagnostic codes, is able to provide a limited epidemiological picture of this disease.

The comprehensive analysis of JHS in the US military population showed an incidence of 0.057 per 1000 person-years. Previous studies on generalized hypermobility, defined by the criteria of Beighton et al. [4], show an overall wide range of prevalence between 11.2% and 64.6% [12, 25, 36, 38] in children and adolescents. The variability of these results suggests that methods of evaluation and stringency of criteria varied among previous studies. Current literature suggests JHS, defined as

Table 5. Comparison of incidence of JHS in previous literature

Author and year	Type of population	Incidence of joint hypermobility syndrome	Population denominator
Jessee et al. 1980 [22]	Healthy blood donors	48 per 1000 person-years	637
Biro et al. 1983 [6]	Pediatric rheumatology clinic at academic referral center	22 per 1000 person-years	262 over 2.5 years
Didia et al. 2002 [13]	Randomly selected undergraduate students in Nigeria	129 per 1000 person-years	550
Klemp et al. 2002 [24]	Randomly selected Maori and European New Zealand residents, as part of a large epidemiologic study	52 per 1000 person-years	792
Leone et al. 2009 [26]	Italian schoolchildren aged 7–15 years	222 per 1000 person-years	1046
Scher et al. 2009 [current study]	Military personnel on active duty	0.06 per 1000 person-years	Estimated 1.53 million persons per year over 9 years

generalized hypermobility associated with musculoskeletal symptoms, occurs in approximately 5% to 6% of adults [6, 22, 24, 26] (Table 5). The lower incidence of JHS seen in the US military population may be secondary to a protective effect of the muscle strengthening and endurance training programs required by the US military, because a strong relationship has been noted between muscle strength and control of joint motion and function [39].

Consistent with previous studies in the literature [6, 13, 15, 24], we found an increased rate of JHS in women with an adjusted incidence rate ratio of 3.72 (95% CI, 3.21–4.32). Didia et al. [13] noted 17% of females showed features of JHS compared with males at 8% in a population of 550 university students. Our study is the first to report an incidence rate ratio between genders. The predominance of JHS in women has been hypothesized to be due to hormonal influences [37], or other molecular level gender-specific distinctions [40].

In contrast to other studies in the literature, we found a higher adjusted incidence rate of JHS in whites compared with blacks (adjusted rate, 0.07 compared to 0.05 per 1000 person-years). In a study from Nigeria, a prevalence rate of JHS of 13% was observed [13], whereas a New Zealand Maori population was seen to have a similar prevalence of JHS compared with previously studied Caucasian populations [22, 24]. However, Wood [42] noted no major difference in hypermobility between black and white subjects. It has been hypothesized that the increase in joint mobility among nonwhite races may be secondary to increased laxity of the joint capsule [20].

In our small subpopulation with the syndrome of JHS in the US military population we found no differences in the incidence by age group. This is perhaps because this is a primarily young population that does not include either children or the elderly population. Previous studies of JHS suggest a trend toward decreasing prevalence of the disorder with increasing age [1, 13, 24].

The definition of JHS includes its association with other musculoskeletal abnormalities. Frequent joint sprains may cause repetitive joint damage, which may lead to early osteoarthritis [27]. In addition to joint laxity, patients with JHS have reduced joint receptor activation and therefore a disturbance in proprioception [27]. Hall et al. [19] demonstrated proprioceptive performance in the subjects with JHS was considerably poorer in the midrange of motion compared with their age- and gender-matched control subjects. They hypothesized that this may be secondary to decreased feedback from joints and suggested neuromuscular training for these patients as a potential way to decrease future degenerative joint disease. These findings suggest a need to identify those with JHS who are at high risk for musculoskeletal injuries and institute programs in neuromuscular training to decrease their risk of long-term disability and osteoarthritis, both in the military and civilian populations [19].

Until recently, there was no definitive diagnostic criterion for JHS and the literature was replete with studies confusing JHS with generalized hypermobility and lacking reliability and reproducibility in their definitions [18]. For this reason, and because of its tendency to be overlooked as a benign disorder, several authors believe JHS is frequently misdiagnosed and more prevalent than is suggested by the current literature [1, 18].

Joint hypermobility syndrome is currently a rare diagnosis defined by joint hypermobility with associated musculoskeletal symptoms. Using a comprehensive database for US military health care, we noted an overall low incidence of this diagnosis. In this population, women were nearly four times more likely to be diagnosed with JHS than men with an increased rate of JHS in white military personnel compared with other races. In a population screened for musculoskeletal issues, JHS is less frequently diagnosed but is still a health concern, particularly in female soldiers.

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