Beighton Score: A Valid Measure for Generalized Hypermobility in Children

Bouwien Smits-Engelsman, PhD, Mariëtte Klerks, MS, and Amanda Kirby, MRCGP, PhD

Objective To evaluate the validity of the Beighton score as a generalized measure of hypermobility and to measure the prevalence of hypermobility and pain in a random population of school age children.

Study design Prospective study of 551 children attending various Dutch elementary schools participated; 47% were males (258) and 53% (293) females, age range was 6 to 12 years. Children's joints and movements were assessed according to the Beighton score by qualified physiotherapists and by use of goniometry measuring 16 passive ranges of motion of joints on both sides of the body.

Results More than 35% of children scored more than 5/9 on the Beighton score. Children who scored high on the Beighton score also showed increased range of motion in the other joints measured. Moreover 12.3% of children had symptoms of joint pain, and 9.1% complained of pain after exercise or sports. Importantly, this percentage was independent of the Beighton score. There were no significant differences in Beighton score for sex in this population.

Conclusion The Beighton score, when goniometry is used, is a valid instrument to measure generalized joint mobility in school-age children 6 to 12 years. No extra items are needed to improve the scale. *(J Pediatr 2011;158:119-23)*.

Joint hypermobility, defined as a more-than-normal range of movement (ROM) in a joint, is either localized (increased ROM of a single joint) or generalized. The prevalence of asymptomatic generalized hypermobility in children has been variably and widely reported, between 3% and 30%.[1-12] Generalized joint hypermobility (GJH) is said to be more prevalent among girls than boys with sex ratios of approximately 3:1 to 2:1, females/males.[1-8] In children, joint mobility is also inversely related with age, with younger children showing higher joint mobility than older children and with sex differences noted as they get older.[1-3,6,12]

Symptomatic generalized hypermobility is believed to be less common[10-12] and poorly recognized in childhood.[12] In 1967, Kirk et al[11] described musculoskeletal complaints in association with general hypermobility in adults, which was called *hypermobility syndrome*.

Joint hypermobility syndrome (JHS) is diagnosed when, in addition to the hypermobility, individuals report musculoskeletal symptoms in more than 4 joints, including pain over a period of more than 12 weeks, and when other heritable disorders of connective tissue and other causes of the symptoms have been excluded.[13-15] Individuals with collagen disorders, such as Ehlers-Danlos syndrome, have also been described with the term JHS with their heritable disorders of connective tissue diagnosis.[16]

Joint hypermobility in children is commonly diagnosed with criteria for an adult population and ROM is judged by eye. To evaluate hypermobility, clinicians mainly use two scoring systems: the Beighton score (**Table I**; available at www.jpeds.com)[1] and the Bulbena Criteria.[17]

The Beighton score, more commonly used in diagnosing hypermobility in childhood,[2-9,18] has its cutoff point internationally debated.[2,6,9,18] Originally the Beighton score cutoff points offered no differentiation between adults and children, sex, and ethnicity. However, given the noted variations, it would seem that cutoff values that take these into account are required. The lack of specific criteria for children motivated this study. A standardized protocol is lacking, and a uniform description of the test items in children is needed for reliable testing of hypermobility. For example, it is not clear whether the Beighton score has to be performed actively or passively.[1,19] Juul et al[19] defined a standardized protocol for the Beighton score with passive range of motion for clinical studies of reproducibility in adults. To standardize the Beighton score for children, we described and tested a goniometry protocol (**Appendix**; available at www.jpeds.com).

The Beighton score has never been tested for validity, although it is used clinically as a basis of examination and diagnosis.[20,21] Therefore a second aim of the study concerned the validation of the Beighton score as a measure of generalized hypermobility in children. A third aim was to examine the prevalence of reported pain after exercise or sport, and pes planus in a random population, to consider whether this

GJH	Generalized joint hypermobility
JHS	Joint hypermobility syndrome
ROM	Range of movement
SBP	Standardized Beighton score protocol
SJP	Standardized joint-mobility protocol

From the Faculty of Kinesiology and Rehabilitation Sciences, K.U.Leuven, Avans, University for Professionals, Breda (B.S.), The Netherlands; Private Practice, Peize (M.K.), The Netherlands, and the Dyscovery Centre, School of Education, University of Wales, Newport, Wales, United Kingdom (A.K.)

