

The Lumbar and Hamstring Flexibility between Crossed Leg Sitting and Bench Sitting Posture In School Children of 6 to 12 Years- A Cross Sectional Study

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ABSTRACT

Introduction: Children adapt various postures for sitting like sitting on benches and sitting on ground in school. In India, there are benches and desks in the classroom in urban setups, however in some rural areas the students sit on the floor with folded knees in an Indian traditional sitting posture. Lumbar spine and hamstring flexibility is measured by sit-and-reach-test (SRT) and active-knee-extension (90-90)-test (AKET) respectively. To date correlation between different sitting postures, flexibility in spine and hamstring among children is not yet performed in Indian school children.

Material and Methods: Four schools were selected by random number table method (2 Schools with crossed leg sitting & 2 schools with bench sitting posture). Permission was obtained from school authorities. Out of 7 subgroups (6 to 12 years) each group has 60 children. Consent was obtained and test procedure was elaborately explained and demonstrated. Anthropometric data were obtained. Both SRT and AKET values were recorded.

Data analysis and Results: The STATA statistical software version 13.0. was used. Pearson's correlation moment product was used to determine correlation between anthropometric data with AKET and SRT in both genders. Regression analysis was performed to determine the contribution of anthropometric factors to AKET and SRT. Bench sitting children exhibit greater hamstring

flexibility and children in crossed leg sitting exhibit more lumbar flexibility. Lumbar flexibility is found to be more in girls than boys in 6 to 12 years in both crossed leg and bench sitting.

Conclusion: The bench sitting children exhibit more hamstring flexibility, whereas lumbar flexibility is more in crossed leg sitting children.

Key words: Crossed leg sitting, bench sitting posture, lumbar flexibility, hamstring flexibility, school children.

INTRODUCTION

Children are the backbone of a nation. [1] On their health and prosperity depends the health of a nation. India has the second largest child population in the world. [1] Numbering over 2.2 billion worldwide and 263.9 million in India (Census, 2011). [2] In school, children adapt various postures for sitting according to infrastructure available like bench sitting, crossed leg ground sitting and long sitting. [3] They spend around 5.5 to 6.5 hours per day. [4] Sitting on benches and sitting on ground in school may affect posture among children. Good posture is a state of muscular and skeletal balance which protects the supporting structures of the body against injury or progressive deformity whereas, poor posture is defined as a faulty relationship of various parts of the body

which produce abnormal strain on the supporting structures and in which there is less efficient balance of the body over its base of support (BOS).^[5]

Children spend about 80% of their school time in the classroom performing various activities like reading, writing, etc. which require them to sit continuously for long hours.^[6] Children in rural areas adapt crossed leg sitting not only in school but also at home while eating, doing homework etc, moreover children today spend considerably less time playing outdoor games.^[7] In India, there are benches and desks in the classroom in urban setups, however in some rural areas the students sit on the floor with folded knees in an Indian traditional sitting posture.^[3] Thus, school children are at special risk of suffering backache due to the prolonged periods spent seated during school and the formation of poor postural habits.^[4] Poor postures are often the result of pelvic tilting (forwards/Backwards), abnormal spinal curvatures, pronated feet, rounded shoulders, muscle tightness (mainly hamstrings).^[8] Anthropometric factors like height, body mass, lower limb length also influence the postural balance.^[9-11]

Hamstring is an important antigravity muscle and its flexibility is important for maintaining normal posture and gait in both adults and children.^[12] The hamstring muscles are located in the posterior thigh and are connected to the hips from one side and to the knee to other side.^[13] Hamstring remains in shorten position in sitting posture- hence prolong sitting can cause hamstring shortening or tightness in children; more in children with ground crossed leg sitting- Indian traditional sitting posture.^[14] In crossed leg sitting, ankles are crossed and hips are flexed (90-100⁰) and strongly abducted and laterally rotated (40-45⁰), knees are flexed (135-160⁰), so that the lateral aspect of knees and ankles are pressed to the floor.^[15] The tension on the hamstrings is reduced but the adductors of the hip are stretched and whole body weight is transferred to the ground from sacrum and

coccyx.^[15] In bench sitting, thighs are fully supported, hips and knees are flexed. The feet rest on the floor with the heels vertically below the knees.^[15] While sitting without a backrest, the children acquire a 'slumped' posture to compensate for fatigue and discomfort, resulting in posterior tilting of the pelvis, accentuation of thoracic kyphosis and cervical lordosis, loss of lumbar lordosis of the spine.^[6] Lumbar spine is more flexible in children as compared to the adults whereas girls are more flexible than boys.^[16,17] Developmental factor may contribute to this observation such as ligamentous laxity, strength and length of spinal musculature and factors such as body mass index -BMI and length of muscles like hamstring can also have an effect on mobility of lumbar spine.^[18]

There were many methods of assessing lumbar spine and hamstring flexibility such as modified Schober's test,^[19] inclinometer,^[20,21] toe touch test,^[22] sit and reach test (SRT),^[23] active knee extension (90-90) test (AKET).^[24] SRT can be considered an appropriate and valid test for evaluating lumbar mobility in school age children and its reliability range from 0.89 to 0.98.^[23] It requires minimum equipment and is easy to setup, conduct and easily understood by all age groups. AKET is an objective and reliable tool for measuring hamstring muscle tightness.^[24] It involves less motion in the lumbar spine and pelvis, it is considered to be gold standard for hamstring flexibility.^[6] AKET can be done by stabilizing the hip at 90 degrees of flexion with the help of wooden frame, PVC pipe frame, metal frame, cross wire etc.^[6] Metal frame was used as stabilizing apparatus for the performance of active knee extension test as it is reliable, simple, easy and commonly available in hardware stores.^[24] When used with a universal goniometer, this apparatus allows measurement in the active knee extension test to be conducted by a single assessor without assistance.^[24] AKET is a valid test and its reliability is 0.99 for right as well as left lower extremity.

