

ORIGINAL ARTICLE

Intra and inter-rater reliability of the Libra Electronic Wobble Board for Dynamic balance Evaluation in Healthy young adults

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ABSTRACT

Dynamic postural control is an essential component in the assessment of motor performance tasks. Libra is an electronic oscillating balance board that is portable and user-friendly. It is designed for testing, rehabilitation, and training of proprioception, kinaesthesia and dynamic balance. However, its reliability has not yet been established. The aim of the present study was to investigate the inter-rater and intra-rater reliability of the Libra electronic balance board for assessing dynamic balance in young adults. Fifty-seven (57) young adults aged 18–24 years (31 females and 26 males; mean age  $19.9 \pm 1.3$  years; mean height  $161.5 \pm 11.2$  cm; mean weight  $56.2 \pm 12.8$  kg) participated in study. Balance tests were performed in two planes—anteroposterior and mediolateral. Each participant completed three trials after two practice attempts, each lasting 30 seconds with a 60-second rest interval. The global index was used to assess internal consistency. Data for inter-rater reliability were collected by three raters, while one rater collected data on three different days under identical conditions for intra-rater reliability. The stability index showed a good inter-rater reliability in both AP (ICC = 0.785) and ML (ICC=0.802) directions. Intra-rater reliability was moderate for both AP (ICC=0.702) and ML (ICC=0.697) planes. These results demonstrate that the libra balance board yields consistent and reproducible dynamic balance measurements. The Libra balance board demonstrated excellent inter-rater and intra-rater reliability for both anteroposterior and mediolateral planes in assessing dynamic balance.

**Keywords:** Postural balance, reliability, Proprioception, Balance board, Young adult, Postural control, Libra balance board

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INTRODUCTION

Balance is the integral component of motor performance tasks (1). Static and dynamic balance are two distinct types of balance. Static balance refers to the ability to maintain body's centre of gravity (CoG) within its base of support (BoS) while maintaining stationary position either standing or sitting (2,3). Dynamic balance is the ability to maintain body's balance when CoG is projected outside the BoS or while CoG and the BoS are not fixed(4) or maintaining postural equilibrium while body segments are in motion (5). Balance control requires integrated and coordinated use of proprioceptive, visual, tactile and vestibular systems to control body's CoG displacement over its BoS by producing sensory-motor strategies. (4,6) In comparison to a stable BoS, maintaining an upright stance on an unstable surface is more challenging and thus requires higher postural control mechanisms. In order to quickly and effectively adapt the position to a changing environment, it is necessary to utilize afferent information, the inflow of which is considerably constrained by all sensory inputs (7). A balance platform (seesaw) is an illustration of a tool that produces these circumstances. On unstable surfaces, individuals use different postural strategies depending on the direction and magnitude of platform tilt. In healthy individuals one-third uses the hip postural strategy, one-third uses the ankle strategy, and And one third on mixed strategy when balancing on unstable platform (7,8). There are various methods to test dynamic balance, ranging from observational assessments of an individual's ability to maintain sitting or standing postures on unstable surfaces such as a Swiss ball, foam, wobble board, or during bouncing on a mini trampoline (8); however,

such observational methods are largely subjective and do not provide quantitative measures of balance performance. The gold standard for evaluating balance performance is the measurement of centre of pressure (CoP) sway using force platforms, but these laboratory-based assessments are expensive, time-consuming, and require specialized infrastructure and trained personnel, thereby limiting their feasibility for large-scale assessments and routine clinical application (4,9). It has been shown that functional tests such as Y Balance Test (YBT) and Star Excursion Balance Test (SEBT) have wide spread acceptance as they are valid and reliable measure to evaluate the dynamic balance(10,11) and best tool to detect possible lower-extremity impairments(12) and predict injuries(13). But both YBT and SEBT are performed on stable surfaces and therefore do not challenge sensory system or compensatory strategies. Equipment with controlled instability can quantify performance during dynamic destabilization in different directions. Although the functional tests are also used to evaluate neuromuscular control, they are performed on the stable surface unlike the unstable platforms such as Libra which measures dynamic balance for the Mediolateral (ML) or Anteroposterior (AP) tilt from  $-15^{\circ}$  to  $+15^{\circ}$  to an accuracy of  $1^{\circ}$ (14,15). Libra is an Electronic Oscillating Balance Board with variable radius designed to improve balance and stimulate the proprioceptive system. It is a fundamental device for testing, rehabilitation and training proprioception and kinesthesia which is manufactured by EasyTech s.r.l. Borgo San Lorenzo, Italy (Dimensions: 420x430x65 mm, Weight: 3.5 Kg, Maximum patient's weight: 100 Kg, Movement range:  $-15^{\circ}$  to  $+15^{\circ}$ , Maximum measurement error: 0.2 degrees) in 2019. This software provides feedback and allows one to adjust the instability so it is useful device for testing and training.

