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RESEARCH ARTICLE

ESTIMATION OF REFERENCE VALUES FOR UPPER QUARTER Y-BALANCE TEST IN 6-TO-12YEARS INDIAN SCHOOL GOING CHILDREN: A CROSS SECTIONAL STUDY

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ABSTRACT

Background: Balance is important in various physical therapy evaluation in school going children for performing various physical performance activities. Specific dynamic test for evaluation of upper limb performance, YBT-UQ is reliable method for assessment. Normal reference values for YBT-UQ have not been established in school going Indian children aged between 6-12 years. **Objective**: To estimate reference values of Y- Balance test in 6-to12-years Indian school going children. **Methods:** Total 350 children (175 boys and 175 girls) was the estimated sample size with 7 sub-groups (6,7,8,9,10,11 & 12 years), 50 in each group i.e. 25 boys and 25 girls. Balance was evaluated by YBT-UQ in both groups. **Results:** The total excursion score(TES) of YBT-UQ among boys 102.15±6.97 to 187.94±10.18cm and in girls 96.36±4.49 to182.63± 3.61cm. The composite score (CS) ranged from 55.14cm to 86.85 cm in both gender. **Conclusion:** As age advances the YBT-UQ scores also increase in both genders. No significant gender differences existed, whereas males showed slightly greater values than females in all three reach directions (M,IL&SL),TES and CS.

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INTRODUCTION

Balance is defined as the center of gravity when falls within the limits of base of support.[1] There are two types of balance, static and dynamic i.e. at rest and during movements.[1] Balance performance is influenced by the integration of main subsystems i.e. somatosensory, vestibular & visual.[1] Balance requirements vary depending on the characteristics of the task and the environment which allows an individual to appropriately modify sensory and motor systems in response to changing demands.[1] Balance is important in children for motor skill development.[2] By six to ten years of age, child's ability to maintain balance and posture is increased and matured.[3] A study reported that balance abilities depend on the developmental status from the age between 5 and 18 years.[4] Children from 9 years of their age start using adult like postural strategies.[5] Impaired balance leads to less stability which in turn lead to increased risk of falls and injuries in children hence any developmental abnormality may lead to serious problems in the later life of child.[6] A study (2012) by Hjalmarsson ES et al, in Sweden, found that one of the factor affecting the balance of a child is hypermobility syndrome and concluded that joint hypermobility can lead to arthralgia (pain) which appears to affect activity and participation in children with hypermobility syndrome compared to healthy controls of age group 8-16 years as well as they concluded, balance decreases in children with hypermobility syndrome.[7] The Beighton's scale is considered to be the gold standard test for diagnosis of joint hypermobility and found an acceptable concurrent validity against goniometer in 6 to 12 years children.[8] It is easy to administer, cost effective and quick to perform.[8,9] There are various tests available in children to evaluate their balance performance such as Pediatric Balance Scale (PBS)[10-12], Functional Reach Test/ Lateral Reach Test[13-16], Star Excursion balance test[17-20], Timed up and Go test[21],Tilt board balance test[22], One arm hop test[23], Y balance test {upper quarter(UQ) [24-27] and lower quarter(LQ)[28-31] but very limited test evaluates upper quarter performance other than UQ-Y Balance Test. A study proved that, in children of age 15-19 years, shoulder dynamic stability is important for various upper limb functional activities like in athletes and sports thus, good upper limb balance control is also necessary for participation.[32] Upper quarter (UQ) Y balance test is a valid and reliable tool for assessment of upper extremity mobility and stability in adult age group(19 to 47 years) with test -retest reliability of 0.80 to 0.99.[24] The YBT-UQ is a reliable functional test[24] demonstrating a fair to moderate association with several tests that measure core stability (push-up and lateral side bend endurance, range, 0.38–0.45) and upper extremity function (closed kinetic chain upper extremity stability test, range, 0.43–0.49).[25]

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The test- retest reliability of star excursion balance test has been established in age group of (12 to 16 years) with values of 0.68(inter-rater) and 0.95(intra-rater).[33] The YBT-UQ is a physical performance measure, which allows for the quantitative analysis of a participant's ability to reach with their free hand while simultaneously weight bearing on the contralateral hand.[24,26,27] It is low cost, easy to understand and administer, multi–directional, objective tool for dynamic upper quarter balance.[24,34] The YBTUQ requires the combination of scapular mobility, stability, thoracic rotation, core stability and are challenged as the participant reaches as far as possible in three direction [medial(M), supero-lateral(SL) , infero-lateral(IL)].[25,27]

