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Reliability and Validity of Hand Reach Star Excursion Balance Test in Badminton Players: A Cross-Sectional Study

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ABSTRACT

Background: Badminton requires high dynamic postural stability and complex upper-limb movements to prevent frequent injuries. The Hand Reach Star Excursion Balance Test (HSEBT) is a clinical tool assessing mobility across eight directions, yet its psychometric properties in badminton players remain unestablished.

Purpose: This study aimed to evaluate the Inter-Rater and Intra-Rater Reliability and Validity of the HSEBT in badminton players.

Method: A cross-sectional study was conducted with 105 purposively selected badminton players (aged 9–40 years). Participants performed the HSEBT on both right and left leg stances using alternate hands. The Upper Quarter Y Balance Test (UQYBT) served as the criterion measure for validity. Intra-class correlation coefficients (ICC) and Pearson's correlation coefficient (r) were used for analysis.

Results: The HSEBT demonstrated excellent reliability, with inter-rater and intra-rater ICCs ranging from 0.91 to 1.0 across all directions and stances. Moderate positive concurrent validity was found between the HSEBT and UQYBT ($r = 0.314–0.451$, $p < 0.001$).

Conclusion: The HSEBT is a reliable and valid tool for assessing dynamic postural control in badminton players, offering a more comprehensive assessment of upper-limb dynamics than traditional tests.

Keywords: Hand Reach Star Excursion Balance Test, Upper Quarter Y Balance Test, Reliability Validity, Badminton players, Dynamic Postural Control.

INTRODUCTION

Badminton is a popular sport and the second most common sport in India which is easily accessible to young adolescents. It is a non-contact racquet rapid sport [1]. Epidemiological research of badminton has reported that the superiority of maintaining as a minimum one injury varies from 49.6% to 82% in youngsters' badminton players [2]. In India, studies have shown that the most common onset was acute injuries (59.26%)[3], current papers[4] states that "incidence of badminton accidents" is relatively advocated for young adolescent gamers as youth sports have dramatically changed in recent many years and now there may be a strong awareness on early sports activities specialization and attention on aggressive success, which has lead to increase pressure to carry out to high – intensity player at a younger age[4]. Badminton sports require a high level of balance, particularly those dominated by open movement structures, and nature of

this diversified sport necessitates physical features that include basic motor skills, upper extremity musculature needed for throwing and catching the badminton shuttle as well as quick reflex [5]. Since badminton is a fast-paced, racquet sport, dynamic postural stability requires a certain amount of movement around the base of support, consequently. Dynamic postural stability tests appear to be more effective at capturing the demands of badminton motions. As two primary tests used in clinical practice for lower limb flexibility are the Lower Quarter Y-Balance Test (LQYBT) and the Star Excursion Balance Test (SEBT) [6]. For Upper Limb, Recent studies indicate that the Upper Quarter Y-Balance Test (UQYBT) [7] is a frequently used test for upper limb stability across a range of demographic sports as well. It has proven good validity and reliability of UQYBT in young adults [7]. The Hand Reach Star Excursion Balance Test (HSEBT), which tests the whole kinematic chain from foot to hand, is a task-based clinical assessment of mobility and dynamic postural control [8]. However, UQYBT only provides information from three directions, which may not properly assess possible dangers. As a more complete upper-limb dynamics. The Hand Reach Star Excursion Balance Test (HSEBT) provides information across eight directions and two rotation movements, helping healthcare professionals, Coaches and Clinicians identify shortcomings. Nevertheless, the reliability and validity of HSEBT among badminton players have not been established. The Hand reach star excursion balance test could potentially serve as a valuable supplement to current functional mobility techniques. The purpose of the current study is to investigate the validity and reliability of the HSEBT among badminton players. The aim of the study is to present HSEBT's inter- and intra-rater reliability. And evaluate the HSEBT's criterion validity, in particular concurrent validity (which is a subtype of criterion validity) by checking a correlation between HSEBT and UQYBT. The purpose of this study is to check inter-rater and intra-rater reliability and validity of Hand Reach Star Excursion Balance Test in badminton players.

METHODOLOGY

This cross-sectional study was conducted over a period of six months among 105 purposively selected badminton players from clubs in the South Gujarat region, India. Inclusion criteria: Badminton players, Training onset more than 3 months, Participants with no past medical or surgical history within the previous six months. Exclusion criteria: Participants with any acute muscular injury and acute previous surgery for last 6 months, Participants with psychological or cardiovascular conditions, and a history of epilepsy. Materials used were custom-made HSEBT mat, Y-balance test kit, weighing scale, Stadiometer.