[6]

Vadivelan K and colleagues [6] conducted a study to assess influence of two different sitting postures on hamstring muscle flexibility in school going children and concluded that hamstring flexibility was greater in bench sitting children as compared to crossed leg sitting children. Varangaonkar VC and colleagues [18] did a study on relationship between Lumbar range of motion with hamstring flexibility among 6 to 12 years children from South India and concluded that females were identified as have a significantly higher forward flexion, lateral flexion, and rotation range of motion than males. Dutta S and Dhara PC [3] conducted a study on evaluation of different sitting postures of rural primary school boys in the classroom and found that Indian traditional sitting posture i.e. sitting on the floor with folded knees had lesser muscular stress and greater stability in posture than sitting on the bench among the primary school children.

To date correlation between different sitting postures, flexibility in spine and hamstring and gender wise differentiation among children is not yet performed hence the aim of study is to compare hamstring and lumbar flexibility in different sitting postures and to find gender wise differentiation in Indian school children of age 6 to 12 years.

METHODS

A cross sectional comparative study was performed on typically developing children of age group 6 to 12 years selected from urban and rural schools. Permission was obtained from the principal of institute. Schools list was obtained from the block education office (BEO). Four schools were selected by random number table method out of 244 schools (2 Schools with crossed leg sitting posture and 2 schools with bench sitting posture).

Permission was obtained from school authorities to carry out the study. Total 840 children of both gender (420 girls and 420 boys) were selected by stratified

simple random sampling method. Children were divided into 7 subgroups depending upon age i.e. 6 to 12 years.

Out of 7 subgroups (6 to 12 years) each group has 60 subjects both in which subjects were selected according to inclusion and exclusion criteria. Consent was obtained from children. Test procedure was elaborately explained and demonstrated to the subjects. Age, gender and anthropometric data (height, weight, BMI, limb length, trunk length) was obtained. Both SRT and AKET were performed and values were recorded.

Procedure

Children of both gender of age group 6 to 12 years who willing to participate, included in the study with normal body Mass Index (BMI) 13.37 to 22.15 Kg/m². [6] BMI between the 10th percentile and less than the 90th percentile for age 6 to 12 [25] and ability to sit in long sitting position for 2 minutes were included in the study. Any impairment of nervous and musculoskeletal system (any history of hip or back pain), previous back and lower limb surgery, spine/lower extremity injury in last 6 months and physically challenged children were excluded from the study. [6]

Procedure of tests

Height was measured in centimetres by stature meter, weight was measured in kilograms by weighing machine, BMI was calculated by using formula: weight (kg)/height (m)². Trunk length [26] (Figure 1 and appendix I) and the Limb length (Lower extremity) [15] was measured in centimetres by using measuring tape (Figure 2 and appendix II). Active knee extension test [6,24] (Figure 3(a), 3(b) and appendix III) was performed in hip stabilizing frame for AKET and hamstring tightness angle was measured by Universal half circle goniometer. The sit and reach test [20] (Figure 4(a), 4(b) and appendix IV) was performed.



Figure 1: Trunk length measurement



Figure 2: Limb length-Lower extremity measurement



Figure 3(a): Starting position for active knee extension test



Figure 3(b): End position for active knee extension test



Figure 4(a): Starting position for sit and reach test



Figure 4(b): End position for sit and reach test

DATA ANALYSIS

Data analysis was performed using STATA statistical software version 13.0. (p value <0.05 is significant and <0.0001 is highly significant). Karl Pearson's correlation moment product was used to determine correlation between age, height, weight, BMI, trunk length and leg length with AKET and SRT in both genders. Regression analysis was performed to determine the contribution of anthropometric factors to AKET and SRT.

RESULT

Out of 840 children of both gender (420 girls and 420 boys) were included in the study. The height among boys and girls ranged from 124.71 ± 13.53 cm to 134.86 ± 15.69 cm and 123.90 ± 14.63 cm to 131.06 ± 19.35 cm and weight among boys and girls ranged from 24.36 ± 5.69 Kg to 31.18 ± 9.08 kg and 24.01 ± 6.96 Kg to 29.99 ± 8.73 Kg respectively. The height, weight and BMI of children were within 10th and 90th percentile normal limits for age group of 6 to 12 years among both genders for Indian population. [17] The demographic data, anthropometric measures, AKET and SRT values of children are given in Table 1.

