Joint Laxity and the Benign Joint Hypermobility Syndrome in Student and Professional Ballet Dancers

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ABSTRACT. ***Objective.*** To ascertain the prevalence of hypermobility and the benign joint hypermobility syndrome (BJHS) in male and female student and professional ballet dancers, and explore whether BJHS has any effect on a dance career.

Methods. Students from the Royal Ballet School and professional dancers from the Royal Ballet Company, London, were compared with a control group of teenagers and adults from a local secondary school and The Royal Opera House, respectively. The data, examined by variance analysis, included anthropometric variables, the Beighton score, and clinical features constituting BJHS. Odds ratios for hypermobility and BJHS in dancers were calculated, and the prevalence and distribution of BJHS was examined.

Results. Hypermobility and BJHS were common in male and female dancers compared with controls. An OR of 11.0 (95% CI 3.3–31.8) was found for hypermobility in dancers for both the ballet school and the professional company. The prevalence of BJHS was found to decline both from student to professional and within the ballet company from corps de ballet to Principal. Odds ratios for BJHS in student dancers were significant, OR = 3.9 (95% CI 1.3–11.3), but not so in professional dancers: OR = 1.7 (95% CI 0.6–4.7). Arthralgia was common in dancers and was reported more often in males than females. In females, pain was reported most by dancers with other features of BJHS, in particular stretchy skin.

Conclusion. Hypermobility and BJHS are common in both male and female student and professional ballet dancers. The fall in prevalence, and the greater reporting of arthralgia with other features of BJHS in young female dancers, suggests that BJHS may have an important negative influence, and this may have implications for training. The same pattern was not observed in males, suggesting that their pain-reporting and injury are related to factors other than BJHS. (J Rheumatol 2004;31:173–8)

Key Indexing Terms:
BENIGN JOINT HYPERMOBILITY SYNDROME BEIGHTON HYPERMOBILITY SCORE
JOINT LAXITY HYPERMOBILITY BALLET DANCERS

Injury is a serious hazard among ballet dancers and may jeopardize a dancer's career. In the early 1970s Grahame and Jenkins compared the range of joint movements in 53 female dance students from the Royal Ballet School with that in 53 student nurses from Guy's Hospital, London. The study showed that inherent joint laxity was more common among the dancers even in joints such as the wrist and elbow that were not normally encouraged to become hypermobile in training. The inference was that inherent laxity was positively favored in the selection process of the ballet school[1]. It was subsequently shown in a study performed in South Africa that hypermobile professional dancers were more at risk of injury[2].

Over the past 25 years it has become apparent that hypermobility may indicate the presence of an heritable connective tissue disorder known as the benign joint hypermobility syndrome (BJHS)[3,4], now validated and identifiable by internationally acknowledged criteria (1998 Brighton criteria)[5]. This condition is considered synonymous with the hypermobile type of Ehlers-Danlos syndrome (formerly Ehlers-Danlos type III)[4].

Individuals with BJHS are vulnerable to the effects of injury and overuse. In particular they may have delayed tissue healing and poor proprioception. As such, dancers with BJHS may have an inbuilt vulnerability to the effects of injury that may be a disadvantage to them in their dance career.

The purpose of this study was 3-fold. First, to ascertain the degree of hypermobility in both female and male student and professional ballet dancers. The presence of hypermobility in present-day male ballet dancers has not, to our

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knowledge, been previously assessed. Second, we wished to determine whether there exists among this population a group who have clinical features of BJHS. Finally, we explored the nature and distribution of cases of BJHS among student and professional dancers, seeking evidence for an effect (positive or negative) of BJHS on dancers and identifiable clinical signs or histories that could alert trainers to this.

MATERIALS AND METHODS

One hundred forty-nine dance students, 85 from the Lower School and 64 from the Upper School, and 71 professional ballet dancers were recruited from the Royal Ballet School and the Royal Ballet Company, London. Thirty-six pupils from a local secondary school and 31 adults working at The Royal Opera House, London (home of the Royal Ballet) were recruited as controls for the senior student and professional dance cohorts, respectively. Where applicable, parental consent was obtained and the study had ethical approval. Controls were excluded if they had received ballet training in the past or were musicians, and were not sought for the Lower School as the tools outlined below for assessing hypermobility and BJHS have not been validated in children below the age of 16. The opportunity to assess the Lower School was undertaken as an observational exercise with the intention of developing a composite baseline student cohort for future longitudinal studies.

