

A Study of Joint Mobility in a Normal Population

C C D Seow,*^{MBBS}, P K H Chow,*^{MBBS, M Med (Surg), FRCSE}, K S Khong,**^{FAMS, FRCS, M Med (Surg)}

Abstract

Joint hypermobility is a clinical entity that has been little studied in Southeast Asia in contrast to the many studies that have been conducted in the West.

A pioneer study was conducted in Singapore involving 306 subjects from the three major races i.e. Chinese, Malays and Indians. Their ages ranged from 15 to 39 years. The objective was to ascertain the joint mobility profile in a study sample representative of the Singapore population and the prevalence of joint hypermobility amongst normal individuals.

Joint mobility was assessed using criteria according to Carter and Wilkinson modified by Beighton et al. The distribution of the three major races in the study sample was based on the 1990 census of the Singapore population.

The prevalence of joint hypermobility was found to be 17%. The results showed that joint mobility decreases with age and that females had consistently higher degree of joint mobility compared to males throughout the age group. Among the racial groups, Malays had the highest degree of joint mobility followed by Indians and Chinese.

Ann Acad Med Singapore 1999; 28:231-6

Key words: Hypermobility, Population, Races

Introduction

Joint mobility varies between individuals and factors such as age, sex, race and heredity influence the range of motion of a joint.^{1,2} Excessive mobility of a joint(s) or hypermobility is a feature found in normal individuals as well as in patients with connective tissue disorders such as Ehlers-Danlos syndrome, Marfan's syndrome and osteogenesis imperfecta.^{1,3} Patients with common rheumatological diseases such as rheumatoid arthritis and systemic lupus erythematosus^{1,4} have also been found to have some degree of joint laxity. Rare diseases such as homocystinuria and hyperlysinaemia^{1,3} also have hypermobility as a feature.

In most normal individuals, hypermobile joints have no sequelae or ill effects. However, there are a group of individuals with hypermobility of joints who suffer from musculoskeletal symptoms without any stigmata of the systemic connective tissue disorders. Such individuals suffer from a condition known as the hypermobility syndrome.

Hypermobility Syndrome

The term "hypermobility syndrome" was first coined

by Kirk, Ansell and Bywaters in 1967³ to describe a group of patients with joint laxity and otherwise unexplained rheumatic complaints encountered in clinical practice. Since then, hypermobility syndrome has been defined by the occurrence of musculoskeletal symptoms in hypermobile subjects in the absence of demonstrable systemic rheumatological diseases.

The emerging importance and recognition of hypermobility syndrome is highlighted by the large number of clinical and epidemiological studies conducted overseas. Such studies have shown that hypermobility syndrome may be a form of multisystem disorder associated with articular and extra-articular manifestations (Table I). Patients may suffer from a simple myalgia or arthralgia with no other clinical abnormalities or may present with several clinical abnormalities in addition to hypermobility.

Assessment of Hypermobility

Over the past three decades various clinical scoring systems have been devised for measuring joint laxity. It is noteworthy that while the mobility of a joint has been shown to follow a Gaussian distribution,^{2,3} the assess-

* Medical Officer

** Registrar

Department of Surgery
Singapore General Hospital

*** Senior Consultant

Department of Orthopaedic Surgery
Alexandra Hospital

Address for Reprints: Dr K S Khong, Department of Orthopaedic Surgery, Alexandra Hospital, 378 Alexandra Road, Singapore 159964.

TABLE I: HYPERMOBILITY AND ITS ASSOCIATIONS

Articular
. arthralgia and myalgia ^{1,4,6}
. soft tissue lesions ⁵
. chondromalacia patellae ⁵
. acute lesions e.g. traumatic synovitis of joints ⁵
. chronic polyarthritis or monoarticular arthritis ^{7, 8}
. dislocation of joints e.g. shoulder, ⁷ patella ^{5, 9} and temporomandibular joint ¹⁰
. premature osteoarthritis ¹⁻¹³
. spinal complications ^{7, 5}
. bone fragility disorders e.g. stress fractures ^{1,5,14}
. idiopathic protrusio acetabuli ¹⁵
Extra-articular
. hyper-extensible skin associated with striae and easy bruising ¹⁶
. mitral valve prolapse ¹⁷⁻¹⁹
. hernia ²⁰
. rectal prolapse ²¹
. uterine prolapse ²²

ment of joint mobility has continued to be based on non-parametric scoring systems in most epidemiological studies.

