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Original Research Article

Inter- Rater and Intra- Rater Reliability of Limits of Stability Using Reaction Board Method in Young Healthy Population

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ABSTRACT

Balance control requires multiple system adjustment and coordination and is a necessity for daily activities. Due to its diverse nature of control to assess balance in a single parameter has been a problem as no one parameter describes its all component but Limit of stability (LOS) has been found to be more reliable by far. For this study a reaction board was used to test the limit of stability i.e. the maximum horizontal excursion an individual could perform in his/her base of support (BoS) just before falling. To apply this method of assessing balance in a clinical setting where force plate system affordability is not feasible the inter-rater and intra-rater reliability must be established for the same. For the purpose of study 10 healthy subjects were selected to test the inter-rater and intra-rater reliability at a week difference. The inter-rater reliability was found to have an acceptable reliability for anterior shift (0.78) and left lateral shift (0.78), good reliability for posterior shift (0.87) and poor reliability for right lateral shift (0.28).The intra-rater reliability was found to have good reliability for anterior shift (0.86) and posterior shift (0.82) and poor reliability for left lateral (0.35) and right lateral shift (0.44) and all the values are within 95% confidence interval with p= 0.05. Henceforth we conclude that reaction board can be used as a reliable tool to measure the anterior and posterior limits of stability of an individual.

Key words: Limit of stability (LOS), reaction board, inter-rater and intra-rater reliability

INTRODUCTION

"*We come into this world head first and go out feet first: in between it is all a matter of balance":- PAUL BOES*

Postural balance refers to the ability to stay upright within the base of support, or to recover equilibrium after external force has been applied. [1,2] Deterioration of balance has been considered as a dominant intrinsic cause of fall. [3]

Balance control involves maintenance of a position, postural adjustment prior to voluntary movement (anticipatory control) and reaction to external perturbation. It is a baseline necessity to carry out activities of daily living and the practice of physical and sport activities. The relationship between the COG and BOS is regulated by the postural control system. [3] Structurally, the postural control system has three components: the sensory input system, the central processing control system, and the effector system. [4] The central processing control system functions to assess and integrate sensory input from the visual, vestibular, and somato-sensory senses. The vestibular system provides information about the position of the head relative to gravity as well as information regarding the linear and angular acceleration of the head. [5,6] The somato-sensory system, including proprio-ceptive, cutaneous, and joint inputs, provides information concerning movement of body segments with reference to each other. The body's position in the environment is monitored by the visual system. Musculoskeletal responses are selected by the central processing control system and executed by the effector systems to adjust the COG position or the BOS. [2,7] These responses should be appropriate, in terms of timing, direction and magnitude, to the characteristics of the disturbance and the constraints of the surrounding environment.

The neuromuscular responses are necessary to guarantee, for example, that in the erect posture with the feet immobile, the vertical projection of the body's centre of gravity (CoG) remains within the base of support (polygon formed by the lateral part of the feet), providing stability and allowing the execution of a variety of movements with the upper segments of the body. The CoG (or CoM), in simple terms, is defined as the point of application of the resultant gravitational force on the body. [8] A concept associated with the base of support is the limit of stability, which expresses the proportion of this base of support that the subject is able to use remaining stable. In other words, the limits of stability express the functional base of support of an individual.

Mechanically, body balance conditions depend on the forces and torques applied on it. A body is in mechanical equilibrium when the sum of all the forces (F) and torques (M) that act on it equal to zero ($\Sigma F=0$ and $\Sigma M=0$). The forces acting on the body can be classified as external and internal forces. The most common external forces that act on the human body are the gravitational force over the whole body and the ground reaction force, which, during erect posture, acts on the feet. The internal forces can be physiological disturbances (for example, heartbeat and breathing) or perturbations created by the activation of the muscles necessary for the maintenance of posture and the performance of the body's own movements. [8,9] All these forces accelerate the human body in all the directions around its CoG continuously. Therefore, from the mechanical point of view, the human body is never in a condition of perfect equilibrium, because the forces acting on it are only temporarily zero. Thus, it is possible to state that the human body is constantly unbalanced, in a continuous search to keep the body in balance. If no force acts to nullify the effect of these perturbations, the body will not return to its initial position; then, depending on the intensity of the perturbation, a fall may occur. Under normal conditions in the quiet erect posture, the forces and torques are very small, resulting in small body sways. In a healthy adult, they are almost imperceptible. It is common to consider this condition, in an approximately correct form or balance and creates confusion between postural control and balance control. Due to this complex nature of postural control and balance, it becomes hard to assess it as a single entity or a single parameter.