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was associated with the classification of mobility. A final consideration was to measure the prevalence of hypermobility in a random population of elementary school–age children and to consider whether there were sex or body side differences in the population.

Method

Standardized Beighton Score Protocol

All the items were described and visualized with photos. Cutoff points for declaring an item as positive or negative were included (Appendix). Goniometry was used to measure the passive bilateral dorsiflexion of the fifth metacarpophalangeal joint and the passive bilateral hyperextension of the elbow and knee.

Standardized Joint Mobility Protocol

To obtain a reliable impression of overall joint mobility, an extended "standardized joint mobility protocol" (SJP) was developed. This describes test position, positioning of the goniometer, anatomic landmarks, and motion to be tested. In this protocol passive range of motion was used to standardize the measurement as much as possible and to be less dependent on the child's notion of a full range of movement. Sixteen ROMs of 8 different joints were measured bilaterally to the nearest 1-degree with a standard 2-legged 360-degree type Collehon extendable goniometer (01135; Lafayette Instrument Company, Lafayette, Indiana). For small joints, a plastic 180-degree goniometer (type HIRes) was used. Included in this protocol are several extra observations that are clearly described, including pes planus and "heel-to-the-buttock" movement.

Training Procedure

To collect reliable data, 6 pediatric physical therapists were trained. The protocol was explained, and items were taught under supervision. Then therapists used SBP and SJP to measure the passive joint mobility and the Beighton score of 6 healthy Dutch children. Intraclass correlation between the first and second measurements was high (0.99), indicating excellent reliability. The mean difference (absolute [Measurement 1 − Measurement 2]) between all the joints measured by the 6 therapists was 8.05 degrees (SD 5.9), with the exorotation of the shoulder being the least reliable (mean absolute difference of 15.8 degrees) and the passive extensions of the hip and knee being the best reproducible maneuvers (mean absolute difference of 4.5 degrees). The standard error of measurement for the ranges of motion for the joints included in the SBP (knee and elbow extension and dorsiflexion of the fifth metacarpophalangeal) was 2 degrees.

Test Procedure

All children were measured by the 6 trained pediatric physical therapists according to the SBP and the full bilateral SJP. Children wore shorts and shirts and no shoes. Before the assessment, the movement was demonstrated by the tester first, supported with verbal instructions. Children were instructed to relax their muscles as much as possible, and the maneuver was performed without evoking pain. Additionally, the presence of pes planus (the arch lowers and flattens fully, excessively and easily, with the talus bulging medially[22]) and muscle length of the rectus femoris were assessed (heel to buttock in prone position) (Appendix). Background information about the child's health was also gathered with a questionnaire.

Table II. Demographic information

	Mean	Range
Age	8 years, 9 months	6-12 years
Weight	31 kg	17-83 kg
Height	1 m 37cm	1m 5 cm–1 m 73 cm
BMI	16.5*	10-36

*Overall, 14% of the children in this sample were overweight.

Participants

A total of 551 children, attending 11 Dutch elementary schools, participated in the study. Teachers selected every second child of the register in the respective classes. Approval was gained from the local ethics committee. Parental consent was obtained and additional assent from children before participation (Table II).

Of this sample, 86% were white, and 14% were from first-generation Dutch families (all the children were born in the Netherlands). There were 46.8% males (258) and 53.2% (293) females in the group. Nearly 13% of children were left handed.