Many studies have been done on YBT-UQ in college aged population and adolescent population involved in physical activities.[25,26,34-36] A study (2013) was performed to see the reliability(inter-rater and intra-rater) of star excursion balance test (SEBT) performed on age group 12-16 years by Shaikh A, Walunjkar R.[33] Reference values for upper quarter Y balance test have been established in age group 14-15 years (Butler ,2014)[26] ,18-19 years(Richard B, 2012),[25] 18-28 years (Dorien Borms,2016)[34], 23-39 years (Josh Cramer, 2017)[27], (18-50 years)Borms D et al[35], (Taylor JB)[37], 25-26 years (Salo TD)[38]. To date reference values for upper quarter Y balance test are not yet established in children with age group of 6-12 years. Hence, the present study aim to establish the reference values for upper quarter Y balance test in 6-to-12 years Indian School Going Children in both genders.

MATERIALS AND METHODS

A descriptive, observational, cross-sectional study was performed at public schools of the city of children of age 6-to-12 years. Total 350 children (175 boys and 175 girls) was the estimated sample size with 7 sub-groups (6,7,8,9,10,11& 12 years). The primary schools were purposively selected from the city according to the convenience and feasibility. Sampling frame was comprised of all sections and classes for the age group of 6-12 years. One section from each class was randomly selected by lottery method. All students from the selected class were assessed for measurement of Upper quarter Y balance test (YBT-UQ). Care was taken to include at least 25 boys and 25 girls from the selected section/class. Thus a random sample of total 350 students from the entire schools (25 boys and 25 girls per class in 7 age subgroups) was selected for study purpose. Children of age 6-to-12years (both boys and girls) with height and weight within 10^{th} to 90^{th} percentile for age group, cooperative and children willing to participate[25] were included in the study and any history of injury to the upper and lower limb in last 6 months[24,25], children with hypermobility syndrome (Beighton's test for upper limb score cut off)[8,9], any known neurological involvement[25], and cerebral concussion within the previous 3 months[24] were excluded from the study.

The study was performed on asymptomatic healthy children of age group 6-to-12 years going to public schools of the city. Permission from the institutional head and ethical committee was taken. Schools were selected randomly from the school list provided by block education officer (Random number table) and permission from the school authority was taken. For participation in the study the consent from the parents and students was taken and the importance of study was explained in detail.

Class teacher permission for target population was taken. Children from 6-12 years of age group were selected and children with joint hypermobility syndrome were excluded with the help of Beighton's scale score. [8,9] Demographic data of the subjects included was taken (height, weight and BMI). Total 7 sub groups of boys and girls (6, 7, 8, 9, 10, 11, and 12) were divided including 25 boys and 25 girls (50 in each group) were enrolled in the study from the respective sections. One trial session was given to every child to adapt for the test. Upper quarter Y balance test was performed from starting position (Figure 1) in all three directions i.e. medial, inferolateral, superolateral (Figure 2,3 and 4), three trial attempts were given and maximum score reached out of three attempts was recorded for data analysis. Rest period of 20 sec was provided between each reach direction. Data was collected and results were analyzed.

Outcome measures: Primary outcome: Upper quarter Y balance test.

Data analysis

Data was coded and entered in Microsoft Excel Worksheet. Data was analyzed in a Statistical Software, STATA, version 10.1, 2011**.** Descriptive statistics like Mean & Standard Deviation (SD) were calculated to summarize Quantitative variables (UQ-YBT, height, weight). Frequency and percentages were calculated to summarize categorical variables (For eg. age, gender, dominance). Inferential statistics procedure was performed to estimate the reference values by age and gender along with 95% confidence interval. Chi Square Test of association was performed to find association between categorical variables i.e. UQYBT score with height, weight. The t-test for 2 independent samples was performed to compare mean of UQYBT score with anthropometric measure by age and gender. The *p* value of less than 0.05 was considered statistically significant.