Table 1: Descriptive statistics of anthropometric parameters, AKET, SRT in Boys and Girls of crossed leg sitting and bench sitting groups

Parameters	Crossed leg sitting (Mean ±SD)		Bench sitting (Mean± SD)	
	B	G	B	G
Weight(kg)	24.36 ± 5.69	24.01 ± 6.96	31.18±9.08	29.99±8.73
Height(cm)	124.71± 13.53	123.90 ±14.63	134.86±15.69	131.06±19.35
BMI (kg/m ²)	15.49±1.56	15.30±1.59	16.80±2.38	16.93±2.49
Limb length Right(cm)	65.53±7.81	66.90±9.33	72.34±10.03	73.83±10.45
Limb length left(cm)	65.53±7.81	66.90±9.33	72.34±10.03	73.83±10.45
Trunk length(cm)	46.68±4.06	47.26±5.20	49.71±4.86	50.84±5.87
AKET Right(degrees)	137.62±14.71	134.86±14.99	167.29±12.74	168.99±8.67
AKET Left(degrees)	138.20± ±12.91	134.84±14.11	167.64±10.28	167.84±8.30
SRT(cm)	16.46±4.38	17.43±4.00	15.61±4.05	16.86±4.06

G-Girls; B-Boys, AKET-Active Knee Extension Test, SRT- Sit and Reach Test

Table 2: Descriptive statistics of various parameters in boys and girls of crossed leg sitting

Age (year s)	Weight(kg)		Height(cm)		BMI(kg/m ²)		Limb length(cm)		AKE test Right (degrees)		AKE test Left (degrees)		SRT(cm)		Trunk length (cm)	
	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G
6	17.57 ± 1.84	15.47 ± 1.69	108.87 ± 6.60	101.61 ± 5.59	14.77 ± 0.94	14.9 ± 1.36	57.95 ± 3.68	52.87 ± 3.31	128.0 ± 14.46	132.60 ± 11.98	128.60 ± 11.04	132.37 ± 11.92	13.83 ± 3.07	15.05 ± 3.48	43.75 ± 2.678	40.08 ± 1.62
7	19.87 ± 2.36	18.62 ± 1.86	114.63 ± 6.35	113.93 ± 5.45	15.11 ± 1.16	14.3 ± 0.56	60.57 ± 3.92	60.53 ± 3.09	134.43 ± 12.98	118.20 ± 13.35	134.33 ± 11.27	119.57 ± 12.70	14.93 ± 3.38	17.25 ± 2.77	43.98 ± 2.14	45.40 ± 1.71
8	21.20 ± 3.33	20.30 ± 2.42	117.92 ± 10.84	117.88 ± 6.60	15.49 ± 1.81	14.6 ± 1.01	61.97 ± 4.48	61.35 ± 3.45	140.0 ± 10.52	139.77 ± 10.58	140.87 ± 10.11	142.07 ± 10.14	16.05 ± 4.26	16.30 ± 3.63	43.98 ± 3.53	44.18 ± 3.69
9	23.37 ± 3.05	22.40 ± 3.24	124.36 ± 10.1	123.19 ± 6.96	14.93 ± 1.11	14.4 ± 1.23	60.23 ± 3.23	68.23 ± 4.06	134.73 ± 15.07	134.87 ± 13.06	137.17 ± 12.51	136.30 ± 11.80	15.98 ± 4.21	15.65 ± 3.95	46.23 ± 2.88	45.95 ± 3.43
10	26.82 ± 2.83	27.07 ± 3.30	138.33 ± 6.01	131.45 ± 6.53	15.69 ± 1.16	15.6 ± 1.23	71.85 ± 6.14	72.55 ± 4.54	131.87 ± 10.52	130.93 ± 9.17	132.87 ± 11.38	130.03 ± 10.13	20.32 ± 4.97	22.22 ± 3.58	49.82 ± 1.72	50.92 ± 2.81
11	29.63 ± 2.66	29.63 ± 2.90	135.42 ± 5.89	134.55 ± 5.88	16.21 ± 1.63	16.3 ± 1.78	71.30 ± 3.97	73.27 ± 5.19	140.40 ± 11.97	147.77 ± 10.29	140.77 ± 9.44	144.97 ± 11.06	16.50 ± 3.48	17.40 ± 3.23	49.55 ± 5.25	51.20 ± 3.67
12	32.07 ± 3.59	34.58 ± 5.17	141.42 ± 9.71	144.72 ± 6.26	16.21 ± 2.16	16.4 ± 2.05	74.85 ± 5.84	79.50 ± 3.49	153.90 ± 12.34	139.87 ± 17.16	152.77 ± 9.97	138.60 ± 15.09	17.62 ± 4.25	18.12 ± 3.02	49.42 ± 2.27	53.10 ± 2.95

G-Girls; B-Boys

Table 3: Descriptive statistics of various parameters in Boys and Girls of Bench sitting

