

“INTER AND INTRA-RATER DIFFERENCES IN THE EXTENT OF LEAN RELEASE AND ITS INFLUENCE ON FORWARD-STEPPING CHARACTERISTICS.”

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ABSTRACT

BACKGROUND: Forward Stepping is the immediate response when faced with an external destabilizing perturbations leading to fall and loss of independence. Unique bio mechanical features and stepping characteristics are seen in forward stepping. This study aim to understand the inter and intra-rater differences in terms of spatio-temporal parameters of stepping reaction to the forward stepping characteristics evoked by a release from lean methods of reactive postural control assessment in healthy young adults so that the results obtained would be useful for making a proper balance evaluation.

METHODOLOGY: Thirty healthy young adults aged between 18 and 26 years, without any history of musculoskeletal injuries recruited for this observational study. Reactive forward stepping evaluation was performed using the Balance Evaluation System Test. Video recording of the test procedures were done, and the spatio-temporal parameters of the forward-stepping reactions such as Lean angle, FST, FSD, BRD and Number of steps were measured using “TRACKER” software.

RESULTS: Intra-rater ICC shows reproducibility of lean angle modulation. There were differences in FST, FSD, BRD. However, it did not reach statistical significance.

CONCLUSION: There is a consistency in the first step time and length, which were only within acceptable limits in Intra-rater performance when compared to Inter-rater performance. By enhancing physiotherapists' skills, this BESTest tool can be implemented in clinical practice for balance evaluation and determining treatment protocol for balance impairments.

KEY WORDS: Reactive postural control, Reactive forward stepping, Balance Evaluation System Test, waist belt

INTRODUCTION

Falls occurs as a result of loss of balance and can cause severe physical impairments and disabilities, resulting in a loss of independence (1). A loss of balance in which an individual's capacity to maintain their center of mass (COM) without their base of support (BOS) when faced with an external destabilizing perturbation (2). In our daily living activities, we will experience different types of perturbations while sitting, standing and walking those destabilizing forces helps us to prevent a fall (3). That is usually managed by making compensatory reactive postural responses, which occurs rapidly after the onset of postural disturbance (4). Compensatory reactive postural responses act much faster than a voluntary movement (5). These reactions occur quickly due to integration of the signals from the Somatosensory, vestibular, musculoskeletal and central nervous system to maintain balance and to prevent a fall (6-7). There are two different types of strategies in reactive postural control, referred as (a) fixed support strategies -ankle and hip strategy, are important for maintaining equilibrium (b) change in support strategies-stepping strategy, when the COM is situated within the BOS, compensatory stepping is initiated to prevent a fall (8,9). Stepping strategy is the immediate response seen in individuals in static stance and while walking to avoid a fall after a perturbation from all the directions (2).

There are various assessment strategies for reactive postural control that are very difficult to assess, at the same time it is least examined component like balance evaluation system tests, waist pulls and surface translation, but the destabilizing forces or perturbations in each of the assessment methods are different (10,11,12). One of the commonly used assessment methods for forward stepping is by suddenly releasing a cable that was supporting the subject in a forward-lean positional, which tends to involve relatively large initial steps (13). Feet alignment and vision have an influence on maximum forward lean leads to forward stepping, causing a single step or the rapid step to regain balance during forward fall (14,15).

Even though in clinical setting therapist use BESTest as it is the gold standard approach for evaluating balance, but it has its own limitations and now days several approaches are being developed, e.g.,

perturbation (lean and release) applied in different directions, intensities, time interval and in safe conditions which resembles more realistic events as in our daily life (16)

As the lean angle can vary, the instruction for compensatory forward stepping in the BESTest postural control is constructed in a way allowing examiners the flexibility in determining lean angle. The appropriate lean of an individual and release angle of the examiner is not mentioned. To determine an individual's optimal capacity to react to destabilizing situations and to prevent a fall, it is ideal for the test to resemble real life experience.