Objective measures of balance are important to assist with differential diagnosis, to provide an indication of risk of fall, and for assessment of the effectiveness of treatment and training programs. The measurement of balance is important for prediction of fall risk and evaluation of effectiveness of balance-training programs in preventing falls.

Many researchers have used variety of methods both quantitative and qualitative to asses balance and not one has satisfied the various aspects of balance. In 2002, Riann M. Palmieri, Christopher D.ingersoll et al in their study of Center of pressure parameters used in the assessment of postural control concluded that there is no consensus in the literature as to which variable most accurately represents changes seen in postural control. Although changes in these variables enables us to detect changes in postural control, we still lack the knowledge of aspect of posture each parameters represent and further research is needed for the same. [10]

The use of scales as the Berg Balance Scale, [11] Timed Up-and-Go [12,13] Tinetti test, [14,15] Short Physical Performance Battery [16,17] Mini Balance Evaluation Systems Test, [17] Unified Balance Scale, [18] Functional Ambulation Classification, [19,20] and the Postural Assessment Scale for Stroke patients [11] are still a part of routine clinical assessment due to their availability and shorter duration of usage but these were mainly designed to evaluate older subjects' postural abilities as well as their risk of falling whereas there are only a few tests for subjects of young ages with pathologies affecting the balance. These practical tests are of interest to subjects whose postural abilities are very weak but they do not make it possible to carry out qualitative analyses of postural control, especially for young subjects with pathologies and only technology and instrumented tests offer this possibility. This also provides a gross indicator of postural control efficiency and performance capacity, decision making needs skill, as mostly are subjective.

For a more objective analysis different instruments have also been employed as kinetic devices as force platforms and kinematic devices as 3D motion analysis, electrogoniometer, EMG. [11] Force platforms are the most widely used devices in assessing postural function, among all these are considered to be the gold standard, with COP being the most widely measured parameter from which various variables can be calculated to assess postural function. [11] Force platforms are made of a dimensionally stable board under which load sensors are positioned. They can be incorporated in specific motorized or non motorized devices in order to generate instability. The high accuracy of the system has made it a gold standard but due to the high cost setup the availability and accessibility to such delicate and intricate is not possible in every healthcare department due to which our interest was caught on the use of a simple reaction board based on the principle of lever for assessing balance, owing to its simplicity of design and low cost setup

Reaction Board also known as the "moment table" [21] was at first proposed by Reynolds e Lovett in 1909 with the purpose of estimating the location of the CoG of the human body or the body parts [22] and immediately used in biomechanical and clinical applications up to the present days. It consists of a rectangular wooden-board supported at the ends by two knife edges horizontally leveled, one of them mounted on a scale, and the other end is considered the pivot point. Knowing the board's weight and length, along with the weight of the subject and the scale reading, the equilibrium conditions of a rigid body are applied to calculate the distance of the body CoG from the pivot point. The method also allows the estimation of the location of CoG relative to a reference point of the subject, provided its location on the board is known. It is based on the principle of levers.

Advantage: Low cost setup and the time taken is less to perform.

Disadvantage:

- Create human errors of calculations
- An oversimplification of the parameters
- Body's angular moment is not considered
- Only the translatory projections can be calculated unlike on force plates

But due to the Reaction Board's simplicity and low cost it drew our attention to use it as a clinical tool and establish it reliability to assess balance using LOS as a parameter.

Limits of stability; definition

The LOS test is used for the assessment of postural limits by assessing the degree to which an individual is able to lean in several directions while maintaining balance with a fixed base of support. The LOS performance variable, maximum excursion is based on COG movement and is expressed as a percentage of a theoretical limit of stability. [23] It may also be defined as the distance of shift a human body is able to move in various directions just before the fall occurs or the anticipatory control of balance control starts. LOS has been proven as a reliable parameter for assessing balance using force plates. Grzegorz Juras [2] et al in their study "evaluation of limits of stability balance test" concluded that measurement of the range of COP excursion, which is most commonly analyzed in such tests, showed to be quite reliable with ICC2 above 0.85. LOS test conducted along the standard procedure should be considered as a very useful method in clinical and research conditions and the specific parameters of the LOS test should be given more thorough insight. Feng Huo et al [3] in their study of "limits of stability and Postural sway in young and older people" demonstrated that the test-retest reliability of LOS measures were good (ICCs 0.70-0.92).