Age (year s)	Weight(kg)		Height(cm)		BMI(kg/m ²)		Lower limb length (cm)		AKE test Right (degrees)		AKE test Left (degrees)		SRT(cm)		Trunk length (cm)	
	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G
6	20.63 ± 3.10	20.40 ± 3.04	115.35 ± 5.95	114.79 ± 5.03	15.53 ± 1.65	16.11 ± 1.76	63.72 ± 2.50	62.42 ± 3.57	168.83 ± 11.04	167.03 ± 9.95	165.97 ± 10.46	164.50 ± 10.86	12.55 ± 2.59	12.97 ± 2.76	43.88 ± 2.72	44.33 ± 1.96
7	21.27 ± 2.23	21.37 ± 2.82	116.94 ± 5.93	116.60 ± 6.09	15.57 ± 1.47	15.95 ± 1.93	60.27 ± 6.01	60.27 ± 6.01	169.00 ± 7.59	171.07 ± 10.5	171.07 ± 10.05	169.0 ± 7.59	18.67 ± 3.24	18.86 ± 3.24	46.92 ± 4.03	44.90 ± 1.94
8	29.57 ± 7.38	28.23 ± 3.95	128.93 ± 12.39	127.73 ± 8.26	17.84 ± 2.42	16.73 ± 2.37	67.57 ± 8.69	75.60 ± 7.47	163.0 ± 23.22	167.57 ± 7.79	166.33 ± 10.33	167.67 ± 7.55	15.87 ± 3.68	14.90 ± 3.0	50.17 ± 4.31	51.99 ± 4.04
9	36.27 ± 7.78	27.53 ± 3.86	149.02 ± 11.63	127.52 ± 12.11	17.06 ± 2.71	17.11 ± 3.33	77.90 ± 7.89	75.36 ± 6.60	167.87 ± 8.94	169.20 ± 9.23	167.37 ± 9.10	167.27 ± 8.87	14.70 ± 3.98	16.70 ± 3.73	52.67 ± 3.69	52.97 ± 4.47
10	35.47 ± 6.22	36.70 ± 5.87	142.23 ± 6.72	148.50 ± 12.78	17.49 ± 2.58	16.70 ± 2.35	75.47 ± 6.84	78.90 ± 6.66	168.90 ± 10.83	169.83 ± 7.88	166.47 ± 10.58	167.83 ± 8.14	17.97 ± 4.30	16.73 ± 3.14	48.38 ± 4.02	52.20 ± 5.17
11	36.70 ± 6.13	37.93 ± 7.12	147.58 ± 6.23	144.96 ± 8.66	16.86 ± 2.31	17.90 ± 2.19	79.47 ± 3.58	84.78 ± 5.01	167.57 ± 10.65	169.07 ± 7.85	167.80 ± 11.37	169.17 ± 6.86	14.05 ± 2.64	19.00 ± 4.69	52.90 ± 3.41	56.65 ± 5.03
12	38.37 ± 6.04	37.77 ± 7.74	148.93 ± 7.28	148.86 ± 11.64	17.24 ± 2.39	18.03 ± 2.63	81.68 ± 6.05	79.50 ± 7.45	167.87 ± 10.75	169.13 ± 7.82	168.50 ± 10.04	169.43 ± 7.95	15.45 ± 4.19	19.05 ± 3.64	53.05 ± 3.7	52.85 ± 5.35

G-Girls; B-Boys

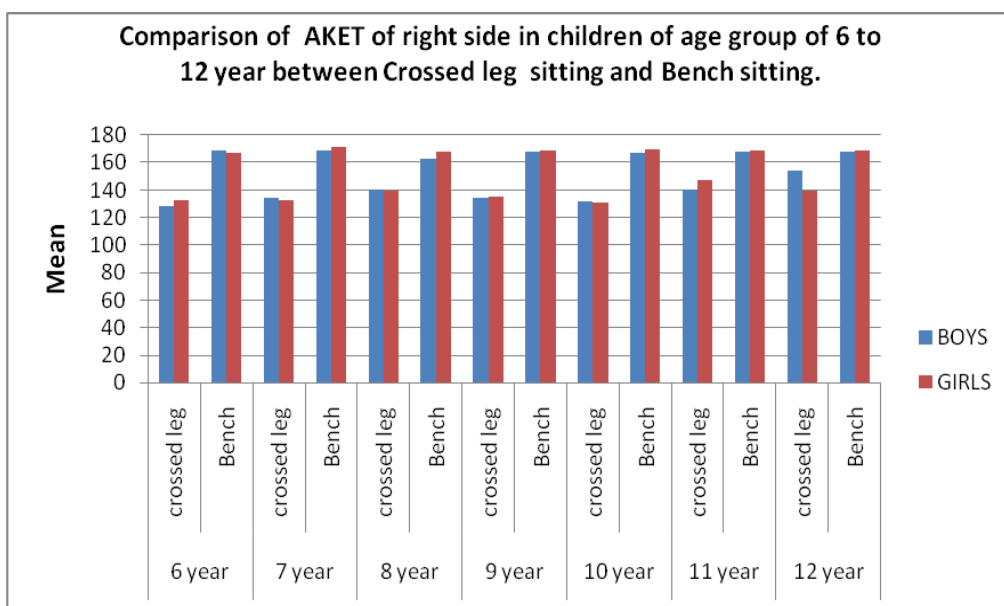
Table 2 and 3 showed crossed leg sitting and bench sitting group wise distribution of anthropometric data, AKET and SRT values among both boys and girls.

Table 4: Comparison of AKET of right and left side in children of age group of 6 to 12 year between Crossed leg sitting and Bench sitting