**Need of study:** Despite the growing use of balance boards assessment rehabilitation and performance training, the reliability of the Libra electronic balance board had not been scientifically validated prior to this study. Existing tools such as force platforms (gold standard) and functional tests (e.g., Y-Balance Test, Star Excursion Balance Test) have following remarkable limitations:

- Expensive, non-portable, require considerable time and expertise
- Performed on stable surfaces, not reflecting true dynamic balance.

The Libra system is portable, relatively cost effective with built in sensors, and capable of quantifying balance parameters. Therefore, if proven reliable, it could bridge the gap of costly systems, enable objective, large scale balance assessment in clinical and field settings.No peer reviewed evidence is available on intra and inter-rater reliability of LIBRA system. Therefore present study addressed a critical gap by evaluating the consistency and reproducibility of dynamic balance assessment on consistent and reproducible assessment of dynamic balance.

To determine the inter-rater and intra-rater reliability of the Libra electronic balance board for assessing dynamic balance in young adults.

## MATERIAL AND METHODS

The present study adopted a test-retest reliability design and was conducted at P P Savani University, Surat, over a duration of six months. The target population comprised healthy young adults aged 18-24 years, including both males and females, with no prior exposure to balance, proprioceptive or strength training. A total sample of 57 participants (31 females and 26 males) was recruited using a convenient sampling method. Participants aged between 18 and 24 years with body weight less than 100 kg and no previous balance proprioceptive or strength training were included in the study. Individuals with any musculoskeletal or neurological injuries or diseases, those who had been taking medications that could affect standing balance within six months prior to participation and individuals with limb length discrepancy were excluded. Data were collected using the Libra Electronic Oscillating balance board (EasyTech s.r.l. Borgo San Lorenzo, Italy)

### PROCEDURE

A convenience sample of 57 subjects between 18 to 24 years (41 female and 16 male; mean ages  $19.9 \pm 1.3$  years; mean height  $161.5 \pm 11.2$  cms; mean weight  $56.2 \pm 12.8$  kg) volunteered to participate in the study.

A convenience sample of 57 young adults (41 females and 16 males) aged 18–24 years volunteered to participate in the study. Participant characteristics were as follows: age,  $19.9 \pm 1.3$  years; height,  $161.5 \pm 11.2$  cm; body mass,  $56.2 \pm 12.8$  kg (mean  $\pm$  SD). These data are summarized in Table 1.

Prior to the commencement of testing sessions, anthropometric measurements (height, body mass, and leg length) were obtained for each participant. Leg length was assessed using a flexible tape measure as the distance from the anterior superior iliac spine to the most distal aspect of the medial malleolus, with the participant in the supine position (16).

Table 1: Anthropometric Characteristics of Study Participants

	Female (n=31)	Male (n=26)
Age (years)	19.85 ± 1.24	19.84 ± 1.39
Weight (kg)	54.32 ± 12.06	61.19 ± 12.59
Height (cms)	157.29 ± 9.60	172.44 ± 6.80
BMI (kgs/m <sup>2</sup> )	22.06 ± 5.08	20.48 ± 3.47
Right Dominance	28	23
Left Dominance	3	3
Limb Length (cms)	86.27 ± 4.32	93.42 ± 4.76

BMI= Body Mass Index

Testing was conducted by three trained physiotherapists in a quiet, well-lit, temperature-controlled room to minimize external distractions. During each experimental session, the Libra balance board was interfaced with a computer via proprietary software and calibrated according to the manufacturer's instructions



Figure 1: Experimental Setup for the Libra Balance Assessment

The distance between computer screen and libra board was 1.5 m for each trial. The setting of Libra board used for this study has 3 degrees of difficulty in its setting i.e. 48cm (easy), 24cm (moderate)(17), 10cm (hard)(18). In this study it was set as 24 cm with level of difficulty 5 on the scale of 1-10; 1 being the easiest and 10 being the hardest. The boundaries of the motion marker and target zone were kept standard for all the subjects during each trial. Subjects were asked to stand barefoot (to avoid any balance and stability provided by shoes) on the Libra board in a double leg stance position with feet 20 cm apart for Anteroposterior(AP) direction and 15 cm for Mediolateral(ML) direction (19), by adopting a comfortable position, knee slightly extended (to exclude the effects of the knee joint on maintaining balance(14)). They were asked to focus on the motion marker displayed on the monitor (resolution = 1024\*768 pixel) in front of them with the aim to keep the board flat (0° tilt) as still as possible and for as long as possible within the recording period of 30 seconds. 2 practice trials were given to each participant to get familiarize with the device. The balance test was performed in each plane [ML and AP (1<sup>st</sup> ML and then AP plane)] and 3 trials was conducted after 2 practice trials with each position held for 30 s for double limb test(14). Rest intervals between successive attempts was set at 60 s. (14)