RESULTS

Total 350 children were included (175 boys and 175 girls), 50 in each 7 subgroups with demographic data of age, height, weight and BMI (Table 1). Children participated in present study suggest that children belongs to typically developing and showed height, weight and BMI belongs to normal limits for age group. It was observed that as the age advances the height and weight also increases in study participants. The descriptive analyses (mean and standard deviation) of upper quarter Y balance test for all three direction reach values i.e. M (Medial), IL (Inferolateral), SL (Superolateral) and TES (Total Excursion Score) and CS (Composite Score) in centimeters for 6-to 12 years including both genders were given in Table 2.

The mean values of medial reach showed high significant difference among the age group of 6-12 years in all 7 subgroups (6, 7, 8, 9, 10, 11, & 12) where males showed slightly greater values than females among both gender. The mean values of inferolateral reach showed high significant difference among the age group of 6-12 years in all 7 subgroups (6, 7, 8, 9, 10, 11, & 12) where males showed slightly greater values than females among both gender. The mean values of superolateral reach showed high significant difference among the age group of 6-12 years in all 7 subgroups (6, 7, 8, 9, 10, 11, & 12) including both where males showed slightly greater values than females among both

Table 1. Mean and standard deviation of demographic data (Age, Height, Weight and BMI) of age 6-to-12 years including both genders

Age Group	Age (Years) Mean±SD	Height (cm) Mean±SD	Weight (Kgs) Mean±SD	BMI (Kgs/m^2) Mean±SD
6	6.28±0.21	110.08±4.62	18.00±3.63	14.00±1.28
7	7.16±0.18	115.30±3.09	18.58±1.91	14.19±0.93
8	8.16±0.17	117.80±4.49	20.30±2.74	14.56±1.60
9	9.16±0.17	127.50±4.32	22.98±4.19	14.69±2.21
10	10.12±0.15	128.60±2.61	26.28±2.94	15.54±2.26
11	11.12±0.18	134.96±3.95	30.68±3.77	15.81±1.37
12	12.12±0.18	142.68±5.84	31.76±5.65	16.58±1.67

BMI- Body Mass Index, SD- Standard Deviation

Table 2. Descriptive analyses (Mean and Standard Deviation) of the results of the upper quarter Y balance test (cm) scores in age group of 6-12 years including both boys and girls.

Age (Years)	M (cm)		IL(cm)		SL (cm)		TES (cm)		CS (cm)	
	B	G	B	G	B	G	B	G	B	G
6	49.89 ±4.23	49.98 ±3.68	28.61 ±3.44	23.86 ±1.85	23.65 ± 2.11	22.70 ±1.87	102.15± 6.97	96.36± 4.49	55.02 ±2.75	54.14 ±1.77
7	55.14 ±4.93	53.14 ±5.93	34.76 ±3.01	34.47 ±2.69	24.90± 1.76	23.30 ±1.58	114.80± 5.40	106.14 ± 4.40	58.02 ±3.86	55.50 ±2.41
8	66.47 ±3.07	63.98 ±2.99	45.99 ±2.72	45.21 ±2.72	25.11 ± 1.48	24.63 ±1.45	137.66 ± 6.32	133.47 ± 3.88	65.78 ±3.23	66.46 ±3.17
9	73.30 ±2.52	72.22 ±1.88	52.18 ±2.10	51.85 ±1.93	31.50 ± 2.32	31.26 ±2.10	150.43 ± 4.88	147.61 ± 4.42	73.58 ±1.60	73.67 ±1.30
10	83.47 ±1.74	83.39 ±1.59	55.47 ±2.51	53.89 ±1.61	34.02 ±1.73	34.38 ±1.54	170.39 ± 5.02	168.51 ± 4.13	81.31 ±1.27	80.79 ±2.26
11	88.26 ±5.80	80.67 ±2.99	57.86 ±3.59	62.07 ±1.80	46.63 ±2.36	37.41 ±3.13	186.41 ± 4.09	176.66 ± 5.10	83.54 ±4.34	82.73 ±3.92
12	90.30 ±2.34	85.34 ±1.82	62.53 ±1.92	56.10 ±2.96	55.14 ±4.34	53.14 ±3.92	187.94 ± 10.18	182.63 ± 3.61	86.85 ±1.60	84.18 ± 1.6