In clinical practice, the use of methods and equipment with reliable measures is indispensable, since unreliable measures can compromise evaluation and thus, lead to faulty intervention programs. Therefore, reliability studies in rehabilitation are necessary to ensure that measurement errors are reduced and to do the same the aim of our study is to test the inter-rater and intra-rater reliability of LOS using reaction board method so that it can be reliably examined and successfully applied to different populations and environments – clinical and laboratory. To the best of our knowledge, no studies have been done to assess the inter-rater and intra-rater reliability of LOS on the Reaction Board in healthy Indian population.

The hypothesis of our study is as follows;

- For inter-rater reliability

Null Hypothesis: there is no difference between the readings taken by the two testers at a gap of one week.

Alternative Hypothesis: there is a significant difference between the readings taken by the two testers at a gap of one week.

- For intra-rater reliability

Null Hypothesis: There is no difference between the readings taken the same tester at the gap of one week.

Alternative Hypothesis: There is a significant difference between the readings taken the same tester at the gap of one week.

MATERIALS AND METHODS

This study was carried out to test the inter-rater and intra-rater reliability of LOS using reaction board method in healthy population for the anterior, posterior, right and left side on 10 healthy students of Government Physiotherapy College Jamnagar chosen randomly. The study was carried out from October 2018 to November 2018 that is for a span of 1 month. A week's gap was kept for both inter-rater and intra-rater testing by the testers. The data analysis was done by a different assessor. Both the testers were qualified postgraduate students of physiotherapy in musculoskeletal conditions and were trained beforehand for the examination part of LOS using a Reaction Board. For inter-rater reliability the testers performed the LOS test on reaction board at a gap of a week, for intra-rater reliability, one individual tester performed the LOS test on reaction board at a gap of a week on the same subjects at the same time.

Inclusion criteria

- AGE: of any age able to stand and understand and obey the commands.
- No diagnosed medical condition at time of testing.
- Patient willing to participate in the survey

Exclusion criteria:

- Previously diagnosed medical condition.
- Musculoskeletal condition
- Deformities
- Subjects who are not able to comprehend and non-cooperative subjects

CALCULATION OF LIMIT OF STABILITY

How to construct a Reaction Board?

Materials required:

- Wooden plank (specifications is mentioned later in text)
- validated weighing scale (100/300kg with 50 gm error) (figure 1)

Figure 1 Weighing scale used to make the reaction board and measure the weight of subject

Materials required: To calculate the limits of stability

- Graph sheets or A2 white sheets (figure 2)
- Sketch pens (black, red and blue in colour shown in figure 2)
- 60 cm scale (figure 2)
- Notebook

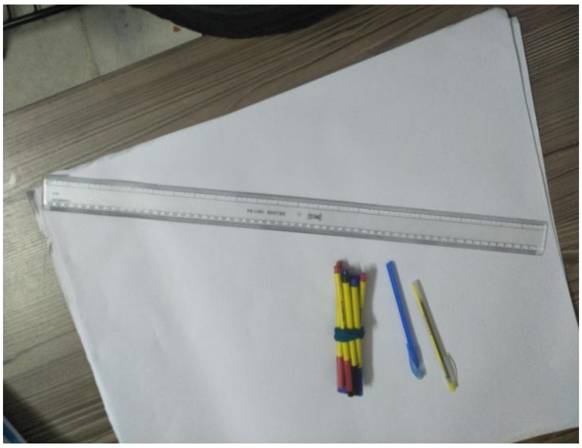


Figure 2 A2 white sheet, 60 cm scale, sketch pens, and pen required to calculate the limits of stability

REACTION BOARD; it's principle of calculation and working

The direct method of calculating the CG involves a device known as a reaction board. The reaction board consists of a long rigid board which is supported as each end on "knife edges", here modified by rectangular edges (figure 1).