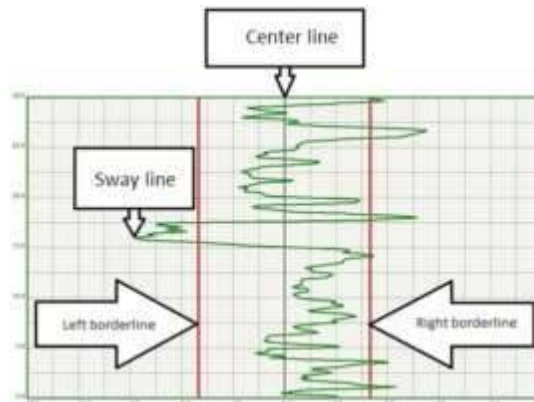


Figure 2: Representative Stabilogram Displaying Sway Line Amplitude Relative to Center and Boundary Limits

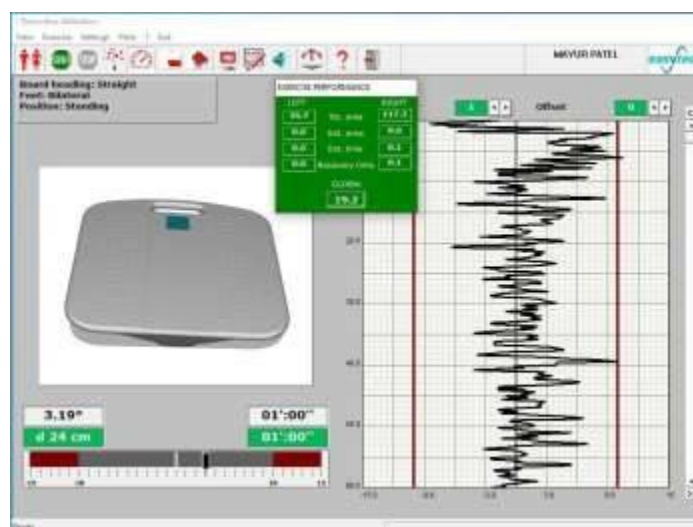


Figure 3: Screenshot of the Libra Software Interface During Dynamic Balance Testing

The Easy Tech 2.2-001-2.0 software processes the data obtained from the platform, determining the angular change in its position with time and calculates 4 stability parameters, separately for lateral deflections (ML) in the frontal plane and those anterior posterior (AP) in the sagittal plane (7) registered during the 30-s trial:

**Total area**- the sum of the area, the curve remains in the profile i.e. the motion marker remains between the marked/pre-set level of difficulty towards right and left side.

**External area**- the sum of the area, the curve remains out of the profile i.e. out of the marked/pre-set level of difficulty towards right and left side.

**External time**- the sum of the times, the curve remains out of the profile i.e. out of the marked/pre-set level of difficulty towards right and left side.

**Recovery time**- the longest individual time when the subject remained outside the area of pre-set level of difficulty.

**Global index (GI)/ Stability index (SI)**—a weighted measure of the variables described for above calculated parameters on a relative 100-point scale which indicates that the lower the score the better functional balance and is assessed in terms of poor, weak, average, good, excellent.

In this study, global index (GI) is used to measure the internal consistency of inter- and intra rater reliability which is in arbitrary units. The mean result of the 3 trials was considered for further analysis.

**INTER-RATER RELIABILITY, (20)** To assess inter-rater reliability and minimize measurement error, the three raters (trained physiotherapists) received comprehensive training and standardized instructions on the use of the Libra balance board prior to the study. Data were collected from the same participants by rater 1 on day 1, rater 2 on day 3, and rater 3 on day 5. Each rater provided consistent, pre-scripted verbal instructions to participants, demonstrated the required maneuvers, ensured participant safety through guarding, and allowed two practice trials before recording measurements. To prevent

information exchange that could influence ratings, raters did not communicate with one another during data collection. Every effort was made to maintain consistency across sessions, including conducting all testing in the same area and ensuring participants wore similar clothing

**INTRA-RATER RELIABILITY, (20)** To assess intra-rater reliability and minimize measurement error, the designated rater (a trained physiotherapist) received comprehensive training and standardized instructions on the use of the Libra balance board prior to the study. Data were collected from the same participants by rater 1 on days 1, 3, and 5. The rater provided consistent, pre-scripted verbal instructions to participants, demonstrated the required maneuvers, ensured participant safety through guarding, and allowed two practice trials before recording measurements. Every effort was made to maintain consistency across sessions, including conducting all testing in the same area and ensuring participants wore similar clothing.

