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RESEARCH ARTICLE

COMPARISON OF BALANCE BETWEEN THE NORMAL VISION & VISUALLY IMPAIRED SCHOOL CHILDREN USING THE BALANCE EVALUATION SYSTEMS TEST (BESTest).

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Manuscript Info | **Abstract**

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Introduction:-

Balance or postural control is a generic term used to describe the dynamic process by which the body's position is maintained in equilibrium (1). Balance is greatest when the body's COM or COG is maintained over its BOS.

A limit of Stability (LoS) is the amount of maximum excursion an individual is able to intentionally cover in any direction without losing his/her balance or taking a step. For normal adults, the A-P sway limit is approximately 12^0. Lateral stability varies with the foot spacing & height; adults standing with 4 inches between the feet can sway approx 16^0 from side to side. Individuals with decreased LoS have an increased risk of falling when they shift their bodyweight forward, backward or from side to side & hence more prone to injuries (2).

Postural Control is a complex task involving anticipatory predictive reactions for the maintenance of one's balance through the harmonious interaction of the somatosensory, vestibular and visual systems, as internal models in the brain imitate the natural behavior of a given movement. Studies have shown that sight plays the major role in Postural Control and the absence of sight in blind individuals leads to impaired postural balance, resulting in poor balance during both static and dynamic tasks (3) .

Visual stimuli ensure creation of a surrounding reference system. On the basis of this system, information about balance deviations is analyzed and their corrections to prevent loss of body balance are possible. Visual impairment (VI) causes partial or total limitation of the use of the spatial reference system and precise correction of body alignment, thereby negatively affects the maintenance of body posture and balance (4)

Vision function is classified in 4 broad categories, according to the International Classification of Diseases -10 (Update and Revision 2006) and WHO:

1. Normal vision.
2. Moderate vision impairment.
3. Severe vision impairment.
4. Blindness.

Current standardized clinical balance assessment tools are directed at screening for balance problems and predicting fall risk, particularly in elderly people.These tools identify which patients may benefit from balance retraining, but they do not help therapists decide how to treat the underlying balance problems. Although many clinical tests are designed to test a single "balance system," balance control is very complex and involves many different underlying

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systems [5]. Balance Evaluation Systems Test (BESTest) has been developed based on a conceptual model of balance control in which 6 different systems or domains contribute to balance control. The BESTest is a 36-item clinical tool that evaluates the following systems: biomechanical constraints, stability limits and verticality, anticipatory postural adjustments, automatic postural responses, sensory organization, and stability in gait [6].

It is known that there is balance impairment in the blind when compared to the same age normal vision population. Absence of vision leads to numerous abnormal sensory & motor interactions that often limit the blind people in isolation [7]. But there is no clarity as to which domain or component of balance is the most affected. Hence the goal of this study was to target 6 different balance control systems.

Objectives of the study:

1. To compare the biomechanical constraints of balance in the sighted and visually impaired children with (BESTest).
2. To compare the stability limits in the sighted and visually impaired children with (BESTest)
3. To compare the postural responses in the sighted and visually impaired children with (BESTest)
4. To compare the anticipatory postural adjustments in the sighted and visually impaired children with (BESTest)
5. To compare the sensory orientation in the sighted and visually impaired children with (BESTest).
6. To compare the dynamic balance during gait in the sighted and visually impaired children with (BESTest).

Materials used were:
Measuring tape , Stop watch , Approximately 60 cm x 60 cm (2 X 2 ft) block of 4-inch, medium-density, Tempur® foam, 10 degree incline ramp (at least 2 x 2 ft) , Stair step, 15 cm (6 inches) in height , shoe boxes , 2.5 Kg (5-lb) free weight , Firm chair with arms , Masking tape.