Below one end of the board is a scale and the other end is simply elevated such that the board is level. Measurement of the CG location is based on the principle of static equilibrium in which the sum of all moments or torques acting on a system about a reference axis of rotation (A) equals zero (figure 3). When the reaction board is unloaded the equation of static equilibrium is

$\Sigma MA = 0$ (1)

The equation used to calculate the location of the CG relative to the reference axis is derived as follows:

$\Sigma = (R_1 d) - (w_b x_b) = 0$ (2)

Where, R1= equals the scale reading when the board is not loaded;

d = is the distance between the supporting edges (i.e., the moment arm of R1 with respect to axis A)

w_b = is the weight of the board;

x_b= is the distance from axis A to the center of gravity of the board (i.e., the moment arm of w_b with respect to axis A).

When a person assumes a prescribed position on the reaction board (see Figure 2), the equation of static equilibrium becomes:

$\Sigma MA = (R_2 d) - (Wx) - (wbxb) = 0$ (3)

Where, W = equals the person's body weight

R_2= reading on the weighing scale when the person is on the board

x = is the distance from axis A to the CG of the person's body (i.e., the moment arm of W with respect to axis A).

Rearranging equation 2, we can show that:

$(R_1 d) = (w_b x_b)$ (4)

Substituting ($R_1 d$) for (wbxb) in equation 3, the equation of static equilibrium when a person is in a prescribed position can be rewritten as:

$(R_2 d) - (Wx) - (R_1 d) = 0$ (5)

Finally, solving for x (i.e., the location of the CG with respect to axis A),

$$x = \frac{(R_2 - R_1)\,.d}{W} \quad (6)$$

Therefore, in the case of the reaction board technique shown, it is not necessary to measure the weight and location of the center of gravity of the board. The contribution of the weight of the board to the moments produced about axis A is accounted for by the scale reading taken from the system when the board is unloaded (R1).

The same principle will be used to calculate the limits of stability in anterior, posterior, right and left lateral directions by asking the subject to reach in each direction maximally and hold the position for 5 to 6 sec. This will help us to calculate the maximum horizontal excursion of COP by the subject.

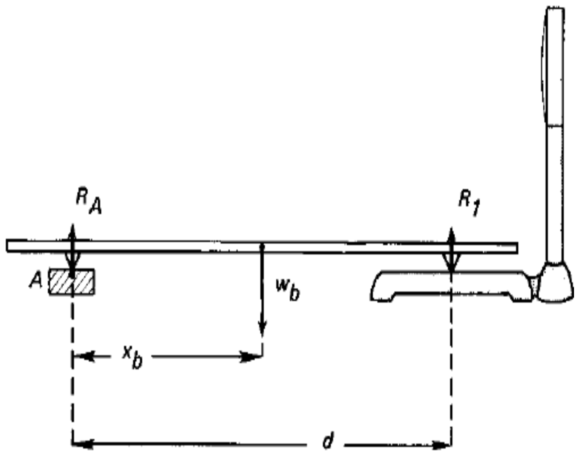


Figure 3: Principle of a reaction board.

Construction;

- A 39*30*1 inch wooden plank of edge heights 6 and 3 inches respectively is used as board of distance between the edges being 89 cm
- A Caltron scalex, an ISO: 9001: 2008 company (with an error of 50 – 100gm) weighing scale. It operates both on battery and electricity.

Determination of limits of stability:

1. Note down R_1 value (in kg) on the scale when the board is kept on the weighing machine
2. Take the graph paper or the white A2 white sheet and place the breadth side of the sheet along the edge of the board with the sheet touching the line marked F on the board (it is the point of axis of the board)
3. Aware the patient of all the commands that are to be used and the movement to be performed let them perform once on the level ground.
4. Ask the subject to stand facing the weighing scale in a comfortable position
5. Trace the border of the feet of the subject with a pen (figure 4)

Figure 4: draw the borders of the foot

6. Ask the subject to stand still on the board with the arms at side and note the reading (in kg) on scale. This reading will be solved for antero-postero neutral (reference value)
7. Command the patient to perform a forward reach with both the arms and hand straight at shoulder level, without bending from the trunk. " move as far as u can reach without lifting the feet or bending from the trunk, don't let the heel lift from its place, when u feel the heels lifting or trunk bending or strain on arm say STOP, try to hold the position for 5 to 6 sec, relax after the command". Repeat thrice and Reading (in kg) is then noted by the therapist.