Two physiotherapists, both working at the Royal Ballet School (MMc and JB), received training from a rheumatologist (RG) in clinical examination and measurement techniques used in the Hypermobility Clinic, University College London Hospitals. To avoid interobserver variation, one physiotherapist measured the same variable in both the dancers and controls. To reduce the bias from diurnal variation, ambient temperature, or physical activity on the degree of joint laxity, all examinations took place in the afternoon, in the same physiotherapy rooms, and after exercise or training.

The following measurements were documented: (1) height in centimetres; (2) weight in kilograms; (3) lower segment length taken in centimetres from the symphysis pubis to the floor with the subject barefoot and in the standing position; (4) the upper segment to lower segment ratio, calculated for each subject using the formula [height (cm) – lower segment (cm)]/lower segment (cm). A value for this ratio < 0.89 constitutes one of the criteria used to determine the diagnosis of a marfanoid habitus. The marfanoid habitus is a minor criterion in the Brighton 1998 criteria[5] for BJHS. (5) Arm span, measured in centimetres with the subject facing the wall, arms out straight and abducted to be level with the shoulder, with the hands facing palm inward touching the wall. The arm span to height ratio was calculated for each subject. A value > 1.03 constitutes a feature consistent with the diagnosis of a marfanoid habitus. (6) The Beighton score, a qualitative measure of hypermobility (Figure 1)[6]. (7) The Contompasis score, a semiquantitative measure of hypermobility, modified from the Beighton score[7]. (8) The angle of passive dorsiflexion of the right 5th metacarpophalangeal joint against a fixed load of 2 lb (907 g) using a push-pull dynamometer gauge[1]. (9) Skin-fold thickness, measured on the dorsum of the hand over the right 3rd metacarpal bone using the Harpenden caliper. The Harpenden caliper was first described in the measurement of fat-fold thickness[8] and has been used as an indirect measure of dermal collagen in other studies[9]. (10) Skin stretch, measured by stretching the skin on the dorsum of the right hand over the 3rd metacarpal bone to its maximum. The amount of stretch was measured in centimetres. Individuals were placed in one of 3 groups: 0–1 cm, 1–2 cm, and > 2 cm stretch, and classified as having a positive skin-stretch if the measurement was > 2 cm[3]. (11) Physical examination and medical history to identify other features of the Brighton criteria for BJHS[5]. A diagnosis of BJHS was made in the presence of the 2 major criteria, one major and 2 minor criteria, or 4 minor criteria (Figure 2). (12) A history of injury among the professional dancers.

Figure 1. The 9-point Beighton hypermobility score.

	Right	Left
Ability to		
1. Passively dorsiflex the 5th metacarpophalangeal joint to ≥ 90°	1	1
2. Oppose the thumb to the volar aspect of the ipsilateral forearm	1	1
3. Hyperextend the elbow to ≥ 10°	1	1
4. Hyperextend the knees to ≥ 10°	1	1
5. Place the hands flat on the floor without bending the knees	1	
Maximum total	9	

One point is gained for each side for maneuvers 1 to 4.

Figure 2. The revised diagnostic criteria for BJHS[5]. BJHS is diagnosed in the presence of 2 major criteria, 1 major and 2 minor criteria, or 4 minor criteria. Two minor criteria suffice where 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). Criteria Major 1 and Minor 1 are mutually exclusive, as are Major 2 and Minor 2.

Major criteria
1. A Beighton score of 4/9 or greater (currently or historically)
2. Arthralgia for > 3 months in ≥ 4 joints

Minor criteria
1. A Beighton score 1, 2, or 3/9 (0 if aged 50+ years)
2. More than 3 months arthralgia in 1–3 joints or back pain, spondylosis
3. Dislocation/subluxation in more than one joint, or in one joint on more than one occasian
4. Three or more soft tissue rheumatic lesions
5. Marfanoid habitus
6. Abnormal skin: striae, hyperextensibility, thin skin, papyraceous scarring
7. Eye signs: drooping eyelids, myopia, or antimongoloid slant
8. Varicose veins, hernia, or uterine/rectal prolapse

Analytical methods. Dancers and controls were compared by sex, for mean differences in age, body mass index (BMI), and anthropometric measures using variance analysis.