Training and demonstration are necessary for safety and excellent intra (between the tester) and inter-rater (among the tester) reliability in clinical practice, particularly the lean and release method, but lack of instant access to technology limits its application

This study aimed to -

1. whether the outcome could be statistically significant, and the results obtained have any clinical importance or not

2. To observe the spatio-temporal parameters of reactive forward stepping to a lean and release type of perturbation

3. Compare these stepping parameters like LEAN ANGLE, FST, FSD, BRD

INTRA RATER - 3 TRIAL * 30 SUBJECTS,

INTER RATER - 30 SUBJECTS * 5 THERAPIST

METHODOLOGY

This an observational study with thirty healthy young adults aged between (18 – 26) years of both genders, who were physically and mentally healthy are screened for inclusion in this study. Healthy Young adults without any recent surgical history, musculoskeletal injuries, cardiorespiratory and neurological problems were included in the study. The duration of study is 4 months, and Samples are recruited from students of Sri Ramachandra Faculty of Physiotherapy

Details of the study were explained to those who met the inclusion criteria, informed consent was obtained from the willing participants. All the participants are to be assessed with evaluation strategies-Balance Evaluation System Test, which is the most common assessing method used in clinical settings.

TESTING REACTIVE FORWARD STEPPING TO LEAN AND RELEASE IN BESTest:

During this procedure, the subject was asked to stand upright with barefoot on the floor and inch tape is placed on the floor, the subject wears the Velcro with a steel pelvic waist belt attached with the non-therapeutic laser pointer which oscillates with limited friction to point out the specific lean (cm) and the examiner stands at in front of the subject placing both the hands over the shoulder bilaterally, then he/she was asked to Lean their body onto examiners hand beyond their forward limit.

The subject will be asked to relax after the lean and then the support from the shoulder by the examiner is released suddenly. In order to prevent a fall, the subject is expected to do a reactive postural adjustment. Concerned with the participants safety, two persons were guarding on both sides. The procedure is done by using Inter (5 therapists with 3 trials), Intra (1 therapist with 3 trials)

2.ANALYSIS OF SPATIO-TEMPORAL PARAMETERS OF FORWARD STEPPING:

The above-mentioned test procedures were captured as a video in a mobile phone camera, at the hip level, the video was analysed using "TRACKER" software. Which was used to calculate the spatio-temporal parameters of the participants reactions for further analysis.

The following spatial-temporal parameters (quantifying data) were calculated in the tracker are

- i. Lean angle(cm)
- ii. First Step Time(s)
- iii. First Step Length(cm)
- iv. Balance Recovery Distance(cm)

Ethical Approval:

The Institutional Ethics Committee for student's projects approved the study with ref.no:(REF: CSP/24/APR/04/131). This study has been registered in Clinical Trial Registry - India (CTRI/2024/07/070383)

LIST OF FIGURES

FIGURE 1: WAIST BELT

“INTER AND INTRA-RATER DIFFERENCES IN THE EXTENT OF LEAN RELEASE AND ITS INFLUENCE ON FORWARD-STEPPING CHARACTERISTICS.”



FIGURE 2: TRIPOD AND MOBILE PHONE CAMERA



FIGURE 3: REPRESENTS THE TESTING OF COMPENSATORY REACTIVE FORWARD STEPPING BY RELEASE FROM LEAN METHOD USING BESTEST (INTER-RATER ANALYSIS)