To perform the test, HSEBT Mat [9] was used with taping of Star (similar to SEBT) in all 8 directions drawn all over the mat with differences marked of over 45°. From Anterior 0 ° to Posterior 180°, each direction was marked with a measuring tape fitted to illustrate the scale (in centimetres) and orientation of the axes.

Reaching was done with the movement patterns, starting from the anterior, moving laterally, then to posterior, and finishing with rotation. The simple plane reaches were defined as A0, P180, R90, L90, LROT and RROT, while the diagonal reaches were defined as R45, R135, L45, and L135 shown in Figures 1 and 2. The hand reaches were performed and demonstrated on the basis of forward plane reaches with using bilateral hands (shown in figures 1,2), and diagonal reaches in unilateral hand with contralateral sides of the hand were used alternatively to perform the test, and rotational reaches were performed with both shoulders flexed to 90°.

The starting position to perform the test in Stance leg (without shoes) shown in figure 1 and 2 positioned on the centre of the mat with axis of foot aligned in A0 and P180

line which were balanced and the other foot (swing foot) which is aligned in positioned at 135° toe out to move and rotate in each reaches in simple plane while during lateral and rotational reaches the foot is fixed and oriented in A0 line . the reaches defined on the bases of movements few instructions should be demonstrated to participant with: (i)Foot should maintain the ground surface with heel, first and fifth metatarsal would be on the floor during reach,(ii)Shoulder flexed to 90° with Elbow extend and wrist in neutral positions,(iii)No weight should be supported during the reach,(iv)Instruct the participant to reach as far as they can.

Measurements of the forward and diagonal planes were measured from centre of mat to tip of middle finger and were recorded in centimetres (cm). For the extension and lateral and rotational reaches a plumb line or a rod was considered to use for taking measurements. Rotational reaches were measured in Degrees (°). For every reach, at least three practice tries were given, with both the hands alternatively used. after three valid reaches, the maximum records were used for analysis.

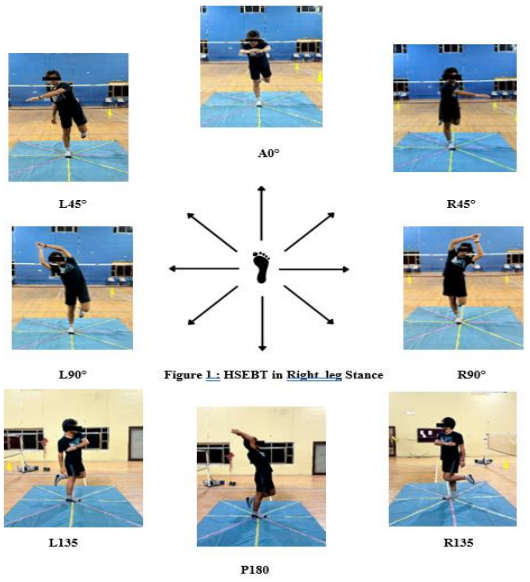


Figure 1.: HSEBT in Right leg Stance

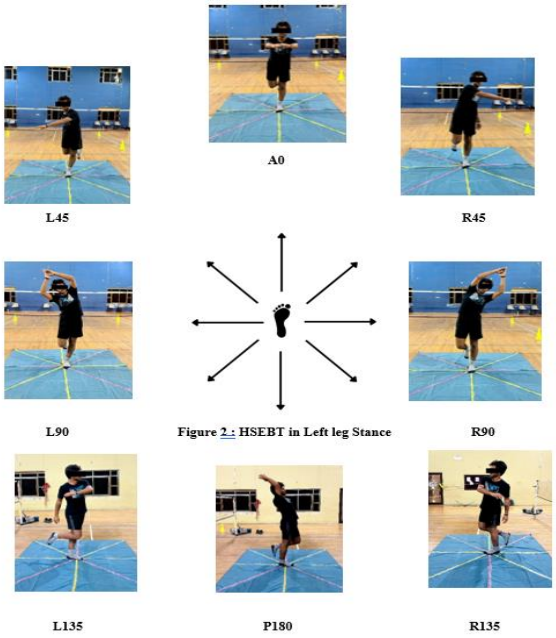


Figure 2.: HSEBT in Left leg Stance

OUTCOME MEASURE

Upper Quarter Y Balance Test [8] were taken to check trunk and upper extremity stability. In which one-handed push-up position, the participants were asked to maintain a push-up position, hold their hands in a foot apart and hands exactly under their shoulders, and try to reach all three directions (Medial reach, Superolateral reach, Inferolateral reach) as far as possible. Three trials were given for each hand.