M -Medial, IL- Inferolateral, SL- Superolateral, TES- Total Excursion Score), CS- Composite score, B- Boys, G-Girls

Table 3. Comparison of Medial, Inferolateral, Superolateral Reach Values, Total Excursion Score and Composite scores in age group of 6-12 years among boys and girls

Age (yrs)	M (cm)		IL (cm)		SL (cm)		TES (cm)		CS (cm)	
	Boys vs Girls		Boys vs Girls		Boys vs Girls		Boys vs Girls		Boys vs Girls	
	t-value	*p*-value	t-value	*p*-value	t-value	p-value	t-value	p-value	t-value	p-value
6	0.08	0.9333	6.05	0.0001**	1.63	0.1007	0.99	0.3252	1.34	0.1847
7	1.29	0.2016	0.34	0.7307	2.05	0.0458*	3.80	0.0004**	2.76	0.0081**
8	2.90	0.0056**	1.01	0.3131	1.15	0.2537	2.82	0.007**	0.75	0.4516
9	1.71	0.0928	0.58	0.5624	3.78	0.0004**	2.14	0.0371*	0.20	0.8402
10	0.17	0.8649	2.65	0.0108*	0.38	0.7043	1.44	0.1551	1.00	0.3177
11	5.81	<0.0001**	1.89	0.0648	7.93	<0.0001**	4.95	<0.0001**	2.40	0.0202*
12	7.35	<0.0001**	0.85	0.3954	0.77	0.4421	3.45	0.0012**	3.42	1.0013*

M -Medial, IL- Inferolateral, SL- Superolateral, TES- Total Excursion Score), CS- Composite score , Significant* -*p* value <0.05, Highly Significant**-*p* value <0.001

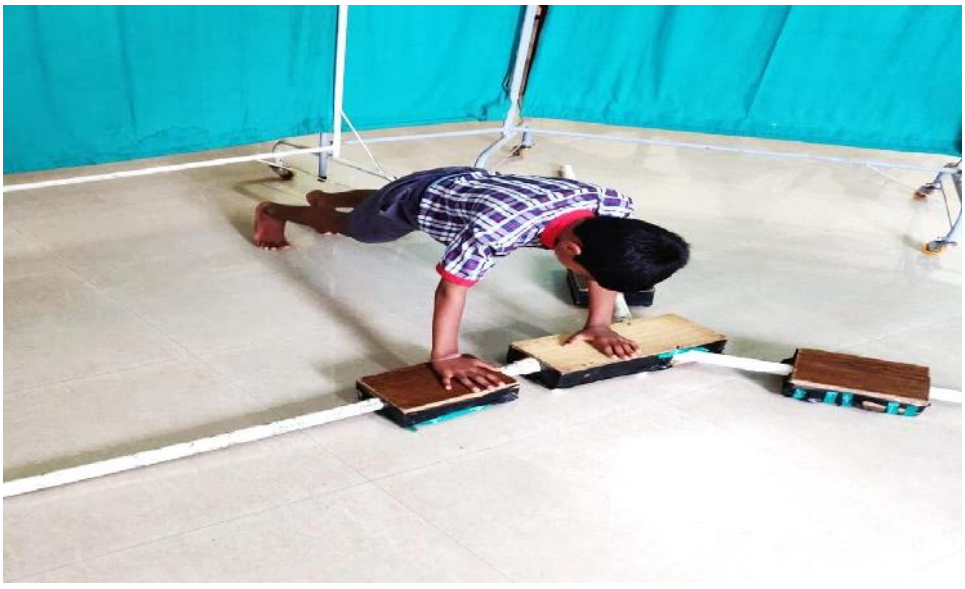

Figure 1. Staring Position For Upper Quarter Y Balance Test

Figure 2. Upper Quarter Y Balance Test (Medial Reach)

Figure 3. Upper Quarter Y Balance Test (Inferolateral Reach)

Figure 4. Upper Quarter Y Balance Test (Superolateral Reach)