This reading will be solved for anterior limit the subject could sway. (figure 5)

Figure 5 Subject performing forward reach on the reaction board

8. Ask the subject to come back to his/her and command for the backward reach with both the arms and hands raised till shoulder level without bending the trunk or folding the knees. " move as far as u can without lifting the feet or bending from the trunk, don't let the forefoot lift from its place, when u feel the forefoot lifting or trunk bending or strain on arm say STOP, try to hold the position for 5 to 6 sec, relax after the command". Repeat thrice and Reading (in kg) is then noted by the therapist. This reading will be solved for the posterior limit the subject could sway.(figure 6)

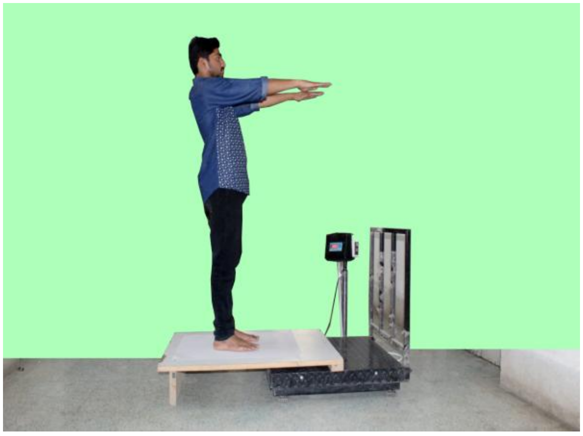


Figure 6 Subject performing backward reach

9. Ask the subject to come down, turn the sheet and place the length of the sheet along the edge of the board along the line marked as F
10. Ask the subject to put the feet on the previously traced feet (the subject's right hand will be facing the weighing scale this time) and help if the feet are not properly placed.
11. Let the subject calm and with the arms at side mark the reading (in kg) on the weighing scale. This reading will be solved for the Lateral Neutral (for the reference of the shifts).
12. Command the patient to raise the right arm to shoulder level and reach towards right without bending from the trunk or lifting the foot. " move as far as possible towards right as if shifting the weight of the body under one foot , don't bend from trunk, don't lift your feet, if u feel u r bending from trunk or putting too much stress on arms say STOP, hold the position for 5 to6 sec, and relax after the command". Repeat thrice and reading is noted by the therapist. This reading is solved for the right lateral limit. (figure 7)

Figure 7 subject performing right lateral reach

13. Likewise, command the patient to raise the left arm to shoulder level and reach towards left without bending from the trunk or lifting the foot. " move as far as possible towards left as if shifting the weight of the body under one foot , don't bend from trunk, don't lift your feet, if u feel u r bending from trunk or putting too much stress on arms say STOP, hold the position for 5 to6 sec, and relax after the command". Repeat

thrice and reading is noted by the therapist. This reading is solved for the left lateral limit.

14. Ask the subject to relax.

How to calculate limits of stability?

Using the equation (6) mentioned above we will calculate the 6 readings, two reference readings named as Antero-Postero Neutral and Lateral Neutral, the readings under STEPS section 6 and section 11 and four shifts i.e., anterior shift, posterior, right shift and left shift under STEPS section 7,8,12 and 13. The shifts will b obtained in Cm(s).

Equation 6, DISTANCE ($_{\text{cog from the axis}}$) = $[(R_2 - R_1)/ W] * d$

Where, R_2 = reading on scale when subject assumes the position on board

R_1 = reading of scale with board on weighing scale alone and no subject

W = weight of subject

D = the distance between the supporting edges

Now, proceed with the calculations the limits of stability in the four direction is obtained

CALCULATIONS AND PLOTTING THE GRAPH

1. Note the readings on weighing scale in kg. Choose the best of three readings for anterior, posterior, left and right reach. Before going for the reach test ask the subject to stand in a comfortable stance and still to note the reference values of Antero- posterior direction and lateral directions.
2. Mark that when the subject is reaching forward and towards the left, the maximum weight reading is noted, and while with the right and posterior reach the minimum weight reading is noted.
3. Put the values for each in the formula,

$$x = \frac{(R_2 - R_1) \cdot d}{W}$$

Where,

R_1= equals the scale reading when the board is not loaded;

d = is the distance between the supporting edges (i.e., the moment arm of R1 with respect to axis A) which is 89cm for our board.