Carter and Wilkinson²⁴ were the first to devise such a system in 1964 and this was later modified by Beighton et al²⁵ in 1973. Rotes' criteria²⁶ have also been used extensively in Spanish speaking countries. Alternative scoring systems¹ are also gaining popularity.

These scoring systems employ similar clinical manoeuvres but vary in number and type of joints involved. The Beighton criteria (based on Carter and Wilkinson), however, remain the universal yardstick⁵ for most clinical and epidemiological studies. It is easily reproducible and suitable for screening large populations. The criteria and scoring are shown in Table II and Figures 1 to 5.

Under the original criteria by Carter and Wilkinson, generalised hypermobility was considered to be present when more than 3 out of 5 joints were found to be lax with both the upper and lower limbs involved.

With the modification of criteria by Beighton et al,

TABLE II: CRITERIA FOR HYPERMOBILITY BASED ON CARTER & WILKINSON AND MODIFIED BY BEIGHTON ET AL (1973)

1. Passive dorsiflexion of little finger beyond 90° at metacarpophalangeal joint (Fig. 1)
2. Passive apposition of thumb to flexor aspect of forearm (Fig. 2)
3. Hyperextension of elbow beyond 10° (Fig. 3)
4. Hyperextension of knee beyond 10° (Fig. 4)
5. Forward flexion of trunk with the knees fully extended so that the palms of the hands rest flat on the floor (Fig. 5)

NB: For criteria 1 to 4, the ability to perform the manoeuvre is scored as 1 and the inability scored as 0. This duplicated for both Right and Left sides. For criteria 5, a score of 0 or 1 is obtained. A score of 5 or more out of 9 has been used by most studies to indicate hypermobility.

subjects were considered hypermobile if they could meet at least 3 of the 5 criteria (i.e. demonstrated joint laxity at 3 or more locations). A score of at least 5 out of 9 would therefore indicate generalised joint laxity. This is consistent with most studies.^{4,14,23,27,28}

Hence in our study, we chose a cut-off point of 5 or more out of 9 to indicate hypermobility.

Aims of Study

Joint hypermobility has hitherto not been studied in great detail in Southeast Asia. While many clinical studies have been conducted abroad, little is known about the prevalence of joint hypermobility in the local population.

We set out to study a heterogeneous Southeast Asian population (Singapore) using the criteria defined by Beighton as an index of joint mobility. The aims were:

1. to determine the joint mobility profile and the prevalence of joint hypermobility of adult Singaporeans from a representative study sample,
2. to see the relationship between joint mobility, age, sex and race, and
3. to compare with similar reported results overseas.

Materials and Methods

The study sample was drawn from the three major ethnic groups in Singapore i.e. Chinese, Malays and Indians from 1993 to 1995. Their ages ranged from 15 to 39 years. We decided to focus on adults only as hypermobility in adults has shown to be associated with osteoarthritis, chondrocalcinosis¹³ and mitral valve prolapse.^{17,18} Adults greater than 40 years of age were excluded because joint mobility tended to decrease after this age as had been shown by other epidemiological studies.^{1,25} Similarly, children younger than 15 years have an innate hypermobility.