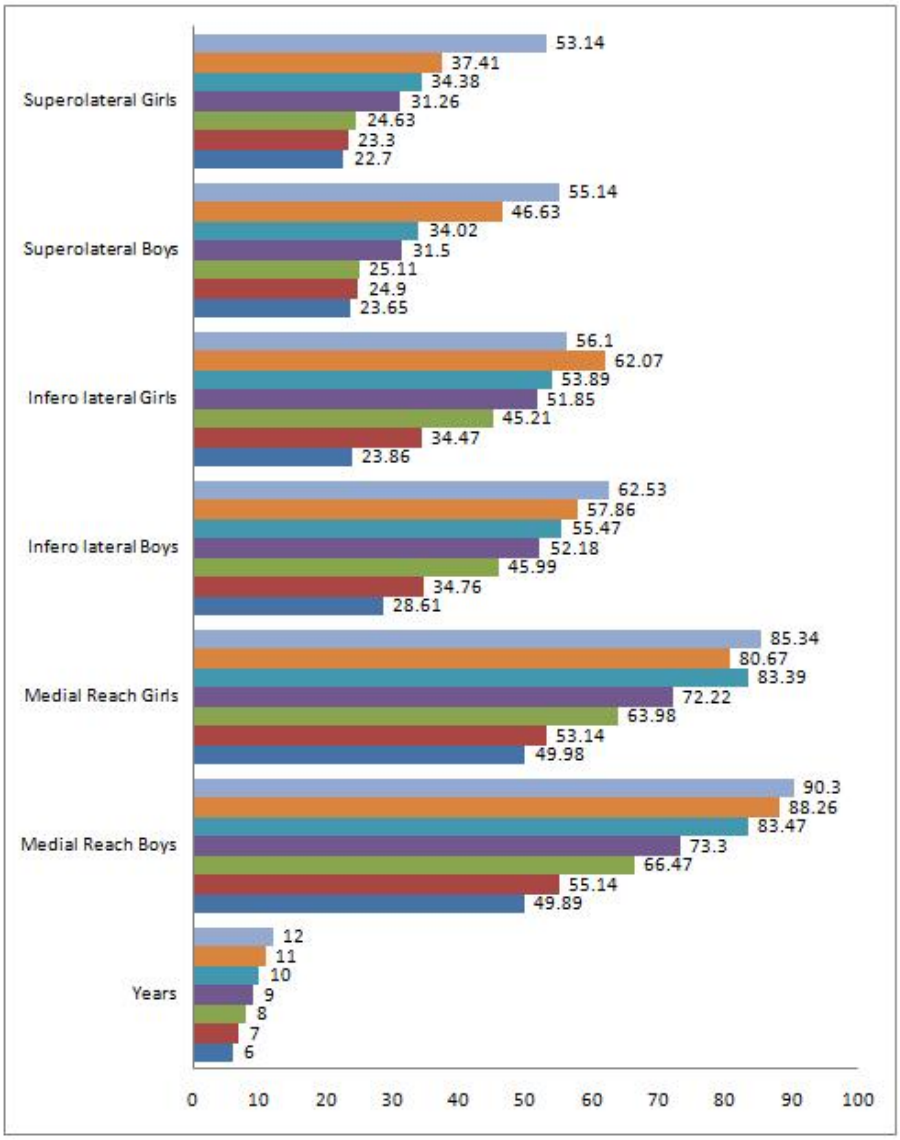

Figure 5. Upper Quarter Y Balance Test (UQYBT) Mean Reach Values of Medial, Inferolateral And Superolateral Direction Among Both Boys And Girls