Data Analysis

Totals on the Beighton score were compared by use of independent samples *t* testing for sex differences and side of the body. Scores on the Beighton score were calculated on the basis of the SBP. Based on cutoff scores reported in the literature, children were placed into 3 bands as follows: band 1: not hypermobile (0-4); band 2: increased mobility (5-6); band 3: hypermobile (7-9). These Beighton score bands were used as independent variables to compare the 16 measured ROM of the joints (means of left and right side were used) with analysis of variance. Frequency of reported pain

Table III. Distribution of Beighton score total

	Frequency	Percent	Cumulative percent
Band 1: 0-4 Normal ROM			
0	40	7.3	7.3
1	46	8.3	15.6
2	102	18.5	34.1
3	64	11.6	45.7
4	103	18.7	64.4
Band 2: 5-6 Increased ROM			
5	69	12.5	77.0
6	77	14.0	90.9
Band 3: 7-9 Hypermobile			
7	33	6.0	96.9
8	16	2.9	99.8
9	1	.2	100.0
Total	551	100.0	

Table IV. ROM in degrees per joint for the 3 Beighton score bands (mean and standard deviation)

Joint	Beighton score Bands	Number of participants	ROM mean	ROM SD
Lower Extremity				
Extension MTP1				
	0-4	355	69	11
	5-6	146	74	9
	7-9	50	77	10
Dorsal flexion ankle				
	0-4	355	24	7
	5-6	146	27	6
	7-9	50	30	6
Plantar flexion ankle				
	0-4	355	61	8
	5-6	146	67	7
	7-9	50	69	6
Flexion knee				
	0-4	355	155	10
	5-6	146	157	4
	7-9	50	158	4
Extension knee				
	0-4	355	4	4
	5-6	146	8	4
	7-9	50	10	3
Flexion hip				
	0-4	355	108	8
	5-6	146	111	8
	7-9	50	114	5
Extension hip				
	0-4	355	22	7
	5-6	146	23	7
	7-9	50	24	7
Exorotation hip				
	0-4	355	49	8
	5-6	146	52	10
	7-9	50	57	12
Endorotation hip				
	0-4	355	49	8
	5-6	146	53	10
	7-9	50	59	11
Upper extremity				
Dorsiflexion MCP Digit 5				
	0-4	355	82	12
	5-6	146	91	10
	7-9	50	96	9
Extention wrist				
	0-4	355	93	8
	5-6	146	100	8
	7-9	50	103	8
Flexion wrist				
	0-4	355	100	10
	5-6	146	109	11
	7-9	50	111	9
Flexion elbow				
	0-4	355	151	6
	5-6	146	153	5
	7-9	50	154	5
Extension elbow				
	0-4	355	9	6
	5-6	146	13	6
	7-9	50	16	5
Flexion shoulder				
	0-4	355	171	14
	5-6	146	178	13
	7-9	50	184	12
Exorotation shoulder				
	0-4	355	88	14
	5-6	146	98	13
	7-9	50	105	13

after exercise and sport and pes planus were analyzed with the χ^2 test. Data were analyzed with SPSS version 15.0 (SPSS Inc, Chicago, Illinois).

Results

In this random sample, 9.1% of the children scored 7 or more out of a possible 9 points on the Beighton score, and 35.6% scored 5 or more (Table III). Complaints of pain in joints, muscles, or ligaments were quite common. Overall, 13.3%, 12.8%, and 4.1% of participants cited this in respective Beighton score bands 1, 2 and 3. Pain after exercise or sport was reported for 8.8%, 9.6%, and 10% of the children, in bands 1, 2, and 3, respectively. These percentages were not significantly different between children with less or more mobility and therefore do not seem to be specific for children with high Beighton scores.

Scale Analysis

The question to be answered in this study was, "Is the Beighton score a valid measure for *generalized* hypermobility in children?" To answer this question, 16 mean ROMs of all major extremity joints were compared between groups on the basis of the 3 bands of the Beighton score (Table IV). The analysis of variance revealed significant differences between the degrees of motion of all joints examined. Moreover, as shown in Table V, post-hoc tests also showed that the ROMs of all joints were significantly different between the classification groups (flexion knee: $P = .02$ extension hip: $P = .06$, all the other joints $P < .001$).