R_2 = reading on scale when the person in on the board

W = weight of the subject

For e.g.(1) for SUB ID 436 of age 36 years, right hand dominancy, height 1.56 m, weight 54.1 kg and BMI 22.23kg/m^2,R_1 = 7.85 kg (reading with the board unloaded), d= 89 cm, R_2= 35.6 kg for best anterior reach, W = 54.1kg, now, solving for x, putting the values in the equation

$$x = \frac{(35.6 - 7.85) \cdot 89}{54.1}$$

We get x= 45.6 cm

Note: the reading given here is hypothetical for example purpose.

4. Solve for all the variables i.e. antero-posterior reference, lateral reference, anterior, posterior, and left and right shifts.
5. Now plot the reading on the sheet with the foot markers of the subject, here, SUB ID 436 is taken for the example with true values solved to plot the graph as follows from figure 10 to 14

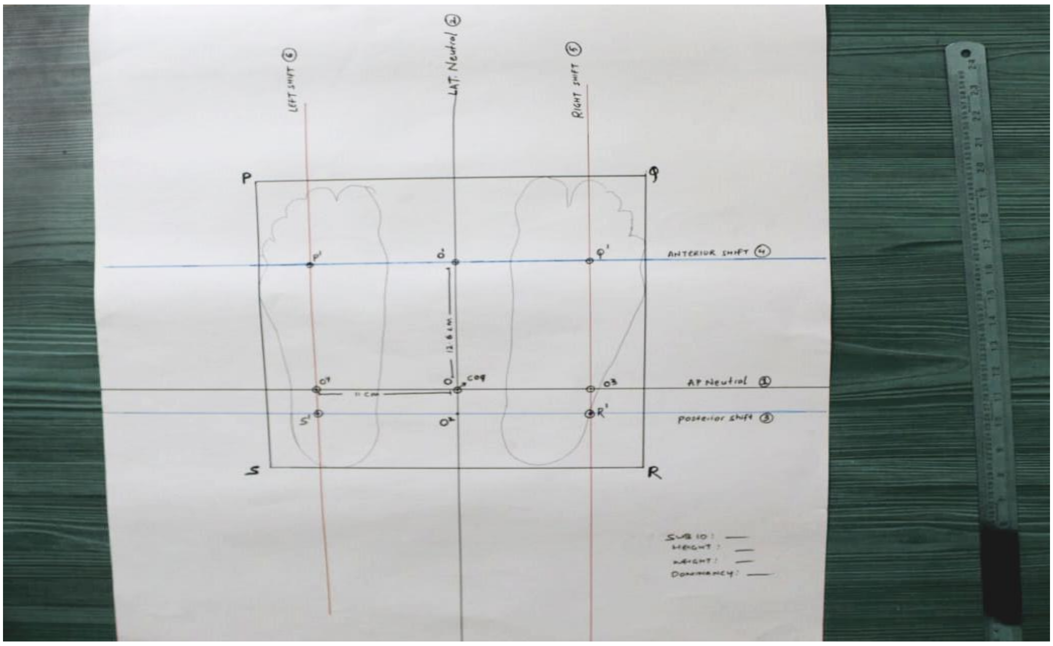
e.g. (2)

ID	AP NEUTRAL (cm)	LATERAL NEUTRAL (cm)	ANTERIOR SHIFT (cm)	POSTERIOR SHIFT (cm)	RIGHT LATERAL (cm)	LEFT LATERAL (cm)	AS	PS	RS	LS
436	26.8	21.7	36.8	23.5	15.6	29.6	10	3.3	6.1	7.9

- Mark the APN and anterior and posterior shift points and draw the APN, anterior and posterior shift lines (blue lines shows anterior and posterior shifts and black is the reference line in figure 8).
- Mark the lateral N, left and right shifts and draw the lateral neutral, left and right shift lines. Mark in figure 8 that the

black lines represent the reference lines with the horizontal line being the reference for anterior-posterior neutral, anterior and posterior shift lines and the vertical line called the lateral neutral, right and left shift lines.