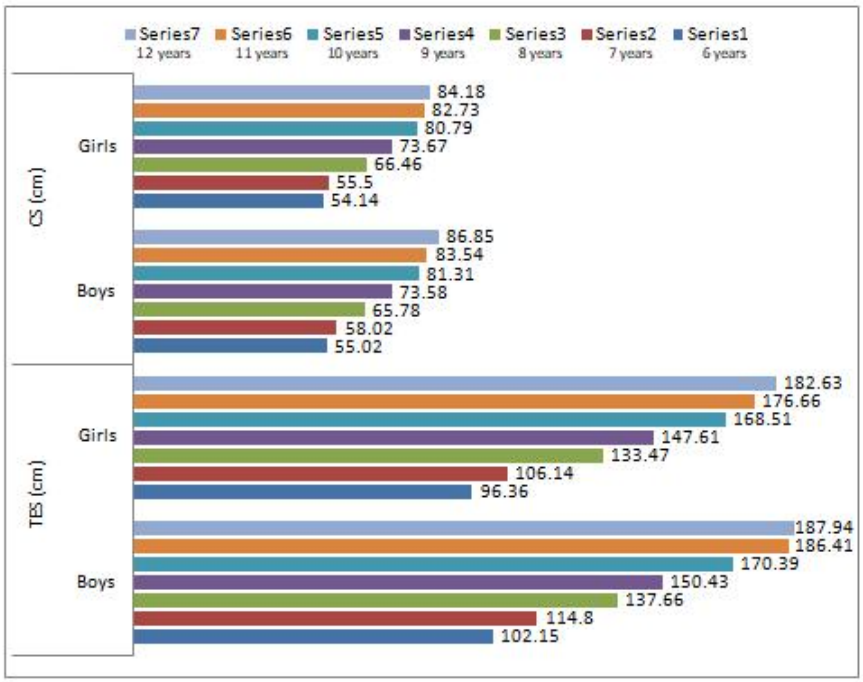

Figure 6. Total Excursion Score (TES) and Composite Score (CS) Of Upper Quarter Y Balance Test In 6-To12 Year Boys And Girls

gender. The mean values of total excursion score (sum of all 3 reach directions) showed high significant difference among the age group of 6-12 years in all 7 subgroups (6, 7, 8, 9, 10, 11, & 12) where males showed slightly greater values than females including both gender. The mean values of composite score showed high significant difference among the age group of 6-12 years in all 7 subgroups (6, 7, 8, 9, 10, 11, & 12) where males showed slightly greater values than females including both gender.

The reference values were established in age group of 6-to-12 years ranging from 54.14 cm to 86.85 cm respectively. The mean values of YBTUQ showed significant differences in all three reach directions (medial, inferolateral and superolateral) and composite scores in all the genders. The highest score was found in the medial reach direction followed by inferolateral and least in the superolateral direction. Males showed slightly greater values than females, but those where not statistically significant in all age groups. Hence, no significant gender differences were found.(Table 2) High significant gender differences were found in the medial reach and total excursion score of age group 8,11 and 12 years,($p<0.001$) whereas superolateral reach, inferolateral reach and the overall composite score does not much significant gender wise difference in all the age groups.

DISCUSSION

The current study was an observational, cross- sectional study and the purpose was to establish the reference values for YBTUQ in school going children of age 6-to-12 years in both genders. Total 350 children (175 boys, 175 girls) were included with 7 sub-groups (6,7,8,9,10,11&12 yrs). The reference values of YBTUQ for 6-to-12 years school going children were established in present study (Table 2) within the range of average composite score (CS) 54.14±1.77 cm to 86.85± 1.60 cm including both genders (Boys,55.02 cm to 86.85 cm and Girls, 54.14 cm to 84.14 cm) in 6-to-12 years. The M, IL, SL and TES values in this age group were 49.89 cm to 90.30 cm, 23.86 cm to 62.53 cm, 22.70 cm to 55.14 cm and 96.36 cm to 187.94 cm respectively including both gender. In the present study it was found that as the age advances the reference values of YBTUQ also increases from age 6-12 years in both gender (Table 2).

The study done by Deshmukh AA[16](2011) in age 6-12 years also found for Functional Reach and Lateral Reach Test values increases as age advances among both gender. Whereas study performed in three age groups (18-25, 26-33 and 34-50 years) by Borms D et al[35]whofound that as the age advances there is decrease in reference values of YBTUQ in all three directions. This can be explained on the basis that, in early age balance matures from 6-10 years[1]hence in the present study YBTUQ balance values increases from age 6-to-12 years in both gender. Whereas in the age group of 18-50 years studied by Borms D et al[35] found that as the age advances the balance values decreases significantly. Remaud A et al stated that physiologically as age advances there is a possibility of deficits in visual, vestibular and somatosensory systems which may show altered dynamic postural control in older compared to younger age groups which modifies the control of balance[39], so it can be stated that in early age balance improves as age advances but in later stages it decreases. In current study both genders exhibited higher scores in medial reach followed by inferolateral reach and least in superolateral reach (Table 2). similar finding was found in the studies carried by Gorman et al[24](19-47 years), Butler RJ et al (2014)[26](14-15 years),Butler RJ and colleagues[40] (18-19 years), Borms D et al[35] (18-50 years),Taylor et al[36] (18-19 years) and Westrick RB[25] et al (18-19 years).This can be explained biomechanically as the shoulder joint requires enough ROM (range of motion) to reach in all three direction (M, IL and SL) which was found in the study done by Gorman et al [24]who stated that for reaching as far as possible outside a narrow base of support, the subject is required to use balance, proprioception, strength and greater joint range of motion. The YBTUQ requires shoulder horizontal abduction range to reach in lateral direction(i.e.M) (135°),whereas to reach underbody (i.e.lL) and overbody (i.e.SL) direction it requires shoulder horizontal adduction range (65°) and flexion range (45°) respectively.[41]In the starting position (push-up position) of YBTUQ, shoulder joint is at 90° of horizontal adduction, so while reaching in all three directions relatively shoulder is having anatomical greater range in lateral (medial) direction compared to underbody (inferolateral) and over-body (superolateral) directions.[41]In present study, TES and CS also follows the similar patterns which shows increased values from age 6-12 years in both genders. There are no studies available in similar age group in order to compare these findings.