Using the 1990 census of the Singapore population,²⁹ we obtained a cross-sectional representative sample stratified according to age, sex and race. For practical purposes, the ratio of study sample size to population was randomly placed at approximately 1:4200 thereby obtaining a sample size of 306 subjects. There were 237 (77.5%) Chinese, 46 (15%) Malays and 23 (15%) Indians

TABLE III: SCORING CHART FOR HYPERMOBILITY ACCORDING TO BEIGHTON ET AL

Criteria	Left	Right
1. Little finger dorsiflexion	0 or 1	0 or 1
2. Thumb apposition	0 or 1	0 or 1
3. Elbow extension	0 or 1	0 or 1
4. Knee extension	0 or 1	0 or 1
5. Trunk flexion		0 or 1
Score		0 to 9

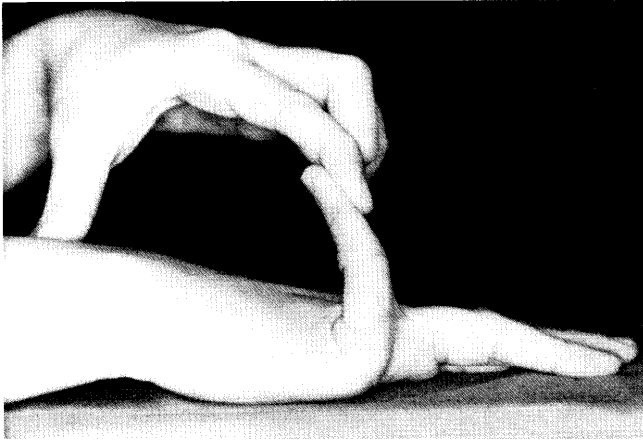


Fig. 1

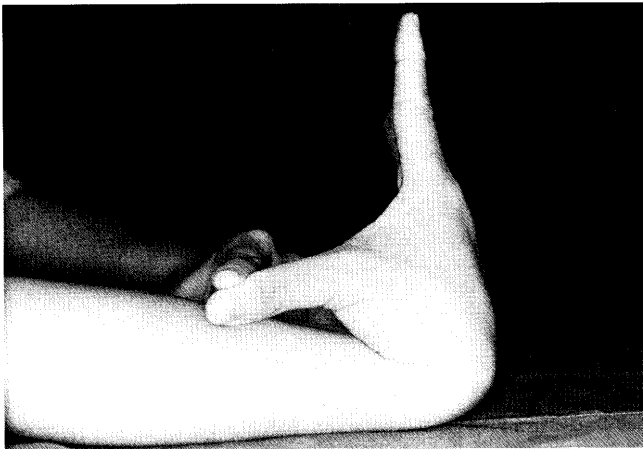


Fig. 2.



Fig. 3.

with the percentage representation matched to the Singapore population. These were further stratified according to sex and age (Table IV). Each subject was either a citizen or permanent resident of Singapore for at least two years.

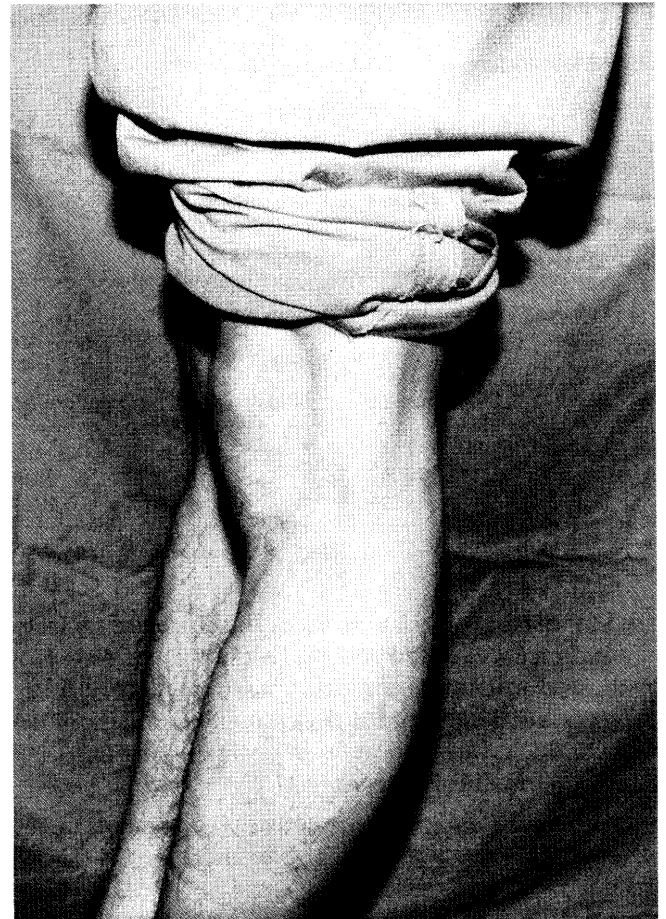


Fig. 4.