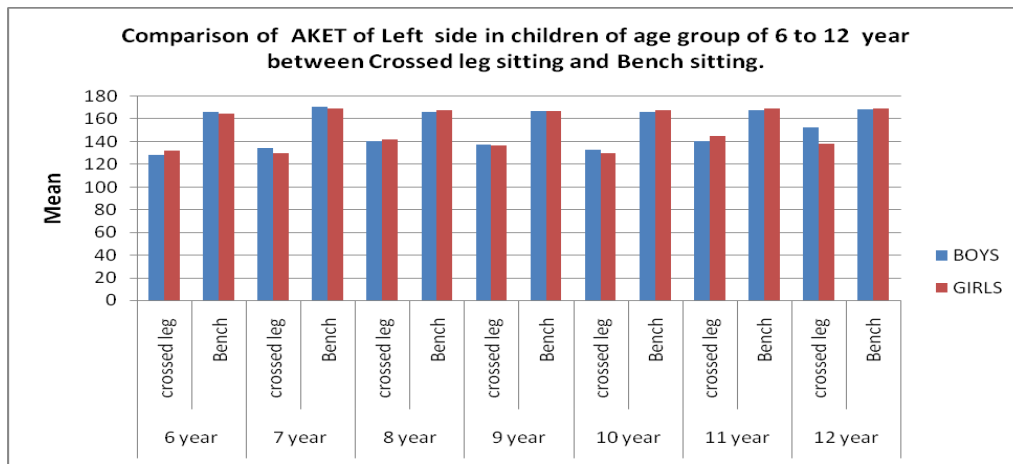
Age group (years)	Group	AKET (Right)		p-value	AKET (Left)		p-value
		B	G		B	G	
6	Crossed leg	128 ± 14.45	132.6 ± 11.97	0.1849,NS	128.6 ± 11.04	132.2 11.91	0.2093,NS
	Bench	168.83 ± 11.03	167.03 ± 9.94	0.5096,NS	165.96 10.45	164.5 10.85	0.5961,NS
	p-value	<0.0001,HS	<0.0001, HS	-	<0.0001,HS	<0.0001, HS	-
7	Crossed leg	134.43 ± 12.97	132.96 7.69	0.5964,NS	134.33 11.27	129.53 9.15	0.0754,NS
	Bench	169 ± 7.58	171.06 ± 10.05	0.3725,NS	171.06 10.05	169.0 7.58	0.3725,NS
	p-value	<0.0001,HS	<0.0001,HS	-	<0.0001,HS	<0.0001,HS	-
8	Crossed leg	140 ± 10.52	139.67 ±10.57	0.9320,NS	140.86 10.10	142.06 10.14	0.6479,NS
	Bench	163 ± 23.21	167.56 ±7.78	0.3113,NS	166.33 10.33	167.67 7.54	0.5704,NS
	p-value	<0.0001,HS	<0.0001,HS	-	<0.0001,HS	<0.0001,HS	-
9	Crossed leg	134.73 ± 15.06	134.86± 13.06	0.9706,NS	137.16 12.51	136.3 11.79	0.7835,NS
	Bench	167.86 ± 8.94	169.2± 9.23	0.5732,NS	167.36 9.10	167.26 8.36	0.9648,NS
	p-value	<0.0001,HS	<0.0001,HS	-	<0.0001,HS	<0.0001,HS	-
10	Crossed leg	131.86 ± 10.52	130.93 ± 9.16	0.7155,NS	132.86 11.37	130.03 10.12	0.3125,NS
	Bench	166.9 ± 10.82	169.83 ± 7.88	0.2351,NS	166.46 10.57	167.83 8.13	0.5770,NS
	p-value	<0.0001,HS	<0.0001,HS	-	<0.0001,HS	<0.0001,HS	-
11	Crossed leg	140.4± 11.96	147.76 ± 10.28	0.0132,S	140.76 ± 9.44	144.96 11.06	0.1192,NS
	Bench	167.56 ± 10.65	169.06 ± 7.84	0.5371,NS	167.8 11.36	169.16 6.86	0.5750,NS
	p-value	<0.0001,HS	<0.0001,HS	-	<0.0001,HS	<0.0001,HS	-
12	Crossed leg	153.9 ± 12.33	139.86 ± 17.15	0.0006,HS	152.76 9.97	138.6 15.09	0.0001,HS
	Bench	167.86 ± 10.75	169.13 ± 7.82	0.6037,NS	168.5 10.04	169.43 7.94	0.6912,NS
	p-value	<0.0001,HS	<0.0001,HS	-	<0.0001,HS	<0.0001,HS	-

Abbreviations: G-Girls; B-Boys; HS-Highly Significant (p value <0.0001), S- Significant (p- value < 0.05), NS-Not significant (p –value > 0.05).

There was no significant gender wise difference seen in AKET (right) of age group 6, 7, 8, 9 and 10 years, whereas there is a significant difference seen in age group of 11 years and a highly significant difference seen in the age group of 12 years. There was a highly significant difference seen between AKET(right) in crossed leg and bench sitting groups i.e. bench sitting group shows more hamstring flexibility as compared to crossed leg sitting.(Graph 1) There was no significant gender wise difference seen in AKET(left) of age group 6,7,8,9,10 and 11 years, whereas there is a highly significant difference seen in age group of 12years . There was a highly significant difference seen between AKET (left) in crossed leg and bench sitting groups i.e. bench sitting group shows more hamstring flexibility as compared to crossed leg sitting group. (Graph 2)



Graph 1: Comparison of AKET of right side in children of age group of 6 to 12 year between Crossed leg sitting and Bench sitting.



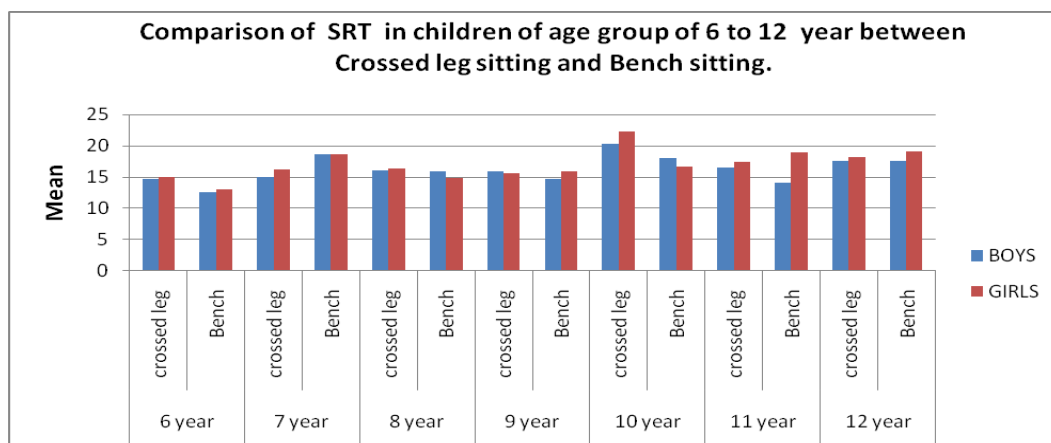
Graph 2: Comparison of AKET of Left side in children of age group of 6 to 12 year between Crossed leg sitting and Bench sitting