Outcome measure:

Balance Evaluation Systems Test (BESTest)

Procedure:

A cross sectional study was done on 40 normal vision children with age 7 to 16yrs with age matched 40 blind school children selected by purposive sampling method from normal & blind schools . Those having any congenital and musculoskeletal, neurological or cardio –vascular conditions were excluded. The written consent was taken from school and / parents. The blind children & the normal children were divided into two separate groups. Baseline parameters were taken for both the groups. Both the groups were assessed for balance & scored on the BESTest. The scale has 6 components each was assessed separately for both groups. The data was then analyzed.

BALANCE ASSESSMENT USING BESTEST

FIG .1 – SECTION 1 (BIOMECHANICAL CONSTRAINTS

FIG.2- SECTION 2 (STABILITY LIMITS/VERTICALITY

FIG.3- SECTION 3 (ANTICIPATORY POSTURAL RESPONSES

FIG.4- SECTION 4 (REACTIVE)

FIG.5- SECTION 5 (SENSORY ORGANIZATION

FIG.6 – SECTION 6 (STABILITY IN GAIT)

Statistical analysis:

The data was analyzed using GraphPad Instat software. Repeated ANOVA test used for different components of BESTest scale in normal and blind children. (Bonferroni multiple comparisons). Unpaired T test used between the normal and blind children total score of the BESTest. Repeated ANOVA test used for different components of BESTest scale in total blind and partial blind children. (Bonferroni multiple comparisons).

Data analysis & results:-

A total of 80 subjects were taken – 40 normal & 40 blind school children. Repeated ANOVA test used for different components of BESTest scale in normal and blind children.(Bonferroni multiple comparisons). Unpaired T test used between the normal and blind children total score of the BESTest. Repeated ANOVA test used for different components of BESTest scale in total blind and partial blind children.(Bonferroni multiple comparisons). Mean age of the blind students was 11.78 years. Mean age of the normal school children was 10.93 years.

Table No 1:-Difference Between the Mean Values Of The Total Scores Of The Bestest Of Blind And The Normal School Children.

CATEGORY	TOTAL SCORE MEAN ± SD	t VALUE	P VALUE
Normal	92.12 ± 2.97	t value = 14.132 With 78 deg of freedom	P value is < 0.0001, considered extremely significant.
Blind	77.08 ± 6.04		

1. The above table shows that there is a difference in the mean total scores between the blind & normal children.
2. The mean total scores of the blind is lesser when compared to normal vision school children showing a balance deficit.

Table No 2:-Mean Values Of The 6 Different Components Of The Bestest Compared Between The Blind & Normal Vision School Children.

COMPARISION (NORMAL Vs BLIND STUDENTS)	MEAN DIFFERENCE	t VALUE	P value
SECTION1: BIOMECHANICAL CONSTRAINTS	10.89	6.34	< 0.001
SECTION 2 : STABILITY LIMITS / VERTICALITY	14.09	8.20	< 0.001
SECTION 3 : TRANSITIONS / ANTICIPATORY	22.66	13.19	< 0.001
SECTION 4 : REACTIVE	13.20	7.68	< 0.001
SECTION 5 :SENSORY NTATION	5.49	3.19	< 0.01
SECTION 6 : STABILITY IN GAIT	20.94	12.19	< 0.001

1. The above table shows that the blind children have lower score in all 6 components of BESTest.
2. The maximum difference/affection is seen in section 3 (transitions / anticipatory) & section 6 (stability in gait).
3. The minimum difference is seen in the section 5 (sensory organization).
4. The P Value Is < 0.0001 That Is Extremely Significant.