6. In figure 8, BLUE Horizontal lines are the anterior and posterior shift lines and the RED vertical lines are the right and left shift lines. The two reference black line intersect at a point O, which is the position of COG for this subject, and is the reference point for the measurements of the excursion from COG or the limits of stability. The red lines and blue lines intersect to form a small polygon (square/rectangle), measure the sides and calculate the area of the small polygon P’Q’R‘S‘. (Figure 8)



7. Draw the base of support for the footmarks. Here, we have taken the big toe of the foot forward as the anterior margin, heel of the foot laid back as the posterior margin, and the lateral most markers of foot as the lateral margins. Draw the square or the rectangle that will be formed according to the natural stance of the subject. Measure the sides of the polygon (square/rectangle) so formed and calculate the area of the big polygon given as PQRS. Now measure the excursion to anterior, posterior, left and right from the COG given as anterior excursion or AS (point O to O^1), posterior excursion or PS (point O to O^2), right excursion or RS (point O to $O^{3'}$) and left excursion or LS (point O to O^4) from the figure 8 above using a scale.

8. Now measure the percentage excursion of anterior, posterior, left, right and area excursion. Given as;

%Anterior excursion = (Anterior shift/ total anterior length from point O) * 100

%Posterior excursion = (posterior shift/ total posterior length from point O) * 100

% Left excursion = (left shift/ total left length from point O) * 100

% Right excursion = (right shift/ total right length from point O) * 100

%Area excursion = (area of small polygon shift/ area of big polygon) * 100

For our subject in the example the percentage excursions are given as,

%Anterior excursion = 55 %
%Posterior excursion = 55%
% Left excursion = 52.23%
% Right excursion = 50%
%Area excursion = 46.2%

STATISTICAL ANALYSIS

All the data was analysed using Microsoft excel office 2008, the graph and tables were created using excel sheet and Microsoft office word 2008. The Shapiro-Wilk test for normalcy was used to check if the data is normally distributed and it was found to be normally distributed, significant at p=0.05. Pearson's correlation was used to find reliability and the student's paired t-test was used to test the hypothesis of the data. There were no significant differences found between the baseline characteristics of all the participants. (Table 1)

Table 1 baseline data of the 10 subjects

SUB ID	AGE	HEIGHT	WEIGHT	BMI
1	20	1.58	73.25	29.3
2	20	1.56	42.9	17.6
3	19	1.53	42.4	18.1
4	19	1.58	60.8	24.3
5	20	1.58	42.45	17
6	20	1.79	53.05	16.5
7	21	1.76	56	18
8	20	1.68	48.8	17.2
9	19	1.74	59.45	19.6
10	20	1.65	51	18.3

RESULTS

The inter-rater reliability for anterior shift is 0.78, posterior shift is 0.87, left lateral shift is 0.78 and right lateral shift is 0.28 and was found to have acceptable reliability for anterior shift and left lateral shift, good reliability for posterior shift and poor reliability for right lateral shift.

The intra-rater reliability for anterior shift is 0.86, posterior shift is 0.82, left lateral shift is 0.35 and right lateral shift is 0.44 and was found to have good reliability for anterior shift and posterior shift and poor reliability for left lateral and right lateral shift.

The Null Hypothesis for both inter-rater and intra-rater reliability was accepted i.e. no significant difference were found between the readings taken by the testers at a gap of 1 week at 95% confidence interval.

Table 2: inter-rater reliability of two testers at a gap of one week, day one is the first day and day 2 is the 8th day. The test of significance using student's paired t test was found to be non significant allowing us to accept our null hypothesis. r= pearson's correlation coefficient, t= t value from student's paired t test, significant at p=0.05, T1= tester 1, T2= tester 2.

SUB ID	Anterior shift T1	Anterior shift T2	Posterior shift T1	Posterior shift T2	Right shift T1	Right shift T2	Left shift T1	Left shift T2
1	10.8	11.2	1.9	1.4	10.2	9.7	10.9	10.85
2	7.2	7.5	3.5	2.7	5.8	6.1	5.5	6.9
3	7.6	7.2	2.5	2.3	8.9	7.5	7.9	8.4
4	6.5	8	3.5	4.6	8.2	10	10.9	8.1
5	12.7	9.5	3.2	2.4	7.3	8.9	7	6.6
6	11.8	9.8	3.9	4.2	8.7	8.5	8	6.1
7	11.2	11	3.7	2.6	9.2	7.9	8.4	8.4
8	8.8	8.9	5.8	5.1	10.1	8.4	10.5	9.9
9	10	10.4	5	4.3	7.9	9.7	8	7.3
10	7.9	7.7	2.1	1.6	9.2	6.4	5.9	6.3
pearson's correlation r	0.78		0.87		0.28		0.78	
t value	0.22		0.04		0.32		0.15	

Table 3; Intra-rater reliability at a gap of one week, day one is the first day and day 2 is the 8th day. The test of significance using student's paired t test was found to be non significant allowing us to accept our null hypothesis. r= pearson's correlation coefficient, t= t value from student's paired t test, significant at p=0.05.