Hypermobility was defined in 2 ways: Contompasis score ≥ 26 or a Beighton score ≥ 4. The Contompasis score assesses 9 sites, each scored independently of the rest. Non-lax joints score 2 points or less; hypermobile joints score 4 or more. As such the maximum score in the absence of any hypermobility is 18 and the minimum score for an individual with 4 or more sites of hypermobility is 26. Although the score is a continuum, an arbitrary cutoff of 26 for the Contompasis score was used to define presence of hypermobility in this study. Nonparametric t tests were also used to assess the differences between dancers and controls.

Odds ratios (OR), with 95% confidence intervals (CI), were calculated for the likelihood of dancers being hypermobile and/or more likely to satisfy the Brighton Criteria for BJHS compared to controls.

The prevalence of BJHS was examined across the student and professional groups, and within the dance professionals by status within the Company. The association between signs and symptoms was examined, comparing dancers with BJHS to those without.

RESULTS

The mean and range for age, BMI, and anthropometric variables for the Lower and Upper School, the Ballet Company,

and controls are shown in Table 1. Dancers and controls were well matched for age in each group, both within sex and between the sexes. As might be expected, dancers had in general a lower BMI than controls. The difference within males was not statistically significant, and that within females was, as a result of a mean difference in weight and not height. Surprisingly, given the aesthetic advantage of the longer leg and arm in dancers, the upper to lower segment ratio and the arm span to height ratio were similar for dancers and controls in both sexes.

The distribution of individuals fulfilling hypermobility and BJHS criteria is shown in Table 2. The Beighton score, Contompasis score, and 5th metacarpal dorsiflexion angle were significantly higher for dancers compared to controls. The scoring systems were compared in the Upper School and Adult cohorts. No significant difference was seen between them. The Contompasis score defined 97% of dancers (Upper School and Company combined) as hypermobile compared to 90% using the Beighton score. The difference was small and was accounted for by just 10 individuals. For the purposes of this study hypermobility was defined using the Beighton score, given also that the score is an integral component of the Brighton 1998 Criteria for BJHS[5].

OR for hypermobility (Beighton score criteria) and BJHS in dancers are also shown in Table 2. For hypermobility, similar OR were observed in the Upper School and the Company. The OR for BJHS, however, dropped from the Upper School (OR 3.9, 95% CI 1.3–11.3) to the Company (OR 1.7, 95% CI 0.6–4.7) and in the latter case was not statistically significant.

When the distribution of BJHS was explored from data on 66 of the 71 members of the Company, most cases were found in the corps de ballet (7 of 17 females, and 5 of 9 males), fewer were observed among Artists and First Soloists (3 of 16 females, 5 of 14 males), and none among the 10 Principals (7 females and 3 males). Dancers in the corps de ballet were younger (mean age 23 years, range 18–29) than Soloists and Principals (mean age 27 years, range 18–45). The mean age for dancers with BJHS in the corps was also 23 years (range 18–32), suggesting that older dancers with BJHS do not tend to remain in the corps, and yet do not appear to become Soloists and above. This was not explained by an alternative hypothesis of there being less injury among Soloists. The distribution of type and number of injuries such as ankle sprains, ligament strains, tendonopathies, and fractures in the Company was similar regardless of seniority.

The distributions of arthralgia, dislocations, soft tissue injury, marfanoid habitus, and stretchy skin for the Upper School, Company dancers, and all controls are shown in Table 3. The controls for the Upper School and Company are combined, for ease, as the prevalence for each individual variable was similar in both groups. Arthralgia (pain in 1–3 joints or back pain) was common among both dancers and controls, but was reported more often in male dancers than females, and more often in male dancers than male controls. Chronic arthralgia (pain for > 3 months in ≥ 4 joints), a major criterion for BJHS, was reported in only 4 female dancers. The second most common feature was stretchy skin. Differences in skin thickness approximated to those of skin stretch and were therefore not explored further. Arthralgia and abnormal skin stretch appeared moderately more prevalent in male dancers compared to controls in both the Upper School and the Company. The prevalence of arthralgia was similar for females of all groups, and that for stretchy skin appeared highest in the Upper School, but not different between the Company and controls. For both variables and the other clinical features mentioned the number of cases was too small to make any statistical inferences.