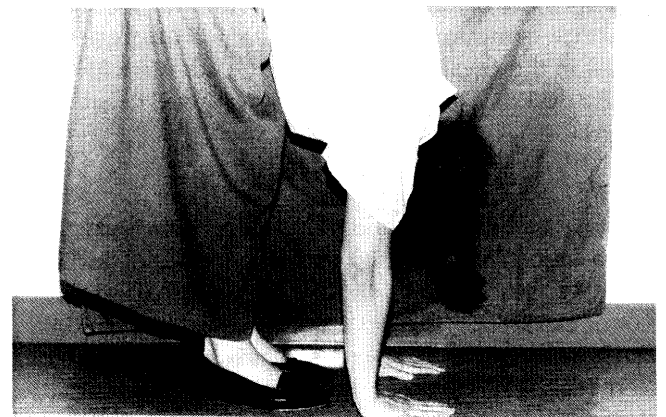


Fig. 5.

Subjects selected were “healthy” and non-patients. These included visitors who were not relatives of patients, service and healthcare personnel and tradesmen of Alexandra Hospital and office workers from its vicinity. As far as possible, individuals with family history of connective tissue diseases were excluded.

TABLE IV: DISTRIBUTION OF SINGAPORE AND STUDY POPULATION ACCORDING TO AGE, SEX AND RACE (15 TO 39 YEARS)

Males (Population no. = 649,224, Study no. = 159)

Race	15 to 24 years		25 to 34 years		35 to 39 years	
	Population	Study sample	Population	Study sample	Population	Study sample
Chinese	178,844	42	224,801	54	104,345	25
Malay	36,062	9	44,477	11	14,981	4
Indian	16,179	4	21,256	6	8,279	2

Females (Population no. = 622,264, Study no. = 147)

Race	15 to 24 years		25 to 34 years		35 to 39 years	
	Population	Study sample	Population	Study sample	Population	Study sample
Chinese	169,685	40	218,340	52	99,967	24
Malay	34,002	9	41,907	10	14,805	3
Indian	15,225	4	20,340	5	7,993	2

A standard protocol was used. Each subject's name, age and race was noted and joint mobility was assessed by the performance of clinical manoeuvres according to the criteria of Beighton et al. Assessment of joint mobility was conducted by two main investigators assisted by three other medical officers.

In this study, subjects were considered to have generalised joint laxity if a score of 5 or more out of 9 was obtained.

Statistical Analysis

Analysis of results was done with the use of the statistical computer software package Statistical Packages for the Social Sciences (SPSS) for Windows 95 (Release 6.1.3). The unpaired t-test was used to compare means.

Results

A total of 159 males and 147 females were surveyed. There were 238 Chinese, 46 Malays and 22 Indians. Seventeen per cent (52/306) of the subjects had a score of 5 or more out of 9; these were considered hypermobile. Of these, 56% (29/52) were females and 44% (23/52) were males. The average age of hypermobile individuals was 24 years and that of non-hypermobile individuals was 28 years. The mean score for the hypermobile individuals was 5.79 and the mean for the rest was 1.75. The mean difference of 4.04 between the two groups was statistically significant at $P < 0.001$.

There was a decline in joint mobility with increasing age. This is shown descriptively in Figure 6.

The mean score for males was 2.03 and that for females was 2.88. The mean difference of 0.85 was statistically significant at $P < 0.001$. Joint mobility decreased with age but females were consistently more lax than males throughout the age range (Fig. 6).