SUB ID	Anterior Shift day 1	Anterior shift day 2	Posterior shift day 1	Posterior shift day 2	Right shift day 1	Right shift day 2	Left shift day 1	Left shift day2
1	10.2	10.6	2.2	2.9	7.4	9.6	7.6	8.2
2	10.9	10.1	2.7	3.3	6.1	7.2	6.9	4.9
3	8.5	8.2	3.3	2.3	5.9	5.4	5	7.8
4	8.3	7.5	4.6	5.6	10	9.8	8.1	9.8
5	9.3	8	3.4	3.1	7.8	7	5.7	7.4
6	12.3	13.5	4.6	4.2	10.2	6.1	6.9	8.5
7	10.5	12.2	2.6	1.8	5.4	6.2	6.7	8.6
8	6.9	7.8	8.7	7.5	7.5	11	8.4	9.3
9	10.6	9.7	4.6	4.6	8.8	9.3	8.7	8.7
10	8.7	9	4	7.4	7	7.9	5.7	6.2
r value	0.86		0.82		0.35		0.44	
t value	0.48		0.28		0.35		0.02	

DISCUSSION

Reliability is defined as the extent to which test scores are *not* affected by chance factors-by the luck of the draw. It is the extent to which the test taker's score does *not* depend on i.e. the specific day and time of the test (as compared with other possible days and times of testing), the specific questions or problems that were on the edition of the test that the test taker took (as compared with those on other editions), and the specific raters who rated the test taker's responses (if the scoring process involved any judgment). [(24)] In other words reliability is defined as the consistency of method or instrument that is used for a particular research or intervention. It is necessary so as to keep the data more useful for the purpose of study or evaluation.

In our study to find the inter-rater or intra-rater reliability for the LOS method to assess balance using the reaction board instrument we found that for inter-rater reliability the anterior shift, posterior shift and left lateral shift were found to have good to acceptable levels of reliability implying that for two different testers using this method except for the values of right lateral shift which was found to have poor reliability we could depend on the values of these 3 directions for the assessment. Juras et al in their study found LOS to be a reliable tool with an intra-session reliability of 0.9 in the anterior direction [(2)] while the other parameters did not show much reliability. For intra-rater reliability we found good reliability for the anterior shift and posterior shift and poor reliability for the left lateral and right lateral shifts which coincide with the study of Feng Huo et al who in their study found that ICC' s for sway in right and left directions were poor and that of anterior and posterior direction were either good or high. Previous studies have used functional reach test (FR) as an equivalent of LOS but was found to be different because of the specificity of the task in FR. [(25)] Hence, FR should not be used interchangeably with LOS. Previous studies discussed has used force plate systems which are more reliable as the chance of error is less in calculation and are considered gold standard but due to their high cost management may not be available at every primary health care centre. Balance as the age increases starts to decrease due the reasons mentioned above in the text and hence becomes a main area to be evaluated. Sophisticated machines add up to the cost and make it impossible to reach for the basic evaluations which led us to develop this system of valuation of balance.

This system not only provides the objective way to assess balance but is a low cost setup making it accessible to the therapist to undertake an important part of the assessment. The error that could possibly arise is as mentioned below;

- Overestimation of the readings, which can be reduced by taking 3 readings instead of one.
- Performance error due to lack of understanding of the method may arise which can be overcome by letting the subjects practice the task on level ground prior hand.
- Calculation errors may develop, which can be overcome using calculators or using excel sheets
- Obligatory errors like the effect of rotational torque component could not be reduced using this method as this method only helps us to calculate the horizontal excursions in different direction.

Some future implications include;

- Studying the normative ranges of LOS using the reaction board method in different directions.
- Establishing the values for diagonal excursions.
- To study the validity of the instrument.

CONCLUSION

We from our study conclude LOS to be a reliable tool for both inter-rater and intra-rater sessions using reaction board method and to commence the use of this method in the clinical setup to assess and evaluate balance.

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