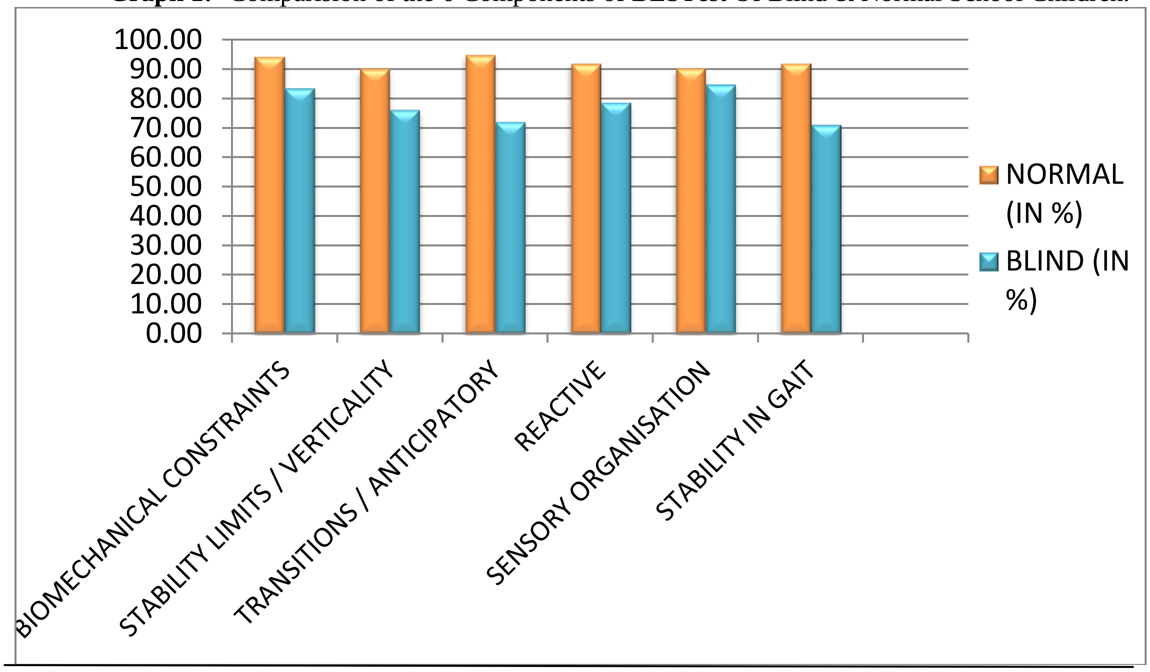
Table No 3:-Mean Values Of The 6 Different Components Of The Bestest Compared Between The Total Blind & Partial Blind School Children.

COMPARISION (TOTAL BLIND Vs PARTIAL BLIND)	MEAN DIFFERENCE	t VALUE	P value
SECTION 1 : BIOMECHANICAL CONSTRAINTS	5.065	1.895	> 0.05
SECTION 2 : STABILITY LIMITS / VERTICALITY	1.475	0.55	> 0.05
SECTION 3 : TRANSITIONS / ANTICIPATORY	7.200	2.69	< 0.05
SECTION 4 : REACTIVE	10.27	3.842	< 0.001

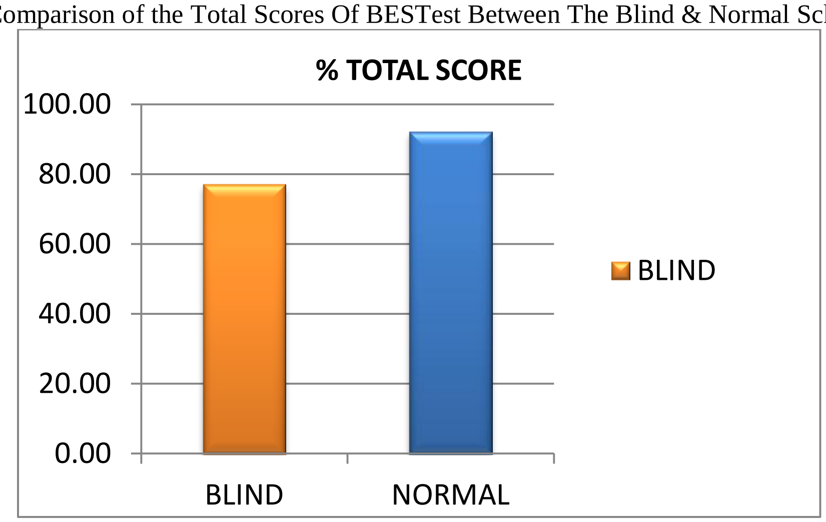
SECTION 5 :SENSORY ORIENTATION	4.335	1.622	> 0.05
SECTION 6 : STABILITY IN GAIT	13.05	4.88	< 0.001

1. The above table shows that there is more affection in the total blind as compared to partial blind children in all 6 components.
2. The mean difference is not very significant as compared to the mean differences of the values of BESTest between the normal & blind children.
3. The P Values Of Sections 1 , 2 , 5 Is > 0.05 Which Is Not Significant.
4. The P Values Of Sections 4 & 5 Is < 0.001 Which Is Considered Extremely Significant.