TABLE V: JOINT MOBILITY OF THE THREE ETHNIC GROUPS

	Mean Beighton score	Males	Females
Chinese	2.29 (SD 1.88)	1.91 (SD 1.84)	2.69 (SD 1.94)
Indians	2.68 (SD 1.96)	2.00 (SD 1.48)	3.50 (SD 2.22)
Malays	3.11 (SD 2.40)	2.67 (SD 2.22)	3.59 (SD 2.54)

SD: standard deviation

Amongst the ethnic groups, Malays had the highest mean score (3.11), followed by Indians (2.68) and Chinese (2.29). Females (in each ethnic group) again had greater joint mobility than males as seen by their mean scores (Table V). The results are purely descriptive as statistical comparison was not tenable due to the disparity in the number of individuals in each ethnic and age group. The joint mobility profiles are shown in Figure 7.

Within the Chinese group, there were 115 females and 123 males. The mean score was 2.69 for females and 1.91 for males. The mean difference of 0.78 was statistically significant at $P < 0.01$. Chinese females also had higher mobility scores throughout the age group studied (Fig. 8).

Discussion

Our study of a representative sample of the heterogeneous population of Singapore has shown the prevalence of hypermobility to be 17%. This figure can be considered close to the actual prevalence of joint hypermobility in the Singapore in view of the methodology involved. In comparison, Beighton's study of hypermobility in a homogeneous African population yielded a prevalence of 14.1%.²⁵ Grahame³⁰ in his study of healthy individuals in England reported that approximately 10% were hypermobile. A study of 637 "healthy" donors at a blood bank in an American study reported

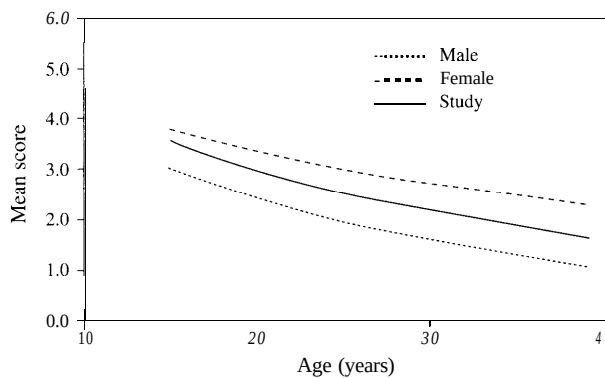


Fig. 6. Mean mobility score vs age.

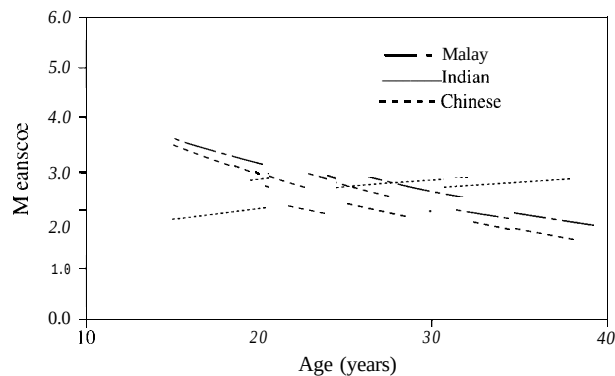


Fig. 7. Mean score (ethnic group) vs age.

the prevalence of hypermobility to be 4.9%.³¹ But in this study a different set of clinical criteria was used to define hypermobility. A study in Iraq which involved 20 to 24 years old medical students showed a prevalence of 29.8%.³² Again, it is to be noted that in this study a Beighton score of 4 or more out of 9 was used to define hypermobility instead. The comparisons are illustrated in Table VI.

Our findings are consistent with the clinical impression that Asians have a greater range of joint mobility than Negroes, who are in turn more mobile than Caucasians.^{1,5}

In comparison of the sexes, females showed a greater range of joint mobility than males. The difference in mean scores was statistically significant and there was also a suggestion of a trend in which females were consistently more mobile than males throughout the age group studied.