Table 5: Comparison of SRT in children's of age group of 6 to 12 year between Crossed leg sitting and Bench sitting

Age group (years)	Group	SRT		p-value
		B	G	
6	Crossed leg	14.73 3.07	15.05 3.48	0.2168,NS
	Bench	12.55 2.58	12.96 2.76	0.5487,NS
	p-value	<0.0001,HS	<0.0001, HS	
7	Crossed leg	14.93 3.37	16.2 2.59	0.1034,NS
	Bench	18.66 3.23	18.68 3.23	0.9842,NS
	p-value	<0.0001,HS	<0.0001,HS	
8	Crossed leg	16.05 4.25	16.3 3.62	0.8075,NS
	Bench	15.86 3.68	14.9 2.99	0.2695,NS
	p-value	<0.0001,HS	<0.0001,HS	
9	Crossed leg	15.98 4.20	15.65 3.94	0.7528,NS
	Bench	14.7 3.97	15.93 3.73	0.2205,NS
	p-value	<0.0001,HS	<0.0001,HS	
10	Crossed leg	20.31 4.97	22.21 3.57	0.0946,NS
	Bench	17.96 4.30	16.73 3.13	0.2098,NS
	p-value	<0.0001,HS	<0.0001,HS	
11	Crossed leg	16.5 3.47	17.4 3.23	0.3033,NS
	Bench	14.05 2.64	19.0 4.67	0.1285,NS
	p-value	<0.0001,HS	<0.0001,HS	
12	Crossed leg	17.61 4.25	18.11 3.01	0.6015,NS
	Bench	17.61 3.48	19.05 3.63	0.1248,NS
	p-value	<0.0001,HS	<0.0001,HS	

Abbreviations: G-Girls; B-Boys; HS-highly significant NS-Not significant

From table 5, there was no significant gender wise difference seen in SRT scores of both groups. There was a highly significant difference seen between SRT scores of crossed leg and bench sitting groups i.e. crossed leg sitting group has more lumbar flexibility as compared to bench sitting group.(Graph 3)



Graph 3: Comparison of SRT in children of age group of 6 to 12 year between Crossed leg sitting and Bench sitting

Table 6: Correlation of various parameters with AKET of right and left side in crossed sitting

Parameters	AKET right side (r-value)		AKET left side (r-value)	
	B	G	B	G
Height (cm)	0.1564	0.1498	0.1315	0.0152
Weight (kg)	0.0956	0.1790	0.0215	0.1547
BMI(kg/m ²)	0.1524	0.0696	0.1045	0.1350
Trunk length(cm)	0.1111	0.1701	0.1673	0.0904
LLL Right(cm)	0.1683	0.1420	0.0416	0.1861
LLL left(cm)	0.1683	0.1396	0.0416	0.1842

Abbreviations: G-Girls; B-Boys; LLL-lower limb length

From table 6, it was found that AKET showed no correlation with height, weight, BMI, trunk length and lower limb length in crossed leg sitting group in both genders.

Table 7: Correlation of various Parameters with AKET of right and left side in Bench sitting

Parameters	AKET right side (r-value)		AKET left side (r-value)	
	B	G	B	G
Height (cm)	0.0195	0.0006	0.0116	0.0653
Weight (kg)	0.0385	0.0493	0.0437	0.1003
BMI(kg/m ²)	0.0091	0.1183	0.0302	0.0101
Trunk length(cm)	0.0509	0.0688	0.0628	0.0785
LLL Right(cm)	0.0420	0.0381	0.0116	0.0802
LLL left(cm)	0.0451	0.0381	0.0128	0.0802

Abbreviations: G-Girls; B-Boys; LLL-lower limb length

Table 9: Correlation of height and trunk length in crossed leg sitting and bench sitting in boys and girls

Values	Crossed leg sitting		Bench sitting	
	B	G	B	G
r-value	0.6698	0.8217	0.5161	0.5071
p-value	<0.0001,HS	<0.0001,HS	<0.0001,HS	<0.0001,HS

Abbreviations: G-Girls; B-Boys.

From table 9, there was a strong positive correlation between height and trunk length in both groups and in both gender.