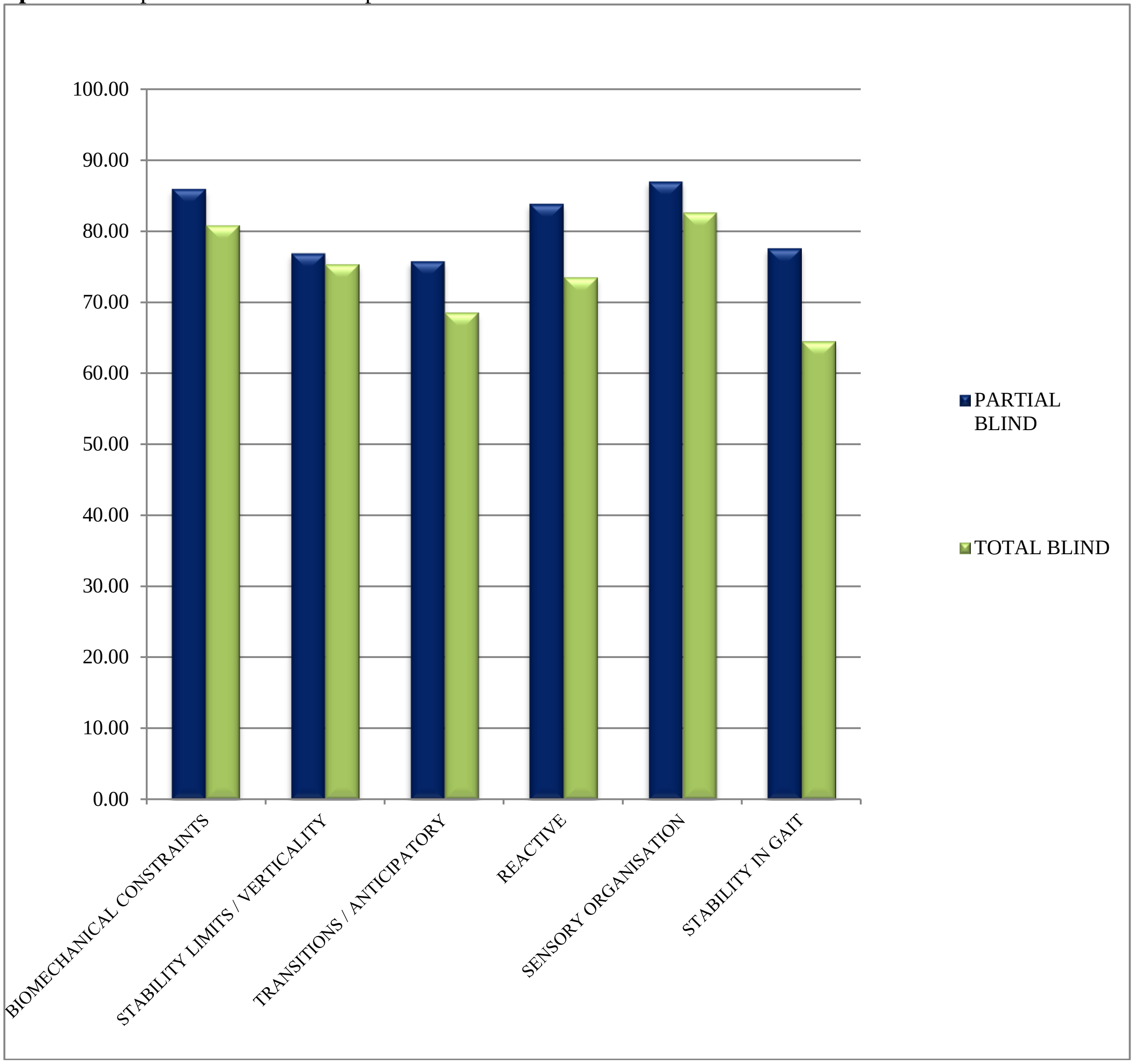
Graph 1:- Comparision of the 6 Components of BESTest Of Blind & Normal School Children.