Our study yielded the mean Beighton scores for joint mobility amongst Chinese, Malays and Indians as well as the differences in joint mobility between males and females of each ethnic group. Literature review has shown no previous reporting of such data. Though no statistical comparisons could be made, the results provide an important set of data to which references can be

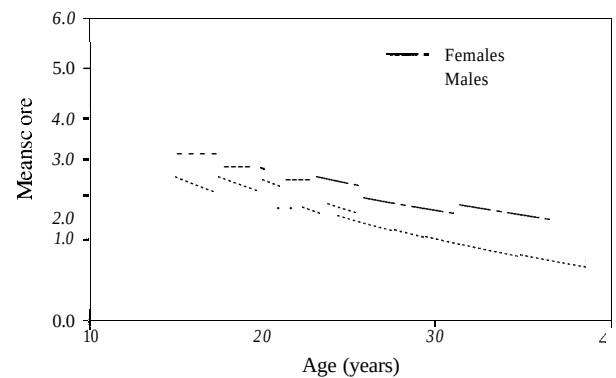


Fig. 8. Mean score (Chinese) vs age.

TABLE VI: PREVALENCE OF HYPERMOBILITY IN STUDIES ABROAD

Study	Age group (years)	Prevalence of hypermobility
Singapore	15 to 39	17%
African (Beighton 1973)	0 to 6.5	14%
British (Grahame)		10%
American (Larsson, Baum, Mudholkar 1987)*		4.9%
Iraqi (Rawi, Al-Aszawi, Al-Chalabi 1985)**	20 to 24	29.8%

* Hypermobility defined by different set of criteria

** Hypermobility defined by a Beighton score of ≥ 4

made in future studies.

It is also important to note that the prevalence of joint hypermobility is greater than the prevalence of symptomatic hypermobility syndrome which was not determined in this study. Studies abroad have shown the hypermobility syndrome to have a prevalence of 1.7% to 5.7%¹ amongst children attending rheumatology clinics. In adults, 1.5% of adults referred to a rheumatology clinic in US⁴ were found to have hypermobility syndrome while in a UK study, hypermobility was diagnosed in 3.25% of all female and 0.63% of all male referrals to a general rheumatology clinic with a total prevalence of 2%.

Conclusion

In conclusion, joint hypermobility is not an uncommon entity in clinical practice. Data on the prevalence of hypermobility in a heterogeneous Southeast Asian population have hitherto not been published. This pioneer study sheds some light on its prevalence in Singapore and will serve as a useful reference for future related studies.

In the orthopaedic setting, greater awareness and diagnoses of hypermobility will lead to better assessment of patients with conditions such as multidirectional instability of the shoulder, recurrent dislocation of

patella and ankle. The inherent laxity of the connective tissue in such cases may significantly affect the outcome of surgical repair.

Acknowledgements

We are grateful to Dr Wong Lee Yui, Dr Foo Ching Li, Dr Celestial Yap, Dr Goh Yaw Chong, Dr David Kwee And Dr Chee Lee Ann for their invaluable time and assistance.