## RESULT AND DISCUSSION

Intraclass Correlation Coefficient (ICC)

Inter-rater and intra-rater reliability were evaluated using the ICC(2,1) and ICC(2,k) models, based on a two-way random-effects model with absolute agreement, as recommended for clinical measurement studies.

Interpretation Criteria (20)

- < 0.50 – Poor reliability
- 0.50–0.75 – Moderate reliability
- 0.75–0.90 – Good reliability
- 0.90 – Excellent reliability

Table 2: Inter-rater and Intra-rater Reliability of the Libra Balance Board (ICC Values)

Direction	Raters Included	Reliability	ICC (2,1)	Mean Stability Index	SD (Overall)	Interpretation
AP	R1, R2, R3	Inter rater	0.785	11.18	3.41	Good Reliability
ML	R1, R2, R3	Inter rater	0.802	11.24	3.36	Good Reliability
AP	R1, R1, R1	Intra rater	0.702	10.33	3.48	Moderate Reliability
ML	R1, R1, R1	Intra rates	0.697	10.51	3.44	Moderate Reliability

Inter-rater reliability for the Stability Index was good, with ICC(2,1) values of 0.785 (95% CI: [insert if available]) in the antero-posterior (AP) direction and 0.802 (95% CI: [insert if available]) in the medio-lateral (ML) direction. Intra-rater reliability was moderate, with ICC values of 0.702 (95% CI: [insert if available]) in the AP direction and 0.697 (95% CI: [insert if available]) in the ML direction. These results indicate that measurements obtained using the Libra balance board system demonstrate good consistency across different raters but only moderate repeatability within the same rater. Consequently, intra-rater measurements exhibit slightly greater variability and should be interpreted with caution.

## DISCUSSION

A reliable and valid instrument for assessing dynamic balance offers substantial clinical utility, particularly for patients with musculoskeletal or neurological impairments. The present study aimed to evaluate the inter-rater and intra-rater reliability of the Libra electronic balance board (Easy Tech) for dynamic balance assessment in young adults, with primary findings indicating good inter-rater reliability and moderate intra-rater reliability. Specifically, this investigation examined the inter-rater and intra-rater reliability of the Stability Index in both the antero-posterior (AP) and medio-lateral (ML) directions. Inter-rater reliability was good in both directions, with ICC(2,1) values of 0.785 for the AP direction and 0.802 for the ML direction. In accordance with the guidelines proposed by Koo and Li (20), ICC values in the range of 0.75–0.90 denote good reliability, indicating that the measurement protocol produces consistent and comparable outcomes across different examiners. This high level of agreement among raters underscores the robustness of the assessment procedure and supports the use of the Libra balance board in clinical or research settings involving multiple evaluators. In contrast, intra-rater reliability was lower, with ICC values of 0.702 for the antero-posterior (AP) direction and 0.697 for the medio-lateral (ML) direction, corresponding to moderate reliability. These findings indicate that, although individual raters achieved acceptable measurement reproducibility across sessions, some variability persisted. Potential contributors to this variability include day-to-day biological fluctuations in postural control, participant fatigue, shifts in attention or motivation between sessions, or subtle inconsistencies in the rater's participant positioning, guarding, or verbal cueing despite standardization efforts. Moderate intra-rater reliability is frequently