Table 10: Comparison of AKET between Right and Left in Crossed leg and bench sitting

	Crossed leg sitting	Bench sitting
Right	136.23± 14.89	168.13 ± 10.91
Left	136.51± 13.60	167.74 ± 9.33
t-value	0.7639	0.8272
p-value	0.4454,NS	0.4086,NS

Abbreviations: NS-Not significant

It was found that (Table 10) there was statistically significant difference among AKET of crossed leg and bench sitting groups but there was no significant right and left side difference in AKET of both groups. (Graph4)

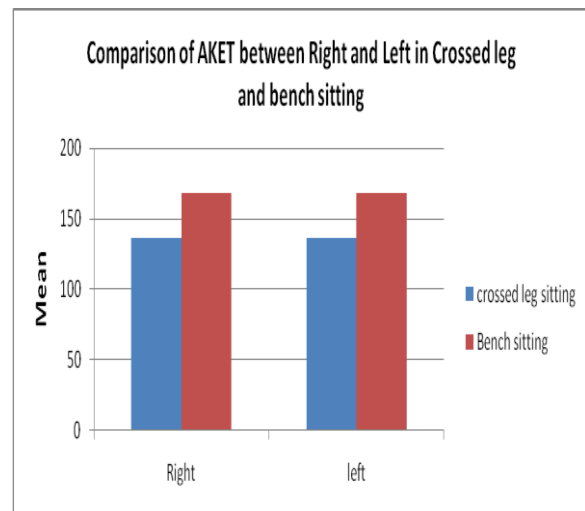
From table 7, it was found that AKET showed no correlation with height, weight, BMI, Trunk length and lower limb length in bench sitting group in both the genders.

Table 8: Correlation of various study variables with SRT in Bench and crossed leg sitting

Variable	Crossed leg sitting (r-value)		Bench sitting (r-value)	
	B	G	B	G
Weight (kg)	0.3224	0.2528	0.3405	0.2635
Height (cm)	0.3019	0.2160	0.3260	0.3078
BMI(kg/m ²)	0.0390	0.1544	0.0954	0.0327
Trunk length(cm)	0.3208	0.2211	0.2268	0.3588
LLL Right(cm)	0.2351	0.2400	0.3185	0.2968
LLL left(cm)	0.2351	0.2400	0.3185	0.2968

Abbreviations: G-Girls; B-Boys; LLL-lower limb length.

From table 8, SRT showed weak positive correlation with weight, height, trunk length and lower limb length in both the groups and in both genders.



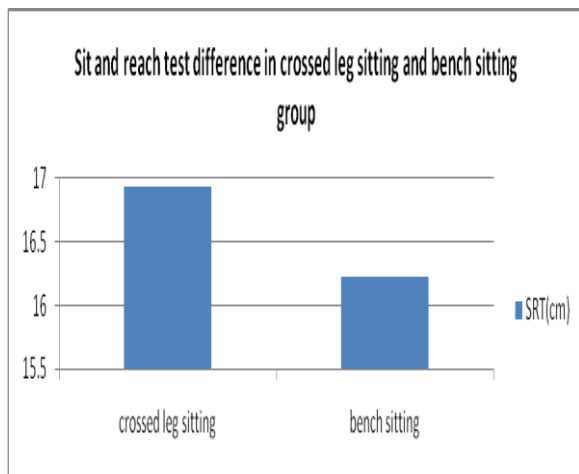
Graph 4: Comparison of AKET between Right and Left in Crossed leg and bench sitting

Table 11: Comparison of SRT between Crossed leg sitting and bench sitting group

Group	SRT (CM) (Mean± SD)
Crossed leg sitting	16.94 ±4.22
Bench sitting	16.23± 4.10
p-value	0.0136, S

Abbreviations: S-significant

From table 11, SRT score was greater in crossed leg sitting as compared to bench sitting i.e. crossed leg group showed more lumbar flexibility as compared to bench sitting group.(Graph 5)



Graph 5: Sit and reach test difference in crossed leg sitting and bench sitting group

Table 12: Correlation of AKET and SRT in crossed leg sitting

Age (years)	AKET(right side) vs. SRT	AKET-(left side) vs. SRT
	r-value	r-value
6	0.0490	0.0411
7	0.1306	0.1339
8	0.1224	0.1410
9	0.0570	0.1074
10	0.1845	0.1319
11	0.0054	0.0448
12	0.0649	0.0134

There was no correlation between AKET and SRT in crossed leg sitting (Table 12).

Table 13: Correlation of AKET and SRT in bench sitting

Age (years)	AKET(right side) Versus SRT	AKET(left side) Versus SRT
	r-value	r-value
6	0.2040	0.1974
7	0.0380	0.0409
8	0.0938	0.0915
9	0.1620	0.1616
10	0.0597	0.0710
11	0.2861	0.2980
12	0.2383	0.2478

There was no correlation between AKET and SRT in bench sitting (Table 13).

DISCUSSION

The study aims to compare the influence of bench sitting and crossed leg sitting posture on the lumbar and hamstring flexibility in school children of age group 6 to 12 years. In the present study it was

found that hamstring flexibility changes as the sitting posture changes (Table 4, Graph 1 & 2) i.e. bench sitting children exhibit greater hamstring flexibility than crossed leg sitting children which is consistent with findings of Vadivelan K. and Priyaraj B. [6] In this study, it was also found that there is no gender wise significant difference in hamstring flexibility which is inconsistent with the findings of Cornbleet SL, Woosley NB [20] who found that girls have more hamstring flexibility than boys. Difference in hamstring flexibility among crossed leg and bench sitting is due to prolonged duration (5 to 6 hours) [4] spent by children in crossed leg sitting posture [4] which causes hamstring muscle to remain in biomechanically shortened position than children in bench sitting also the children perform activities like doing homework, eating etc. in crossed leg sitting posture which increases number of hours spent in crossed leg sitting thus reducing hamstring flexibility [6,7] and also can lead to lower back pain in children. [27]