In current study it was found that males showed slightly greater values than females in all three reach directions of YBTUQ in 6-12 years, which was also found in the study done by Borms D et al[35] who carried out a study on upper extremity physical performance tests in age group of 18-50 years. Gorman et al[24], Butler et al[40] (18-19 years),Westrick RB[25] et al(18-19 years), Teyhen D et al[42](less than and more than30 years)and Taylor et al[36] (18-19 years) (p=0.010) also reported the similar results. These findings can be explained as physiologically males are stronger than females which was also stated in the study by Deshmukh AA et al[12](2011) in 6-12 yrs including both genders. Another study by Butler et al[40](18-19years)and Borms D et al[35] (18-50 years) found statistical significant difference ($p<0.01$) between males and females for average score of all three reach directions which does not coordinate with results of the present study.

The present study also revealed significant gender wise difference in the M and TES values in the age group of 8, 11 and 12 years, which was found in the study done by Borms D et al[35](18-50 years)and Butler et al[40](18-19 years) only for M direction which supports the present study but these studies additionally found significant difference in the IL and CS values. Hence, present study concludes that as age advances, there is an increase in the reference values of YBTUQ in school going children of age 6-12 years in both genders. The YBTUQ is also found appropriate, quick and easy to administer clinical measure in this age group that evaluates the upper quarter performance. For future research, the comparison of these reference values can be done in children, with upper limb joint hypermobility disorders (selective and/or generalized hypermobility) and with mild to moderate motor and balance impairments, on children who will be able to understand and perform the test. These reference values of YBTUQ can also be compared with school going children of same age group including both genders who are involved in different sports activities like swimming, volleyball, athletics etc. Upper limb strength, shoulder joint ROM (range of motion), core muscle strength and trunk strength was not evaluated in children, which might contribute for the YBTUQ

reach values. Hence, the trunk stability, core strength and upper extremity strength can be co-related with the baseline reference values in similar age group in future studies. The physical activity level of children was also not considered while including in the study.

Conclusion

The reference values of YBTUQ (Table 2) were established in present study in the age group of 6-12 years and the composite values (CS) ranged from 55.14cm to 86.85 cm in both gender. It was found that as age advances the YBTUQ scores also increase in both males and females. In addition, no significant gender differences existed, but boys showed slightly greater values than girls in all three reach directions (M, IL& SL), total excursion and composite scores. Hence, these reference values of upper quarter Y balance test can be used as a baseline data for assessment of balance impairments in the age group of 6-to-12 years Indian children in both genders.

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Key Points

- Present study provides reference values of Upper Quarter Y- Balance Test values in Indian school going children of age 6-to12 years.
- As the study sample is small to generalise the data for larger population.
- Data can be used for further reference for evaluation in upper limb joint hypermobility children.
- Policy makers can use these reference values for establishing normal values using multi centric study design in school children.

Glossary of Abbreviations

YBT-UQ: Upper Quarter Y- Balance Test
TES: Total Excursion Score
CS: Composite Score
M: Medial
IL: Infero-Lateral
SL: Supero-Lateral
SEBT: Star Excursion Balance Test
PBS: Pediatric Balance Scale
BMI: Body Mass Index
SD: Standard Deviation

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