REFERENCES

1. Beighton P B, Grahame R, Bird H A. *Hypermobility of Joints*. 2nd ed. Berlin: Springer Verlag, 1989.
2. Larsson L-G, Baum J, Mudholkar G S. Hypermobility: features and differential incidence between sexes. *Arthritis Rheum* 1987; 30:1426-30.
3. Kirk J H, Ansell B A, Bywaters E G L. The hypermobility syndrome. *Ann Rheum Dis* 1967; 26:419-25.
4. Bridges A J, Smith E, Reid J. Joint hypermobility in adults referred to rheumatology clinics. *Ann Rheum Dis* 1992; 51:793-6.
5. Grahame R. The hypermobility syndrome. *Ann Rheum Dis* 1990; 49:199-200.
6. Silman A J, Haskard D, Day S. Distribution of joint mobility in a normal population: results of the use of fixed torque measuring devices. *Ann Rheum Dis* 1986; 45:27-30.
7. Bird H A, Wright V. Joint hypermobility mimicking periarticular juvenile chronic arthritis. *BMJ* 1978; 3:402-3.
8. Scharf Y, Nahir A M. Hypermobility syndrome mimicking juvenile chronic arthritis. *Rheumatol Rehabil* 1982; 21:78-80.
9. Runow A. The dislocating patella. Etiology and prognosis in relation to joint laxity and anatomy of patella articulation. *Acta Orthop Scand Suppl* 1983; 202:1-53.
10. Gage J P. Collagen biosynthesis related to temporomandibular joint clicking in childhood. *J Prosthet Dent* 1985; 53:714-7.
11. Scott D, Bird H A, Wright V. Joint laxity leading to osteoarthritis. *Rheumatol Rehabil* 1979; 18:167-9.
12. Bird H A, Hudson A, Eastmond C J, Wright A. Joint laxity and osteoarthritis: a radiological survey of female physical education specialists. *Br J Sports Med* 1980a; 14:179.
13. Bird H A, Tribe C R, Wright V. Joint hypermobility leading to osteoarthritis and chondrocalcinosis. *Ann Rheum Dis* 1978; 37:203-11.
14. Grahame R, Edwards J C, Pitcher D, Gabell A, Harvey W. A clinical and echocardiographic study of patients with the hypermobility syndrome. *Ann Rheum Dis* 1981; 40:541-6.
15. Shore A, Macauley D, Ansell B M. Idiopathic protrusio acetabuli in juveniles. *Rheumatol Rehabil* 1981; 18:167-9.
16. Child A H. Joint hypermobility syndrome: inherited disorder of collagen synthesis. *J Rheumatol* 1986; 13:239-42.
17. Ondrasik M, Rybar I, Rus V, Bosak V. Joint hypermobility in mitral valve prolapse patients. *Clin Rheumatol* 1988; 7:69-73.
18. Handler C E, Child A, Light N D, Dorrance DE. Mitral valve prolapse, aortic compliance, and skin collagen in joint hypermobility syndrome. *Br Heart J* 1985; 54:501-8.
19. Pitcher D, Grahame R. Mitral valve prolapse and joint hypermobility: evidence for a systemic connective abnormality? *Ann Rheum Dis* 1982; 41:352-4.
20. Wynne-Davies R. Familial joint laxity. *Proc R Soc Med* 1971; 64:689-90.
21. Marshman D, Percy J, Fielding I, Delbridge L. Rectal prolapse: relationship with joint mobility. *Aust NZ J Surg* 1987; 57:827-9.
22. Al-Rawi Z S, Al-Rawi Z T. Joint hypermobility in women with genital prolapse. *Lancet* 1982; 319:1439-41.
23. Bird H A, Brodie D A, Wright V. Quantification of joint laxity. *Rheumatol Rehabil* 1977; 18:161-6.
24. Carter C, Wilkinson J. Persistent joint laxity and congenital dislocation of the hip. *J Bone Joint Surg (Br)* 1964; 46:40-5.
25. Beighton P, Solomon L, Soskolne C L. Articular mobility in an African population. *Ann Rheum Dis* 1973; 32:413-8.
26. Bulbena A, Duro J C, Porta M, Faus S, Vallescar R, Martin-Santos R. Clinical assessment of hypermobility of joints: assembling criteria. *J Rheumatol* 1992; 19:115-22.
27. Biro F, Gewanter H L, Baum J. The hypermobility syndrome. *Paediatrics* 1983; 72:701-6.
28. Gedalia A, Person D A, Brewer E J Jr, Giannini E H. Hypermobility of the joints in juvenile episodic arthritis/arthritis. *J Paediatrics* 1985; 107:873-6.
29. Singapore Census of Population 1990. Advanced Data Release. Singapore: Census of Population Office, Department of Statistics, 1991.
30. Grahame R. Hypermobility in healthy subjects. In: Scott J T, editor. *Copeman's Textbook of the Rheumatic Diseases*. 5th ed. Edinburgh: Churchill Livingstone, 1978:635-7.
31. Jesse E F, Owen D S Jr, Sagar K B. The benign hypermobile joint syndrome. *Arthritis Rheum* 1980; 23:1053-6.
32. Al-Rawi Z S, Al-Aszawi A J, Al-Chalabi T. Joint mobility among university students in Iraq. *Br J Rheumatol* 1985; 24:326-31.