This study also showed that lumbar flexibility is altered in both types of sitting posture among children (Table 5, Graph 3) i.e. children in crossed leg sitting exhibit more lumbar flexibility as compared to children in bench sitting. As the children sitting in crossed leg have to bend comparatively more forward to write or read, whereas children sitting on bench have to bend less. Lumbar flexibility is found to be more in girls than boys in 6 to 12 years in both crossed leg and bench sitting as girls are more flexible as compared to boys, which is consistent with findings of Mellin G, Poussa M. (1992); [17] Haley SM, Tada WL, Carmichael EM(1986) [16] and Varangaonkar VC, Ganesan S, Kumar KV(2015). [18]

In current study, hamstring flexibility is not affected by age, height, weight, BMI, trunk length and lower limb length in both the groups and in both the genders (Table 6 & 7). This is consistent with findings of Vadivelan K and Priyaraj B [6] who concluded that age and body mass

were not statistically correlated with active knee extension in both types of sitting postures as the participants were of growing age and as age increases height and weight also showed an increment in their values and hence their ratio i.e. BMI remained constant [28]. There is scarcity of data on correlation of factors like height, weight, trunk length and lower limb length with hamstring flexibility. The present study showed lumbar flexibility has a weak correlation with age, height, weight, trunk length and lower limb length in crossed leg and bench sitting in both males and females (Table 8). This is consistent with assumption of a study done by Cornbleet SL and Woosley NB (1996) [20] who stated that either anthropometric factors or limited flexibility in spine may prevent the children from reaching the toes during SRT.

BMI did not affect SRT values (Table 8) as the participants were of growing age and as age increases height and weight also showed an increment in their values and hence their ratio i.e. BMI remained constant. Moreover none of the participants in the study sample were obese, therefore obesity and its factors cannot be a contributor for limitation of the movements. [28] The current study found that height and trunk length are strongly correlated in both groups in both gender (Table 9) i.e. an increase in trunk length is proportional to increase in the height. This finding is consistent with the findings of Zhu M, Jiao YH, Xiong F, Xiew F, Guo SJ and Cun YS [29] who found that sitting height, upper arm length and lower leg length were highly correlated with standing height. Another study done by Dare NW, Onyije FM and Iniefe AI [30] stated a linear correlation of the trunk length to lower limb length in Nigerian Adolescents of 12 to 17 years. There is no correlation between AKET and SRT (Table 12 & 13). This is consistent with a study done by Erica N Johnson and James S Thomas (2010) [31] who found no significant correlation between hamstring flexibility and lumbar flexibility and another study done by Varangaokar VC, Ganesan S

and Kumar KV (2015) [18] who found that there was no correlation between hamstring muscle length and lumbar range of motion.

IMPLICATIONS FOR RESEARCH AND CLINICAL PRACTICE

Normative data scores for school going children using AKET and SRT should be determined further at national level. The correlation between hamstring flexibility and lumbar flexibility among children can be evaluated depending upon the duration of sitting posture in both genders. Evaluation of sitting posture, duration spend by children in different sitting and alteration in lumbar and hamstring flexibility can be considered as per results of present study. Time spend by children in different sitting postures other than school were not taken into consideration.

CONCLUSION

This study concluded that hamstring and lumbar flexibility is affected by change in sitting postures. The bench sitting children exhibit more hamstring flexibility than crossed leg sitting children, whereas lumbar flexibility is more in crossed leg sitting children. There is no gender wise differentiation found in hamstring flexibility. Lumbar flexibility in girls is found to be more than boys.

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- Another strap was placed over anterior superior iliac spines to stabilize the pelvis.
 - The hip of the extremity to be measured was maintained in 90 degrees of flexion such that the anterior thigh will rest against the horizontal bar throughout the procedure.
 - The axis of the goniometer was placed over lateral femoral epicondyle. The proximal arm was parallel to the lateral midline of thigh, using greater trochanter for reference. The distal arm was parallel to the lateral midline of fibula, using the lateral malleolus for reference.
 - With the hip stabilized at 90 degrees flexion (with hip stabilizing metal frame) and ankle relaxed in plantar flexion, the subjects were asked to extend the knee till he/she felt slight pain in posterior thigh.
 - The angle of knee was measured by universal half circle goniometer and recorded.
 - The same procedure was repeated for the other extremity.

APPENDICES

I. TRUNK LENGTH MEASUREMENT [26]

- The subject was instructed to sit in erect posture with hip, knees and ankles at 90 degrees of flexion.
- The upper arms held loosely by the side of body.
- With the help of a measuring tape the distance from C7 spinous process to the sitting surface is measured.

II. LIMB LENGTH-LOWER EXTREMITY [15]

- The subject is in supine lying on bench with both legs extended and placed equidistant from the midline.
- With the help of a measuring tape the distance from the ASIS to the lateral malleolus was measured.

III. ACTIVE KNEE EXTENSION TEST [6, 24]

- The apparatus consists of 2 vertical poles on either sides of the bench and a single adjustable horizontal bar {figure 3(a), 3 (b)}.
- Each subject was positioned supine on the bench.
- The lower extremity not being measured was stabilized with a strap across the thigh.

IV. SIT AND REACH TEST [20]

- The apparatus consists of a sit and reach box {figure 4(a),4(b)}.
- Each child was seated on the floor with knees extended and ankles in neutral against the box.
- The child was instructed to place one hand on top of the other with fingers extended and slowly reach forward as far as possible while keeping the knees extended. Three trials were performed and highest score was recorded.
- The SRT score (in centimeters) was recorded as final position of the fingertips on ruler.

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