Examining the signs and symptoms in dancers with and without BJHS (Table 4), male dancers tended to report arthralgia regardless of the presence or absence of BJHS, but female dancers with BJHS reported arthralgia far more

Table 1. Age, BMI, and anthropometric measures (range) for the Lower and Upper School, Company, and controls.

Variable	Lower School	Upper School	Upper School Controls	Company	Company Controls
No. in group					
Female	47	35	21	43	16
Male	38	29	15	28	15
Age					
Female	14.2 (12.0–16.5)	18.0 (16.3–19.8)	16.9 (15.8–18.3)	24.9 (18.0–45.0)	28.0 (23.0–33.0)
Male	14.5 (12.0–16.5)	17.9 (16.8–19.5)	16.6 (15.3–18.8)	26.0 (19.0–40.0)	29.0 (21.0–35.0)
BMI					
Female	16.8 (14.2–20.5)	18.2 (15.5–20.3)	21.0 (15.0–27.1)	18.4 (16.5–21.8)	23.4 (20.0–30.0)
Male	18.0 (15.3–22.1)	20.4 (17.3–23.0)	21.2 (17.7–26.5)	21.2 (18.7–23.4)	26.6 (20.0–36.0)
Upper:lower body ratio					
Female	0.989 (0.889–1.121)	1.066 (0.890–1.290)	1.023 (0.890–1.122)	0.950 (0.820–1.138)	0.963 (0.864–1.025)
Male	1.011 (0.801–1.189)	1.073 (0.943–1.213)	0.998 (0.899–1.103)	0.930 (0.802–1.082)	0.950 (0.779–1.210)
Arm span: height ratio					
Female	1.026 (0.987–1.071)	1.018 (0.979–1.059)	1.019 (0.974–1.095)	1.011 (0.972–1.058)	1.004 (0.968–1.044)
Male	1.028 (0.938–1.067)	1.014 (0.921–1.070)	1.006 (0.968–1.040)	1.029 (0.994–1.081)	1.026 (0.957–1.053)

Table 2. Prevalence and odds ratios for hypermobility (Beighton score ≥ 4/9) and BJHS, and the means for Contompasis score and right 5th finger dorsiflexion.

Variable	Lower School*	Upper School	Upper School Controls	Company	Company Controls
Mean Beighton score (range)					
Female	5.6 (1–9)	7.5 (3–9)	4.3 (0–9)	7.1 (3–9)	3.1 (0–7)
Male	4.3 (1–8)	6.2 (1–9)	2.5 (0–9)	6.4 (3–9)	3.1 (0–7)
Prevalence of hypermobility (Beighton score ≥ 4/9) (%)					
Female	35/47 (74)	33/35 (94)	13/21 (62)	41/43 (95)	8/16 (50)
Male	23/38 (82)	24/29 (83)	3/15 (20)	23/28 (82)	6/15 (40)
Combined OR for hypermobility	—	11.3 (4.1–31.2), p = 0.001		11.1 (3.8–31.8), p = 0.3	
Prevalence of BJHS (%)					
Female	22/47 (47)	16/35 (46)	4/21 (19)	11/43 (26)	2/16 (13)
Male	17/38 (45)	10/29 (35)	1/15 (7)	10/28 (36)	2/15 (15)
Combined OR for BJHS	—	3.9 (1.3–11.3) p = 0.01		1.7 (0.6–4.7) p = 0.3	
Nonparametric t test of Contompasis Score (95% CI)					
Female	—	41.5 (39.2–43.8)	28.7 (25.2–32.2)	38.2 (36.4–40.1)	26.1 (22.5–29.6)
Mean difference		12.8 (8.6–16.7)		12.1 (8.2–16.1)	
Male	—	36.0 (33.5–38.6)	23.7 (19.4–28.0)	35.7 (33.1–38.4)	24.3 (21.3–27.3)
Mean difference		12.3 (7.4–17.1)		11.4 (7.6–15.3)	
Prevalence of hypermobility (Contompasis score ≥ 26) (%)					
Female	—	38 (100)	12/21 (57)	43 (100)	9/16 (56)
Male	—	27/29 (93)	3/15 (20)	28 (100)	6/15 (40)
Nonparametric t test of right 5th finger dorsiflexion (95% CI)					
Female	—	88 (77–85)	68 (60–76)	90 (87–93)	74 (63–84)
Mean difference		21 (12–29)		16 (8–24)	
Male	—	90 (88–92)	62 (50–74)	89 (85–94)	67 (55–79)
Mean difference		28 (16–40)		22 (12–33)	