DATA ANALYSIS

Data analysis was done using the SPSS software (version 23.0). Results were considered significant with confidence interval of 95% [10]. Reliability was measured by Intra-class correlation coefficient for intra and inter-rater reliability [11] which is regarded as a key indicator of reliability, Standard error of measurement (SEM) to calculate the variability in measurements of same individual, Smallest real differences (SRD) was the smallest change that could be interpreted as a real difference. Bland-Altman [12] limits of agreement analysis were done for assessing the agreement between the rater score, to check the criterion validity [13] Pearson's correlation of coefficient were taken to check the correlation between HSEBT and UQYBT

RESULT

In this study, total 105 badminton players, 42 males and 63 females were taken. Where age, height, weight, and training duration of the players were taken and descriptive Characteristics are mentioned in Table 1.

Table 1 shows the descriptive statistics as mean (n) and standard deviation (SD) values of all the players.

CHARACTERISTICS	MEAN (N)	STANDARD DEVIATION (SD)
AGE(YEARS)	19.80	7.08
HEIGHT(CM)	161.04	10.65
WEIGHT(KG)	49.978	14.31
TRAINING DURATION(HR/WEEK)	1.105	0.447

Table 2 shows the descriptive statistics of all components, Mean, Standard Deviation, Inter inter-class correlation (ICC) of inter-rater and intra-rater reliability, Standard error of measurement (SEM), and Smallest real differences (SRD) of HSEBT of right leg stance.

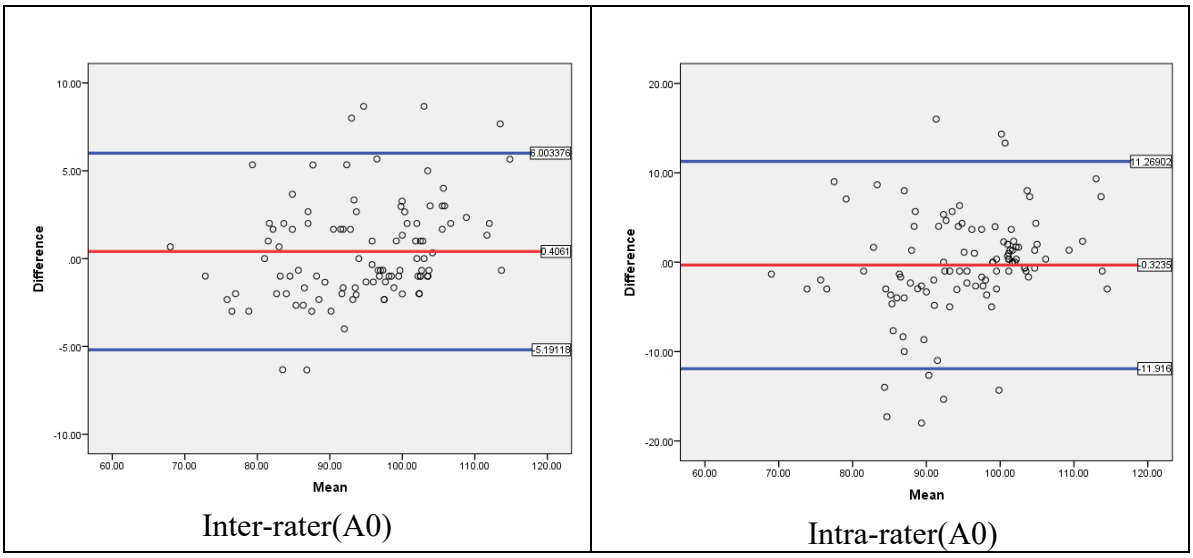
	MEAN		STANDARD DEVIATION	SEM		SRD		ICC	
	Rater1	Rater2		Inter	Intra	Inter	Intra	Inter	Intra
A0	94.92	94.51	10.04	1.48	3.32	4.09	9.17	0.978	0.890
R45	90.23	89.84	12.19	2.13	2.42	5.88	6.68	0.969	0.953
R90	68.10	68.27	10.06	2.18	10.10	6.02	27.19	0.953	-0.09
R135	55.9	56.83	12.05	1.90	3.77	5.25	10.41	0.975	0.902
P180	51.5	53.5	7.50	2.14	3.55	5.91	9.81	0.918	0.775
L135	54.97	55.56	10.9	2.2	3.7	6.07	10.22	0.959	0.885
L90	60.6	62	7.04	2.7	3.0	7.46	8.99	0.959	0.816
L45	84.9	85.1	13.5	2.4	3.6	3.36	9.94	0.967	0.929
Rot. (Rt)	117.7	113.7	10.3	0	0	0	0	1.00	1.00
Rot. (Lt)	118.24	1{4.24	13.6	0	0	0	0	1.00	1.00