FIGURE 4: INTER-RATER ANALYSIS

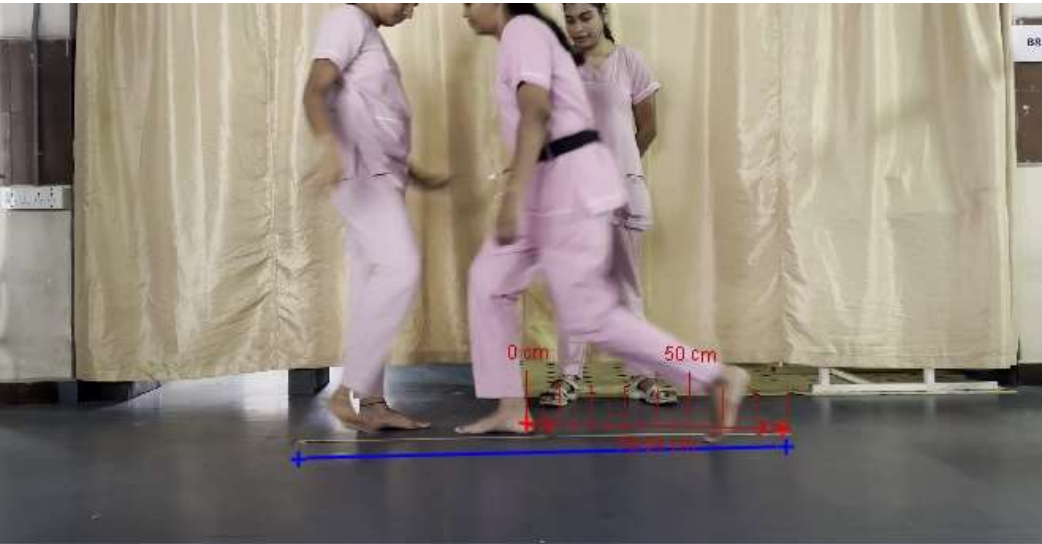
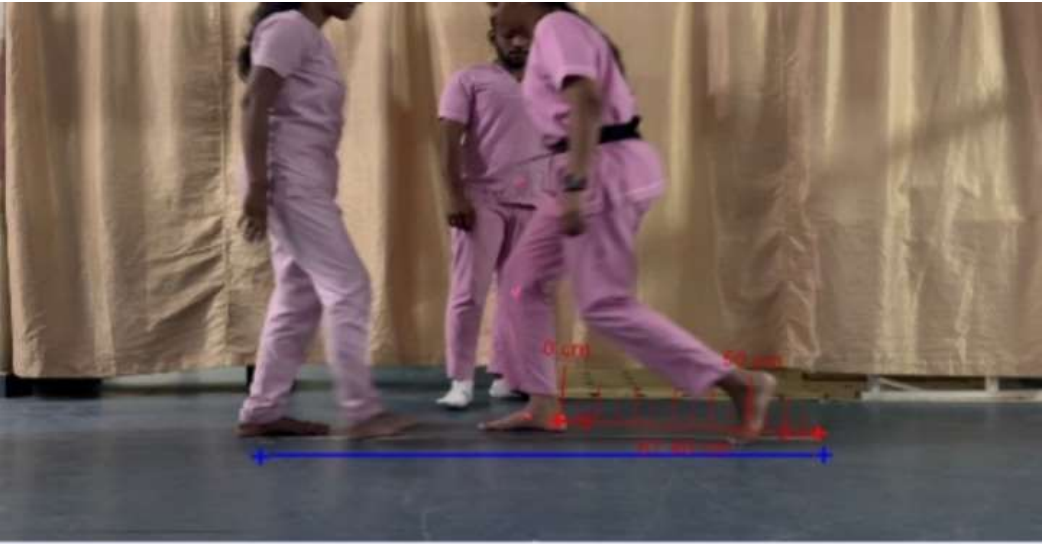


FIGURE 5: REPRESENTS THE TESTING OF COMPENSATORY REACTIVE FORWARD STEPPING BY RELEASE FROM LEAN METHOD USING BESTEST IN TRACKER SOFTWARE



RESULTS

Intra-rater ICC shows reproducibility of lean angle modulate. There were differences in FST, FSD, BRD. However, it did not reach statistical significance.
 $P \leq 0.005$ significant, ANOVA (FST-0.84,FSD-0.84 ,BRD-0.44)

Table 1:Baseline characteristics of the study participants

VARIABLES	MEAN	(SD)
FEMALE (18)	21.66	1.87
MALE (12)	22.55	1.79

Analysis of demographics were done using the Mean and Standard Deviation.