* Observation only and no controls. Scoring systems not validated for children.

commonly than those without the condition. The most common sites for arthralgia in the Company were the ankle (66% of dancers, both male and female), cervical spine (53% of females and 30% of males), and lumbar spine (58% of females and 35% of males). No particular site of arthralgia was overrepresented in dancers with BJHS.

Female Upper School students with abnormal skin stretch were 10 times more likely to complain of arthralgia in comparison to their female peers. The combination of skin abnormalities and arthralgia (both minor criteria) in association with hypermobility (a major criterion) accounted for most of the differences seen in pain reporting in females within the Upper School. This association between skin stretch and arthralgia was not observed in any other group.

Finally, very few cases of isolated recurrent dislocations,

Table 3. Duration of symptoms and signs commonly associated with BJHS.

Variable	Lower School	Upper School	Company	All Controls
Arthralgia (%)				
Female	33/47 (70)	18/35 (52)	26/43 (60)	21/37 (56)
Male	33/38 (87)	23/29 (79)	24/28 (86)	16/30 (53)
Multiple dislocations (%)				
Female	11/47 (23)	3/35 (8)	1/43	6% in adults
Male	3/38 (8)	4/29 (14)	1/28	6% in adults
Multiple soft tissue injury (%)				
Female	10/47 (21)	1/35	5/43	Nil
Male	11/38 (30)	2/29	4/28	Nil
Marfanoid habitus (%)				
Female	1/47	1/35	Nil	Nil
Male	1/38	Nil	4/28 (14)	Nil
Stretchy skin (%)				
Female	5/47 (11)	10/35 (28)	8/43 (18)	6/37 (16)
Male	6/38 (15)	7/29 (24)	8/28 (29)	5/30 (16)

Table 4. The distribution of signs and symptoms associated with BJHS in dancers of the Upper School and Company.

Variable	Upper School		Company	
	With BJHS	Without BJHS	With BJHS	Without BJHS
Arthralgia (%)				
Female	12/16 (75)	4/19 (26)	10/11 (91)	16/32 (50)
Male	8/10 (80)	13/19 (68)	9/10 (90)	15/18 (83)
Multiple dislocations (%)				
Female	3/19 (19)	Nil	Nil	1/32 (3)
Male	4/10 (40)	Nil	1/10 (10)	Nil
Multiple soft tissue injury (%)				
Female	1/19 (6)	Nil	4/11 (36)	1/32 (3)
Male	2/10 (20)	Nil	2/10 (20)	2/18 (11)
Marfanoid habitus (%)				
Female	1/19 (6)	Nil	Nil	Nil
Male	Nil	Nil	2/10 (20)	2/18 (11)
Stretchy skin (%)				
Female	9/19 (47)	1/19 (6)	4/11 (36)	4/32 (12)
Male	7/10 (70)	Nil	8/10 (80)	2/18 (11)

multiple soft tissue injury, marfanoid habitus, or abnormal skin stretch were found in the dancers designated as not having BJHS.

DISCUSSION

The purpose of this study was to shed light on the physical characteristics of students in ballet training and professional dancers, and seek evidence for the presence of BJHS and its potential injurious effect on a dance career. Unlike the earlier study[1], male ballet students and male controls were included in the current study as well as females. In both sexes, this study has established that dancers manifest significantly more hypermobility and BJHS than controls. This was despite unexpectedly high prevalence values for hypermobility in the controls; general population studies suggesting prevalence to range between 10% and 30% depending on race, sex, and whether pauciarticular (< 4 joints) is included[10-14], and also given the exclusion of anyone with a background of training in the performing arts from the control group.