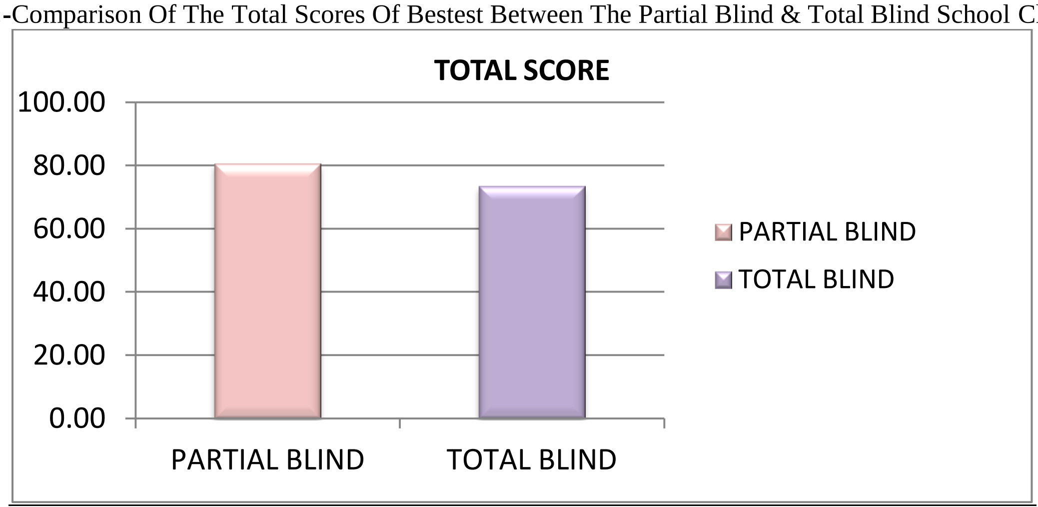
Graph 2:- Comparison of the Total Scores Of BESTest Between The Blind & Normal School Children



Graph 3:- Comparision of the 6 Components of Bestest Between the Partial Blind & Total Blind School Children.



Graph 4:-Comparison Of The Total Scores Of Bestest Between The Partial Blind & Total Blind School Children.



Discussion:-

Balance is the ability to maintain the body's center of mass over its base of support [9].Balance is achieved and maintained by a complex set of sensorimotor control systems that include sensory input from vision (sight), proprioception (touch), and the vestibular system (motion, equilibrium, spatial orientation) [10]. With increasing age, there is a progressive domination of the somatosensory and vestibular systems, with less reliance on visual orientation inputs [11]. Consistent with the "systems model of motor control," recent research has demonstrated how constraints, or deficits, in different underlying systems can impair balance [5]. BESTest has earlier been used to differentiate the different balance deficits in various conditions such as Parkinson's Disease, Stroke , etc as well as in elderly populations.Constraints on the biomechanical system, such as ankle or hip weakness and flexed postural alignment, limit the ability of frail elderly people and patients with Parkinson disease (PD) to use an ankle strategy or compensatory steps for postural recovery. Constraints on the limits of stability (that is, how far the body's center of mass can be moved over its base of support) and on verticality (that is, representation of gravitational upright), affected by sensory deficits or by stroke in the parietal cortex, may result in inflexible postural alignment or precarious body tilt. [5]