Table 2: Description of spatio -temporal characteristics of Reactive forward stepping through variables

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VARIABLES	ICC	CHANGE IN FST p* ANOVA	CHANGE IN FSD p* ANOVA	CHANGE IN BRD p* ANOVA
INTRA RATER r=90	0.79	0.84	0.84	0.44
INTER RATER r=150	0.51	0.55	0.63	0.80

$P \leq 0.005$ significant, ANOVA (FST -0.84, FSD-0.84, BRD -0.44)

INTERPRETATION

ICC measure the consistency in the performance across the raters. ANOVA compares the variance across the group.

In Intra-rater performance there is an excellent consistency in the lean angle, and minimal difference in spatio-temporal characteristics and it were only within acceptable limits when compared to Inter-rater performance suggesting which correlates with the fair consistency with greatest variation. These findings indicates that the same examiner can reliably measure the spatio-temporal parameters across multiple trials but there is a greater variability between different examiners to achieve consistency.

INTRA RATER - 3 TRIAL * 30 SUBJECTS

INTER RATER -30 SUBJECTS *5 SUBJECTS

Table 3: Description of spatio -temporal characteristics of Reactive forward stepping through average values

VARIABLES AVERAGE	CHANGE IN LEAN (cm) Mean (SD) [95% CI]	CHANGE IN FST (S) Mean (SD) [95% CI]	CHANGE IN FSD (cm) Mean (SD) [95% CI]	CHANGE IN BRD(cm) Mean (SD) [95% CI]
Intra rater	0.39(3.31) [0.43 -1.23]	0.005(0.25) [0.05-0.07]	0.86(7.02) [0.90-2.64]	1.35(9.530) [3.77-1.05]
Inter rater	0.62(4.58) [0.19-1.44]	0.05 (0.24) [0.01-0.10]	3.01(13.23) [0.64-5.38]	3.60(14.008) [1.09-6.10]

DISCUSSION

Stepping is the common strategy seen in the individual while performing postural control assessment in the stance. There are various studies that evaluate the stepping strategies but there are only a few studies to compare the spatio-temporal characteristics in young population.

Horak et al (2009) state that ICC (INTRA CLASS CORRELATION COEFFICIENT) for Inter-rater reliability for the BESTest was **.91** with the 6 section ICC ranging from **.79 to .96**, which shows Excellent reliability

No previous study has to compare the Inter and Intra-rater differences in terms of spatio-temporal parameters like FST, FSD, BRD. This study investigates the differences in testing procedure by the examiners across multiple trials and between examiners for the same methodology. These stepping responses were recorded and analyzed through “TRACKER” software version 6.1.2. The results show minimal changes in these parameters, but they were not statistically significant. There is variability in how raters assess the forward stepping parameters, both Intra and Inter-rater individuals. However, these variations are normal and acceptable Therefore, its essential to consider these potential variations with evaluating compensatory reactive forward stepping which correlates with Carolina R et al,2015 states that Intra -rater the repetition of 3 trials may have allowed improvement in performance but there was no observed change after the initial practice sessions (17).

When examining the Inter- rater differences five different examiners with the one trial shows highest variation which coincidence Carolina R because of lack of training and experience which correlates with Carolina R et al,2015

Laura et al,1998, Thelen et al,1996, states that there was no significant difference in mean maximum forward lean angle between male and female young adults so, we included male (12) participants with mean of (22.55) and female (18) participants with mean of (21.66)participants. A study states older adults and women generate high torque in lower limb muscle groups during recovery. Mille et al,2003 states that stepping is triggered response based on selected strategy that may change with age. (14, 15)