The prevalence of hypermobility, judged by the Beighton score, was the same in the Upper School and Company, suggesting that positive selection on grounds of hypermobility occurs early in a ballet career. However, the prevalence of BJHS appeared to decrease in the transition from the student to the professional classical ballet dancer and was also underrepresented in the highest grades of professional dancer in both males and females, suggesting that BJHS may impede a young dancer's chance of becoming a Soloist or Principal.

Professional dancers require flexibility far greater than the normal degree of movement, possibly more so now than 30 years ago as the requirements of choreographers and dance schools change. The classical ballet technique has become more technically demanding and in particular, male dancers are required to have mobility comparable with their female counterparts. In leaps, turns, and high extensions the male dancer is expected to display a degree of lyricism and honed technique similar to that of the female dancer. The requirements of increased flexibility and strength could be an important risk factor for injury in dancers, particularly in those who manifest features of BJHS.

Injury rates appear to be high in professional ballet companies and schools[15]. By understanding more about dance phenotypes and inherent connective tissue weakness, teaching and treatment methods could be modified and preventive measures encouraged. Further studies to explore training techniques and technical demand on the hypermobile joint in both male and female ballet dancers are needed. For example, over-training, too many performances, poor pacing, and an emphasis on flexibility rather than stability may all add to the risk of injury in dancers with a vulnerable physique.

In our cohort, arthralgia was present in 80% of male dancers regardless of the presence of BJHS. Tajet-Foxel and Rose[16] found that dancers perceived and tolerated more pain than non-dancers. Other studies have also suggested that male dancers tolerate more pain than females. Our study showed males to have more pain than females, but this may have been because the method used was direct questioning rather than unsolicited reporting. The latter might be expected to produce a lower prevalence for pain in males if their tolerance is higher. The presence of BJHS does not explain the high level of reported arthralgia in males in the study, where perhaps other factors that relate to the specific nature of technical demands may play a greater role.

Arthralgia was common in females with BJHS, most often in association with abnormal skin stretch. The inference from the findings is that the reporting of injury (using arthralgia as a marker) may occur more often in young female dancers with BJHS than in their peers and that clin-

ical features such as skin stretch may identify those at greatest risk. The subsequent drop in the prevalence of BJHS further up the career ladder might suggest that these dancers are vulnerable to injuries that might jeopardize their professional development. Dancers without the defining skin abnormalities might also be classified with BJHS if, for example, they presented with recurrent dislocation, multiple soft tissue injury, or chronic arthralgia. An alternative explanation why senior dancers in the Company did not appear to have BJHS could be therefore that these individuals have developed specific training programs to prevent injury in the first place. An exploration of injury histories in the Company did not support this hypothesis, in that the distribution of number and type of injury was similar regardless of seniority.

Joint laxity in females might also be influenced by hormonal status, possibly heightened by the presence of raised estrogen levels mid-menstruation at the end of the follicular phase, and in association with raised serum levels of relaxin during pregnancy. Laxity of the anterior cruciate ligament at the knee, for example, has been suggested to vary between the follicular and luteal phases of the menstrual cycle in normal individuals[17,18], and to be greatest late in pregnancy due to the higher estradiol levels of the third trimester[19]. However, other studies of hormonal status, pregnancy, serum relaxin, and use of the oral contraceptive pill in female athletes[20,21], or the general population[22-24], have shown no correlation with general joint laxity. These factors, including presence of amenorrhea, were not taken into account in our study, but might have had some influence in determining the phenotype of hypermobility.

Having BJHS is clearly not a contraindication to entering a career in ballet, or in achieving great success. While the findings of this study should not influence selection methods of students to professional ballet schools, knowledge and understanding of body type and the presence of BJHS ought to be taken into account as they may have important implications for prevention of injury. It is also possible that dancers with BJHS develop strategies to cope with the demands of their profession. Effective proprioception, correct biomechanics, and slow, disciplined training may be examples of such strategies. Identifying these dancers and the techniques they use could be an important advance in helping other people with BJHS.

With the members of the corps de ballet and the Upper and Lower School ballet students we now have a unique opportunity to observe, longitudinally, the effect of BJHS on training and a career in dance.

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