observed in dynamic balance assessments, attributable to the inherent variability of human postural responses. Notably, inter-rater reliability exceeded intra-rater reliability, suggesting greater measurement consistency when the protocol was administered by different examiners than when repeated by the same examiner over time. This pattern implies that the standardized testing procedure was effectively implemented across raters, enabling reproducible outcomes despite examiner differences, whereas repeated assessments by a single rater may have been more susceptible to subtle temporal or contextual influences. The minor differences observed between AP and ML directions further suggest direction-specific characteristics in postural control, consistent with prior literature reporting greater variability in one plane over the other during dynamic stability tasks. The calculated Standard Error of Measurement (SEM) and Minimal Detectable Change (MDC95) provide further insight into measurement precision. MDC values ranging from approximately 4.6 to 5.4 units indicate that changes smaller than this range may reflect measurement error rather than true change in performance. These values are clinically relevant for differentiating between natural variability and meaningful improvement in balance training or rehabilitation programs. Overall, the study supports the use of the Stability Index as a reliable tool for assessing dynamic postural control, particularly when multiple trained raters are involved. However, clinicians and researchers should consider the moderate intra-rater reliability and MDC values when interpreting small changes over time. Future studies may explore protocol refinements, increased examiner training, or larger sample sizes to further improve measurement consistency. The results are also in line with the previous study by Domenico (21), who conducted pilot study to check the repeatability of balance tests carried out on LIBRA platform and found out that three consecutive trials performed after the second one were sufficient in order to obtain a reliable mean value. The results of this study suggests that instrumented portable wobble boards such as LIBRA could be considered of giving more precise values for the dynamic balance performance by giving the time spent in the area out of the target zone, total area spent in the right external area as well as in the left external area and the recovery time of how quickly the subject's able to come back in the target zone after deviating out of it hence evaluating capacity to maintain and restore the state of dynamic balance. Many authors believe that the results obtained on balance platforms not only determine the level of postural stability in individuals, but that the speed of adaptation to the changing circumstances of an unstable ground such as force platform is a key of the individual's level of coordination abilities(22,23). Although the present study evaluated only the inter-rater and intra-rater reliability of the Libra Easy Tech balance board for dynamic balance assessment, few studies in the existing literature have employed this device for evaluative purposes; most have instead utilized it primarily for balance training interventions. Direct comparisons with prior research are challenging, as other investigations have assessed dynamic balance using alternative devices, such as the Nintendo Wii Balance Board or computerized wobble boards. To our knowledge, this is the first study to examine the inter-rater and intra-rater reliability of the Libra balance board specifically for dynamic balance evaluation.

## **CONCLUSION**

This study demonstrated that the Stability Index provides good inter-rater reliability in both the antero-posterior (AP) and medio-lateral (ML) directions, indicating that the measurement protocol can be consistently applied by different examiners. In contrast, intra-rater reliability was moderate, suggesting that repeated assessments by the same rater may show greater variability due to inherent fluctuations in postural control or procedural factors. Overall, the findings support the Stability Index as a reliable tool for evaluating dynamic postural stability, particularly in multi-rater settings. However, caution is advised when interpreting small changes over time, and future research should aim to refine testing protocols to enhance intra-rater consistency.

## **LIMITATIONS**

- Several limitations of the present study should be acknowledged.
- First, dynamic balance was assessed exclusively in a double-limb stance; other challenging positions, such as single-limb stance, were not included. Future investigations should incorporate a broader range of stances to more comprehensively evaluate the Libra balance board's reliability across varying levels of task difficulty.
  - Second, the sample comprised solely healthy young adults without balance impairments. Consequently, the generalizability of these findings to clinical populations—such as individuals with neurological disorders, musculoskeletal pathologies, or other conditions affecting postural control—remains unknown. Additional studies in diverse patient groups are warranted to examine potential differences in reliability and to establish the utility of the Libra platform for dynamic balance assessment in clinical

contexts.

- Third, visual feedback was provided via a computer screen display during testing, which may have augmented participants' balance performance through enhanced proprioceptive and motivational cues. To elucidate the influence of this modality on weight-bearing balance tasks, future research should systematically compare conditions with and without visual feedback, or explore alternative feedback modalities.

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## **COMPLIANCE WITH ETHICAL STANDARDS CONFLICT OF INTEREST**

The authors declare that there is no conflict of interest regarding the publication of this paper. The study was conducted independently without any influence from commercial, financial, or personal affiliations that could affect the objectivity or integrity of the research.

## **ETHICS STATEMENT**

The study was approved by the Institutional Ethics Committee of P P Savani University PERC/PPSU/23/3A/15 dated 27/03/2024. All procedures performed in this study were in accordance with the ethical standards of the institutional research committee

## **INFORMED CONSENT**

Informed consent was obtained from all individual participants included in the study. Participants were informed about the study objectives, procedures, and their right to withdraw at any time without any consequence. The confidentiality and privacy of all participants were strictly maintained.

## **AUTHOR'S CONTRIBUTION**

Dr. Bindesh Patel was responsible for the conceptualization, study design, data collection, statistical analysis, interpretation of results, manuscript drafting, and final approval of the version to be published. Dr. Neeta Vyas provided primary supervision, conceptual guidance, critical review, and expert inputs during the design and interpretation stages of the study. Dr. Anila Paul contributed through co-supervision, assistance in data interpretation, methodological guidance, and review of the manuscript. All authors have read and approved the final version of the manuscript and agree to be accountable for the integrity and accuracy of the work.

## **DATA AVAILABILITY STATEMENT**

All data generated or analyzed during this study are included in this published article and its supplementary files.

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