CORRELATION BETWEEN POOR LANDING MECHANICS, BALANCE AND AGILITY AMONG UNDER-18 INDIAN BADMINTON PLAYERS – A CROSS-SECTIONAL STUDY

By

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MPT II (Sports)

Dissertation Submitted to the

Odisha University of Health Sciences, Bhubaneswar, Odisha.

In partial fulfilment of the requirements for the degree of

Master of Physiotherapy

In

SPORTS

Under the guidance of

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Bhubaneswar, Odisha

2023-2025

Odisha University of Health Sciences

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation/thesis entitled "**Correlation between Poor landing mechanics, balance and agility among under 18 Indian badminton players – Cross-sectional study"** is a bona fide and genuine research work carried out by me under the guidance of **Dr Joydip Saha, Associate Professor** and there is no conflict of interest associated with this dissertation work.

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CERTIFICATE OF ACCEPTANCE

This is to certify that the dissertation entitled: **Correlation between Poor landing mechanics, balance and agility among under 18 Indian badminton players – Cross-sectional study"** carried out by **Ms. Navya R** , bearing University Registration Number 23mp435026 has been **evaluated and accepted** by me as an **Examiner / Evaluator**, appointed by the **Odisha University of Health Sciences, Bhubaneswar**, in partial fulfilment of the requirements for the award of the degree of **Master of Physiotherapy (MPT) in SPORTS**.

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I, **Navya R** of Abhinav Bindra Sports Medicine & Research Institute, Odisha, Bhubaneswar, hereby declare that the Odisha University of Health Sciences and Abhinav Bindra Sports Medicine & Research Institute, Odisha, Bhubaneswar shall have the rights to preserve, use and disseminate this dissertation/thesis in print or electronic format for academic / research purposes.

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# ACKNOWLEDGMENT

I would like to express my heartfelt gratitude to the Almighty, my family and friends for their unwavering encouragement, understanding, and love. Their support has been a constant source of strength during this academic journey.

I extend my sincere gratitude and appreciation to the management and administration of Abhinav Bindra Sports Medicine and Research Institute, Bhubaneshwar, and those who have supported and guided me throughout the journey of this dissertation. Without their valuable contributions, this work would not have been possible.

I am also immensely grateful to Dr Chinmaya Kumar Patra, the Principal, Abhinav Bindra Sports Medicine and Research Institute, Bhubaneshwar. Your encouragement and belief in my abilities have been a source of motivation and confidence.

I would like to express my deepest gratitude to my dissertation guide, Dr Joydip Saha, Associate Professor, Abhinav Bindra Sports Medicine and Research Institute, Bhubaneshwar. Your unwavering support, expert guidance, and insightful feedback have been instrumental in shaping this research. Your dedication to excellence in academia has inspired me to strive for higher goals in my academic pursuits.

Furthermore, I would like to extend special thanks to Dr Deepak Pradhan for their valuable assistance and support throughout this research. Your expertise and constructive criticism have helped me refine my work and explore new dimensions in my study. I am also thankful to all the faculty members, staff, fellow students and subjects who have contributed to my academic growth and provided a stimulating environment for learning.

In conclusion, this dissertation stands as a testament to the collaborative efforts of the individuals mentioned above, and I am deeply grateful for their contributions to my academic success.

Thank you.

Date : **Signature of the Candidate**

Place:

LIST OF ABBREVIATIONS USED

1. ABSMARI - Abhinav Bindra Sports Medicine and Research Institute
2. SPSS - Statistical Package for the Social Sciences
3. SD - Standard Deviation
4. SLDJ- Single leg Drop Jump

ABSTRACT

CORRELATION BETWEEN POOR LANDING MECHANICS, BALANCE AND AGILITY AMONG UNDER-18 INDIAN BADMINTON PLAYERS – A CROSS-SECTIONAL STUDY

Background:A high level of physical condition and the capacity to perform a variety of agility actions, including quick starts, sprints to the shuttle, and stops from rapid movement, are prerequisites for elite badminton. To succeed in badminton, players need to have a strong physical base and good technical skills that allow them to move smoothly around the court and make accurate, forceful shots. This high-energy environment requires athletes to perform repetitive leaping activities that require exceptional agility and balance.

Objective : This study aimed to assess the relation between single leg landing, agility and balance among under 18 badminton players.

Methods : A Cross-Sectional Study was conducted among under 18 Badminton Players, where their single leg landing, agility and balance were assessed using Single leg landing error scoring system, badminton specific agility test and Modified Star Excursion Test.

Results : Significant correlation between single-leg drop jump (SLDJ) scores and agility performance (Spearman's $\rho = 0.828$, $p < 0.05$). This indicates that the quality of landing mechanics does directly influence agility times in badminton players. Significant positive correlation was observed between SLDJ and left composite balance score (Spearman's $\rho = 0.253$, $p = 0.036$).

Conclusion : The present study demonstrated a positive correlation between SLDJ with agility and weak positive correlation between SLDJ with balance.