Table 3 shows the descriptive statistics of all components, Mean, Standard Deviation, Inter inter-class correlation (ICC) of inter-rater and intra-rater reliability, Standard error of measurement (SEM), and Smallest real differences (SRD) of HSEBT of Left leg stance.

	MEAN		STANDARD DEVIATION	SEM		SRD		ICC	
	Rater1	Rater2		Inter	Intra	Inter	Intra	Inter	Intra
A0	95.37	95.12	11.02	1.3	2.9	3.5	8.01	0.986	0.927
R45	86.57	88	12.72	2.24	4.3	6.7	11.88	0.963	0.882
R90	64.15	66.09	9.6	1.95	3.71	5.38	10.25	0.959	0.852
R135	54.22	55.04	10.9	2.74	3.47	6.82	9.58	0.937	0.899

P180	53.03	53.9	8.18	1.77	4.12	4.89	11.38	0.953	0.746
L135	55	56	10.96	2.29	3.60	6.32	9.94	0.956	0.892
L90	63.22	63.66	8.2	1.65	3.55	4.47	9.81	0.960	0.815
L45	87.66	86.66	13.85	2.97	5.52	8.20	15.25	0.954	0.841
Rot. (Rt)	117.83	116.83	10.32	0	0	0	0	1.00	1.00
Rot. (Lt)	118.24	117.24	13.67	0	0	0	0	1.00	1.00

The Bland-Altman scatter plot was used to determine the limits of agreement between raters and the same rater; it plots the difference between two [13]. shown in Graph 1 and Graph 2,



Graph 1 shows the Bland-Altman scatter plot for inter and intra rater reliability of HSEBT- A0 of right leg stance with the mean difference between the two measurements on Y-axis and the average of the two measurements on X-axis.

DISCUSSION

In this reliability study, the main objective was to measure the inter-rater and intra-rater reliability of the Hand Reach Star Excursion Balance Test (HSEBT) in badminton players using 10 different movement directions: A0, R45, R90, R135, P180, L135, L90, L45, Rotation (Rt), and Rotation (Lt).Upon testing, the findings revealed that a brief administration of the HSEBT is an effective and efficient method to evaluate dynamic postural balance by analyzing intraclass correlation coefficient (ICC) values. The ICC is measured on a scale from 0 to 1, where 1 indicates excellent reliability with no measurement error, while 0 indicates poor reliability and no correlation between raters. According to the 95% confidence interval of ICC estimates, values <0.5 indicate low reliability, between 0.5–0.75 indicate moderate reliability, between 0.75–0.9 indicate good reliability, and >0.90 indicate excellent reliability [11].

For inter-rater reliability in right-leg stance, the results showed that the ICC values between rater 1 and rater 2 were consistently 1 across all 10 directions (A0, R45, R90, R135, P180, L135, L90, L45, Rt, Lt) with a 95% confidence interval, which indicates excellent reliability in all cases. For intra-rater reliability in right-leg stance, the ICC values between rater 1 and rater 2 were also consistently 1 across all directions. However, the interpretations varied slightly: A0, R135, P180, L135, and L90 showed good reliability; R45, L45, Rt, and Lt demonstrated excellent reliability; while R90 indicated poor reliability. Similarly, for inter-rater reliability in left-leg stance, ICC values between raters were again consistently 1 at a 95% confidence interval across all directions, reflecting excellent reliability throughout. Intra-rater

reliability for left-leg stance demonstrated similar consistency in ICC values (all equal to 1). Specifically, A0 showed excellent reliability, R45, R90, R135, L135, L90, and L45 demonstrated good reliability, P180 indicated moderate reliability, while Rt and Lt again showed excellent reliability.