Sex Differences

With the Beighton score, where 9 points is the maximum possible score, no significant differences ($P = .22$) for sex were found. If analyzed per item, only hands on the floor (item 5) was different ($t\ (1549) = 4.66$, $P < .001$); with girls being more flexible than boys.

Differences in Right and Left Sides on Testing

Comparing scores on the left and the right sides of the body, there was a significant difference, with right-sided measures showing less mobility than those on the left side ($t\ (1550) = 2.14$, $P < .032$). Mean scores for right side were 1.75 and for the left side, 1.82. If analyzed per item, only the item "thumb to volar aspect of the forearm" (item 2) was significantly different ($t\ (1550) = 2.42$, $P < .016$), with the left thumb being more flexible.

Asymmetric mobility was also examined. Children were defined as asymmetrically mobile if the difference between the summed left and right part of the Beighton score was more than 2 points (4 being the maximum score for one side). In total, 4.9% of the children were classified to have asymmetric mobility (3.5% showed larger movements on the left side, 1.8% on the right). Moreover, 19.6% showed a 1-point advantage in ROM on the left side of the body, and the respective figure was 15.4% for the joints on the right side. No sex differences in asymmetry were found.

Table V. Post hoc test (Tukey HSD)

Dependent Variable	(I) Beighton Band	(J) Beighton Band	Mean Difference (I-J)	*P* value
Lower extremity				
Extension MTP1				
	0-4	5-6	-5.49*	.000
		7-9	-7.98*	.000
	5-6	0-4	5.49*	.000
		7-9	-2.48	.330
Dorsal flexion ankle				
	0-4	5-6	-2.93*	.000
		7-9	-6.48*	.000
	5-6	0-4	2.93*	.000
		7-9	-3.54*	.003
Plantar flexion ankle				
	0-4	5-6	-5.77*	.000
		7-9	-7.71*	.000
	5-6	0-4	5.77*	.000
		7-9	-1.94	.296
Flexion knee				
	0-4	5-6	-1.76	.080
		7-9	-2.72	.078
	5-6	0-4	1.76	.080
		7-9	-.96	.761
Extension knee				
	0-4	5-6	-3.82*	.000
		7-9	-5.96*	.000
	5-6	0-4	3.82*	.000
		7-9	-2.13*	.003
Flexion hip				
	0-4	5-6	-3.22*	.000
		7-9	-5.55*	.000
	5-6	0-4	3.22*	.000
		7-9	-2.33	.177
Extension hip				
	0-4	5-6	-1.58*	.045
		7-9	-2.59*	.031
	5-6	0-4	1.58*	.045
		7-9	-1.00	.636
Exorotation hip				
	0-4	5-6	-3.78*	.000
		7-9	-8.55*	.000
	5-6	0-4	3.78*	.000
		7-9	-4.77*	.003
Endorotation hip				
	0-4	5-6	-3.87*	.000
		7-9	-9.82*	.000
	5-6	0-4	3.87*	.000
		7-9	-5.95*	.000
Upper extremity				
Dorsiflexion MCP Digit 5				
	0-4	5-6	-9.45*	.000
		7-9	-14.10*	.000
	5-6	0-4	9.45*	.000
		7-9	-4.65*	.029
Extension wrist				
	0-4	5-6	-6.55*	.000
		7-9	-10.12*	.000
	5-6	0-4	6.55*	.000
		7-9	-3.57*	.016
Flexion wrist				
	0-4	5-6	-8.55*	.000
		7-9	-10.53*	.000
	5-6	0-4	8.55*	.000
		7-9	-1.97	.481
Flexion elbow				
	0-4	5-6	-1.99*	.001
		7-9	-3.35*	.000
	5-6	0-4	1.99*	.001
		7-9	-1.36	.293
Extension elbow				
	0-4	5-6	-4.23*	.000
		7-9	-7.26*	.000
	5-6	0-4	4.23*	.000
		7-9	-3.02*	.005
Flexion shoulder				
	0-4	5-6	-6.88*	.000
		7-9	-13.11*	.000
	5-6	0-4	6.88*	.000
		7-9	-6.23*	.012
Exorotation shoulder				
	0-4	5-6	-10.41*	.000
		7-9	-16.80*	.000
	5-6	0-4	10.41*	.000
		7-9	-6.39*	.011

*The mean difference is significant at the .05 level.