When assessing with BESTest, we observed that all individuals select stepping responses before hitting the limits of stability, this is supported in the study which states that the speed and direction of movement may have an impact on the response selection (18). In BESTest instruction, the subject were asked to stand with barefoot with shoulder and hip wide apart that shows maximum forward lean which corelates, with Maria, wysoglad et al,2022 states feet alignment (wide and preferred stands) and vision also influence the maximum forward lean.From the statistical analysis, Intra-rater of lean angle with an ICC range 0.79 indicating good to excellent reliability it shows that single examiner with 3 trials, the examiner able to reproducibility amount of lean angle which is consistency. However, it did not reach statistically significant. Whereas in Inter-rater of lean angle, with an ICC range 0.51 indicating fair reliability in different examiner with 1 trial because of alteration in the baseline positioning which has an impact on feedback postural control as this is supported by the study stating that the variation in the stepping characteristics can occur due to change in the initial lean angle (19).

Training and demonstration are necessary for safety and excellent intra (between the tester) and inter - rater (among the tester) reliability in clinical practice, particularly the lean and release method, but lack of instant access to technology limits its application (20).The change in Intra - rater lean angle (0.39cm) substantially increases the step length (0.86cm) and decreases in balance recovery which correlates with Hsiao et al,2007 increase in lean angle substantially increases the length of their steps, decrease of balance recovery was possible

We calculated the body lean angle in cm, which relates Hsiao-Wecksler et al. (2007) calculated the body lean angle in θ (degree) step length of the individuals ($p = 0.003$), young participants were able to recover from larger release angles (2.4 degrees) than elderly participants. We also found that, for a given step length ($p = 0.005$), young participants were able to recover from large release angles (0.39 cm).

We observed that for a given step length, the maximum release angle tended to correlate with the step contact time. The study had step length and step contact times that were similar to the maximum step length coordination, which relates to the change in FST ($P = 0.84s$), FSD ($P = 0.84cm$), and BRD ($P = 0.44cm$). After a post-hoc comparison between the variables, we concluded that Intra-rater of ICC shows excellent reliability of change in lean angle with mean (0.39 cm) shows minimal differences in spatio temporal parameters mean of FST (0.005s),FSD(0.86cm),BRD (1.35cm) whereas Inter-rater of ICC shows fair reliability of change in lean angle with mean (0.62cm) shows maximal or highest difference in spatio temporal parameters mean of FST (0.05s),FSD(3.01cm),BRD (3.60cm) . Hence Inter -rater requires more training among individuals performance of the test.

LIMITATIONS

- This study was done only by giving oral instructions. If a video graph of the testing method can cause a change in their response level.
- A large multicentre study should be conducted so that the results can be generalised to the general population
- Fear, motivation, or exhaustion may have had an impact on some participants' performance.

FURTHER SUGGESTIONS

- compare auditory with visual cues by video-captured instructions
- This was done only in the young population, further can be tested in elderly population with safety precautions.
- Can be used to adapt the Compensatory Stepping Response Following Predictable and Unpredictable Perturbation Training.
- This can be also done by forward lean with BMI characteristics, lateral(left) directions.

CONCLUSIONS

There is a consistency in the first step time and length which were only within acceptable limits in Intra-rater performance when compared to Inter-rater performance. By enhancing physiotherapists' skills, this BESTest tool can be implemented in clinical practice for balance evaluation and determining treatment protocol for balance impairments.

CLINICAL IMPLICATIONS

The results from this study have many crucial implications for clinical practice.

- The excellent intra-rater reliability in individual therapist implies the consistency in measuring reactive forward stepping characteristics, whereas the fair inter-rater reliability shows there is a need for standardising this tool among multiple therapists.

- This consistency is essential to check changes over a period in evaluating the effectiveness of interventions as multiple therapists may be involved in evaluation and treatment of patients in rehabilitation set-up.

Disclosure Statement

The authors declare no competing interests.

Conflict of Interest

The authors have no conflicts of interest to disclose.

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