When comparing these findings to previous research, the studies conducted by Eriksrud. O et al. [14], the results align closely. Their study concluded that the HSEBT demonstrated moderate to high intra-test and test–retest reliability (ICC). In another study by Federolf PA et al. [15], suggested that total reach score comparisons showed fair to moderate correlations (r = .393–.606), while anterior and posterior reaches demonstrated fair to good correlations (r = .269–.823). Individual reach comparisons ranged from no correlation to good correlation (r = -.182–.822), with lateral and posterior reaches showing the weakest correlations (r = -.182–.510). Furthermore, the HSEBT elicited significantly greater joint movements than the SEBT. As no such studies had previously been conducted in badminton players, the present cross-sectional study provides important evidence supporting the reliability and validity of the HSEBT for assessing dynamic postural balance.

To establish validity, it was assessed by using Pearson's correlation coefficient between the HSEBT and the Upper Quarter Y Balance Test (UQYBT), calculating the values to determine if relevant constructs were fulfilled [16]. The correlation coefficient (r) defines the relationship between the two tests. Studies by Xu.Hr et al. [8] suggested that the UESEBT was found ($r = 0.42–0.72$, $p < 0.001$) to be moderately to strongly related to UQYBT, proving reliability and validity in many populations including adults and swimming athletes. Sæland F et al. [17] also reported that the differences between HSEBT and SEBT overall scores showed significant common variances (5.2–67.7%) and reach-specific correlations (r = -.182 to .822). Their data indicated that HSEBT can evaluate both comparable and distinct features of dynamic posture. As there had been no validity measures in badminton players [18], the present study conducted correlation measures for both right-leg and left-leg stance. In the HSEBT, three directions (R45, R135, and L90) were compared with three directions of the UQYBT (superolateral, inferolateral, and medial). For left-leg stance, Pearson's correlation coefficients ranged from r = 0.149–0.451 ($p < 0.001$), indicating weak to moderate correlation. For right-leg stance, the correlation coefficients ranged from r = 0.341–0.395 (p = 0.000), also suggesting weak to moderate correlation. These findings demonstrate that the HSEBT has acceptable criterion validity when compared with the UQYBT, though the correlations varied in strength across directions.

CONCLUSION

By conducting the study of Inter-Rater and Intra-Rater reliability with results showing "excellent reliability with no measurement error" with "positive correlation" between HSEBT and UQYBT. Thus, it concludes that Hand Reach Star Excursion Balance Test is a Valid and Reliable Tool.

Implications For Physiotherapy Practice

The present findings establish the Hand Reach Star Excursion Balance Test as a reliable and valid tool for assessing dynamic balance in badminton players. Its application in physiotherapy helps assist in identifying balance impairments, incoordination and identify shortcomings that will help in assessment and focused interventions, Regardless, the test's adaptability, affordability, and ease of use demonstrate its value in improving performance and preventing injuries in physiotherapy settings.

LIMITATIONS

Data of participants with a wide age range were obtained, Tester blinding was not practicable due to the learning effect. To reduce the effects on the participants, the

testers did not discuss during the recording of the scores.

Future Recommendations

The study can be done with large population; further study can be done to check the psychometric analysis of the HSEBT test. Normative data of this study can be compared with original HSEBT.

Declaration by Authors

Ethical Approval: Approved

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Conflict of Interest: The authors declare no conflict of interest.

List Of Abbreviations

1. HSEBT - Hand reach star excursion balance test
2. UQYBT - Upper quarter Y balance test
3. A0 - Anterior reach at 0°
4. R 45 - Right Anterior-Lateral reach at 0°
5. R90- Right-Lateral reach at 90°
6. R135 - Right Postero -Lateral reach at 135°
7. P180 - Posterior reach at 180 °
8. L135 - Left Postero -Lateral reach at 135°
9. L90- Left-Lateral reach at 90°
10. L45- Left Anterior- Lateral reach at 0°
11. Rot-Rt - Right rotational reach
12. Rot – Lt - Left rotational reach
13. ICC - Inter Class Correlation
14. SEM- Standard Error of Measurement
15. SRD- Smallest Real Differences

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