Pes Planus

In this typically developing sample, 30% of children were observed to have pes planus as described in the protocol. There was an increasing prevalence (χ^2 5.29, df = 1 , $P = .021$) in pes planus per mobility band (band 1: 27%, band 2: 32.2%, band 3: 44%).

Heel to Buttock

To explore supplementary value of other hypermobility maneuvers, "heel to buttock" was also tested. In 87% of the children, the heels could passively be brought to contact the buttocks. Twelve percent of children were unable to do so with two legs and 1% with one leg. Importantly, the frequencies of difficulty with "heel to buttock" were not different for children in the 3 Beighton score bands.

Discussion

The Beighton score is a valid measure for generalized joint hypermobility in children, on the basis of the detailed analysis of the ranges of motion of all major joints. Although the Beighton score covers a sample of joints, it was shown that increased mobility is present in other joints not covered. Pain over a period of time or after exercise does not seem to be valid extra information in hypermobility related complaints in children under 13 years. This concurs with the study by El-Metwally et al who reported that hypermobility (Beighton 6/9) was not predictive of future musculoskeletal pain in preteen and adolescent children.[23] However, it may be useful to explore pain symptoms such as waking in the night.

Pes planus is a frequent symptom in children (33%), not only in children with hypermobile joints but in all children. Adib[12] found that pes planus was one of the main features in children with JHS, and this is confirmed for children with a high Beighton score, but its high frequency is not restricted just to this group. Because the mean ROMs of all joints measured were significantly increased if children were classified as hypermobile, it was concluded that the

currently used standardized protocol of the Beighton score is a valid measure for generalized hypermobility in children. Therefore we see no advantage in adding more joints or maneuvers to this scale, nor adding joint pain as part of the scale, because it is not specific to hypermobility in children. Pain measures a different construct, which may be more time sensitive than joint mobility, and its presence as a complaint in all children should always be explored.

Our impression that too many children are classified as hypermobile by use of a threshold of 5/9 was confirmed. With the Beighton score 5/9 scoring system led to a prevalence of 35.6%, which is greater than an earlier study in which generalized hypermobile joints were reported in 11.1% of the Dutch population between the ages of 4 to 12.[18] Comparison between studies is hard to undertake because no standardized description of the Beighton score existed, and ranges of motion were estimated, but not measured. Future studies with this standardized protocol may help determine the best cutoff scores, and validation of these scores for diagnostic purposes requires scores to show both high sensitivity and specificity. Studies are needed that explore different cutoff scores in groups of children with JHS and typically developing children.

On the basis of statistical grounds and in conjunction with Jansson et al,[6] a stricter cutoff score for hypermobility should be considered. If a score between 7/9 were used to classify hypermobility, the percentage in our study would drop to 9%.

When comparing sides of the body, it was found that hypermobility was greater on the left side of the body. This also confirms earlier results.[1-3,18] Asymmetry in typically developing children was rare (5%), and 60% of the children had an identical Beighton score for the right and left sides. For quick screening procedures, one could rely on the left-sided Beighton protocol. In a clinical situation it is recommended to use the full standardized Beighton protocol.

Sex difference for cutoff points were not found in using the Standardized Beighton Protocol in Dutch children at the age 6 to 12 years, which corroborates with findings of Rikken et al,[2] El-Garf et al,[3] and van der Giessen et al,[18] but contrasts with others.[5-7]

The Beighton score calculated with the standardized Beighton protocol is a valid instrument to evaluate generalized joint mobility in primary school–aged children. No extra items are needed to improve the scale. In white children between 6 and 12 years of age, it is recommended that 7/9 be the cutoff for the Beighton score. ■

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Reprint requests: Bouwien Smits-Engelsman, Avans+ University for Professionals, P.O. Box 2087, 4800 CB Breda, The Netherlands. E-mail: bengelsman@avansplus.nl.