Constraints on anticipatory postural adjustments prior to voluntary movements depend on interaction of supplementary motor areas with the basal ganglia and brain-stem areas and result in instability during step initiation or during rapid arm movements while standing. Constraints on short, medium, and long proprioceptive feedback loops responsible for automatic postural responses to slips, trips, and pushes include late responses in patients with sensory neuropathy or multiple sclerosis, weak responses in patients with PD, and hypermetric responses in patients with cerebellar ataxia. [5]

Constraints on sensory integration for spatial orientation result in disorientation and instability in patients with deficits in pathways involving the vestibular system and sensory integrative areas of the temporoparietal cortex when the support surface or visual environments are moving.Constraints on dynamic balance during gait result from impaired coordination between spinal locomotor and brain-stem postural sensorimotor programs when the falling body's center of mass must be caught by a changing base of foot support. In addition, cognitive constraints on executive or attentional systems can compound constraints in the other systems because each underlying neural control system for balance control requires cortical attention. [5]

Although several separate neural systems underlie control of balance, each task may involve more than one system that interacts with others. For example, the task of tapping alternate feet onto a stair is placed in the "Anticipatory Postural Adjustments" system because it requires adequate anticipatory postural weight shifting from one leg to the other. However, it also requires an adequate base of support and strength in the hip abductors ("Biomechanical Constraints" system). Interactions among systems can be seen by how a single pathology, will likely affect several tasks. [5]

Posture has been referred to as a "psychosomatic affair", as its stability is the key to maintaining balance of the body. The visual system is one of the main sensory systems that enable the body to assess and process information about external factors, such as relative positions of body segments, and to adjust posture according to need. Absence of vision leads to deficiencies in posture due to inadequate interaction with the environment and affects normal patterns of gait and balance [7].

In normal subjects, stabilization of the head in space is a strategy to maintain equilibrium, both during natural movements like locomotion and complex dynamic equilibrium tasks. It seems that vision facilitates this phenomenon, probably because head stability provides both gaze stabilization and a reference for organizing the movement of the other segments. During the continuous movement of the platform, if vision is not available, subjects let the head go and re-reference their balance control on inputs from plantar cutaneous or multiple proprioceptive or labyrinth receptors, all elicited by the moving platform [12].

For blind subjects, half of the normal sensory intake of the brain is lost, disrupting the normal mechanism of neurological integration and disintegration, and preventing the formation of good postural habits [13].

Vision continuously provides information about location and the position of the body in space to the brain, and has an important role in the body's stabilization. In the absence of vision, postural deformities develop due to various interactions, which result in motor and neurological abnormalities [14].

Our study demonstrated reduced balance control in children with visual impairment in comparison to normal same age school children.

If we arrange the components of the BESTest in the order of most affected to least affected according to the values in Table.2:

Transitions / Anticipatory > Stability In Gait > Stability Limits / Verticality > Reactive > Biomechanical Constraints > Sensory Orientation.

This clearly reflects that theanticipatory postural adjustments & stability in gaitin the blind is the most affected when compared to normal school students. One of the reasons for this can be that for the adjusting postural responses, the vision which a major factor is controlling it is absent in the blind and hence the fear of fall accompanies. For gait our vision is the directing force which tells us about the direction, obstacles in between, & also the people around us. In the blind , they rely upon either the touch (of their cane) or any surrounding noises to lead them their way which makes them take longer to complete the given tasks as compared to normal vision school children.

Whereas surprisingly the component of sensory organizationis the least affected. This maybe because that the other cutaneous and proprioceptive receptors overpower and overshoot when the vision component is absent since so many years.

Limitations of study:

Only boys were included in this study. Classification of visual impairment of blind was not done.

Clinical implications & future scope of study:

Specific rehabilitation approaches can be designed for different balance deficits. The study can also compare the balance impairments between the genders.

Conclusion:-

Our findings suggest that there is affection of balance in the blind school children when compared to same age normal school children when assessed using the BESTest. The component of anticipatory postural adjustment & Stability in gait in the blind is the most affectedand the component of sensory organizationis theleast affected when compared to normal school children.

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