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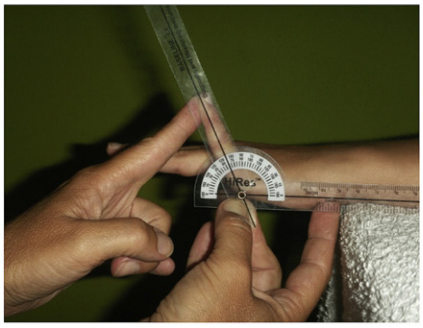
1. Passive dorsiflexion of the fifth metacarpophalangeal joint. Score is positive if ≥ 90° (Bilateral testing)



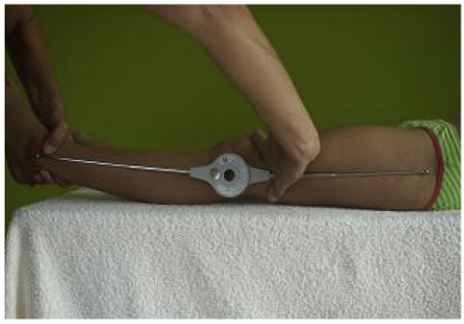
Test position	Motion tested	Positioning Goniometer	Anatomical landmarks	Method
Sit on chair at the short side of the table with arm in 80° abduction, elbow flexed 90°, forearm resting on table, forearm pronated.	Passive Dorsiflexion Digiti 5.	MCP 5.	Dorsal side Metacarpalia 5; in the length of Digiti 5.	Lateral method.

2. Passive hyperextension of the elbow. Score is positive if ≥ 10° (Bilateral testing)

Test position	Motion tested	Positioning Goniometer	Anatomical landmarks	Method
Sit on chair with shoulder 90° anteflexion, forearm supinated	Passive hyperextension of elbow.	Lateral epicondyl Humerus.	Humurus pointed at tub major humeri; Radius pointed at proc styloideus.	Lateral method.

Appendix. Standardized test positions and goniometer positioning of the Beighton score protocol.

3. Passive hyperextension of the knee. Score is positive if ≥ 10° (Bilateral testing)



Test position	Motion tested	Positioning Goniometer	Anatomical landmarks	Method
Lying backwards with legs in horizontal position.	Passive hyperextension knee.	Lateral femur epicondyl.	Femur pointed at trochanter major; Fibula pointed at lateral malleolus.	Lateral method.

4. Passive apposition of the thumb to the flexor side of the forearm, while shoulder is 90° flexed, elbow extended and hand pronated. Score is positive if the whole thumb touches the flexor side of the forearm. (Bilateral testing)

Score: Positive

Score: Negative

Appendix. Continued

5. Forward flexion of the trunk, with the knees straight. Score is positive if the hand palms rest easily on the floor.

Score: Positive

Score: Negative

Scoring

One point may be gained for each side for item 1-4 (max 2 per item if left and right are positive) and only one point in total for item 5.

The maximum hypermobility score is nine points (if all items are positive).

Appendix. Continued

Table I. The 9-point Beighton score of hypermobility

Description	Bilateral Testing	Scoring (max. points)
Passive dorsiflexion of the fifth metacarpophalangeal joint to ≥ 90 degrees	Yes	2
Passive hyperextension of the elbow ≥ 10 degrees	Yes	2
Passive hyperextension of the knee ≥ 10 degrees	Yes	2
Passive apposition of the thumb to the flexor side of the forearm, while shoulder is flexed 90 degrees, elbow is extended, and hand is pronated	Yes	2
Forward flexion of the trunk, with the knees straight, so that the hand palms rest easily on the floor	No	1
Total		9