Keywords : Agility; Badminton Players ;Drop Jump Landing ;Modified Star Excursion test;Badminton Specific Agility test; Single leg landing error scoring system

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INTRODUCTION

CORRELATION BETWEEN POOR LANDING MECHANICS, BALANCE AND AGILITY AMONG UNDER-18 INDIAN BADMINTON PLAYERS – A CROSSECTIONAL STUDY

Badminton is distinguished by a variety of moves in which short intervals of high intensity with frequent accelerations, decelerations, and direction changes alternate with longer periods of low intensity during rally breaks. Complex relationships among technical, tactical, physiological, and psychological skills are critical.[1]

According to epidemiological data on badminton injuries, the lower extremities account for nearly 70% of all injuries, making them the most commonly damaged body region. More than two-thirds of major injuries that require surgery occur at the knee joint, including fractures (2.6%), ligament rips (71.5%), and cartilage tears (20.3%).

Injury incidence among competitive badminton players ranges between 0.9 and 7.38 per 1000 hours, where 1 hour represents one player's participation in the sport. The incidence of badminton-related injuries is variable in diverse communities and even in the same population when comparing male and female players, competitive and recreational players, and players of different ages.[2]

Elite athletic performance necessitates a combination of agility and fitness, as well as exceptional aerobic, anaerobic, and muscular capacities.[3]

Players must make decisions in brief periods of time, based on their predictions about the opponent's moving direction and the flight trajectory of the badminton. This mechanism is strongly related to dynamic balance control, which includes lunges, landing stability, and fast adjustments like acceleration, deceleration, and change of direction (COD) of the body trunk. CODS is the capacity to rapidly shift direction; in badminton, the player engages in numerous multi-directional movement patterns in fast succession to perform defensive/counterattacking retrievals or construct offensive moves.[4]

The ability to maintain dynamic balance has been associated with higher COD speed, better control of jumping and running to smash, and performing lunges. Strategies aimed at improving dynamic balance and agility have the potential to enhance badminton players' performance. Badminton at the elite level requires a high standard of physical fitness as well as the ability to execute a wide range of agility movements, such as fast starts, sprinting to the shuttle, stopping from fast movements, and intermittent bursts of activity supplied through anaerobic energy sources.[5]

To outmanoeuvre their opponents and gain a competitive advantage, players must use a variety of shot variants, such as smashes, clears, drops, and drives. The game's quick and dynamic nature needs a high level of physical fitness, making strength, endurance, power, response time, agility, speed, adaptability, balance, and coordination critical traits for successful players. To excel in badminton, athletes must combine solid technical skills with a strong physical foundation to execute precise and powerful shots while maintaining fluid mobility throughout the court.[5]

COD performance was governed not just by the SSC function, but also by dynamic balance capability. All COD performance tests feature a stop-and-go movement pattern, and balance is expected to strongly influence the efficacy of the directional change. Body segments prefer to maintain the direction of movement due to inertia, while balance ability ensures stability for positioning and subsequent direction shift.[7]

Furthermore, stroke play and footwork performance are two important characteristics in badminton. Eye-hand synchronisation has a significant impact on stroke play, whereas footwork is largely concerned with maintaining balance. The speedy return of the shuttlecock in under one second requires swift cognitive processing and quick reflexes to stimuli during games.[5]

Amateur badminton players began training when they were teenagers (average age 12 years). The postural control system matures between the ages of 14 and 16 years.
Good balance is essential in badminton because it allows players to create effective motions, boost endurance, and lower their risk of injury (Ferriyani et al., 2021). Balance is achieved through a range of movements in each body segment, which are supported by the musculoskeletal system and the fulcrum. Badminton players require balance when running, jumping, or swinging a racket (Ahmed et al., 2022).

Throughout the game, badminton players must react to the moving shuttlecock and change their body position quickly and consistently. They must keep their centre of gravity inside the base of support while undertaking extremely quick and asymmetrical upper limb motions. As a result, great body balance is essential for badminton skill development, athletic performance and injury avoidance.[8]
According to Masu, Muramatsu, and Hayashi, high-level badminton players sway less than low-level players when standing on their nondominant leg with their eyes closed.

Balance is necessary for badminton players to control their centre of gravity (COG) during difficult movements such as twisting moves during jump smashes (particularly involving the pivot foot) and transitions between offensive and defensive positions.[9]

Because balance is not fully mature and is still in the developmental stage, training methods that improve static and dynamic balance will improve athletic performance.

The Star Excursion Balance Test (SEBT) is a reliable, responsive, and clinically relevant functional assessment of lower limbs' dynamic postural control.

Several investigators have reported excellent intra- and interrater reliability regarding all three directions (ICCintra = .85–.91 and ICCinter = .99–1)

Under the smash condition, the hip abduction, knee flexion ranges at first contact with the ground, and knee valgus angles were all noticeably greater than under the target and shadow circumstances. Females may be more susceptible to ACL injuries than males due to their larger frontal range of motion (ROM) of the knee joints on landing.

The low flexion landing pattern causes an increase in sagittal and frontal plane loads at the knee, regardless of the rationale for our research participants' diverse landing techniques. This is important for ACL injury since in vitro studies have demonstrated that knee valgus loading plus anterior shear (Markolf et al.) and increased quadriceps contraction at modest knee flexion angles (Renstrom et al.) increase ACL strain.

Lower limb injuries can result from improper landing. This movement produces a force that can be two to twelve times the body's weight, so the skeletal system must absorb this mechanical shock.

As a result of rising impact pressures during landing, the soft tissue surrounding the joint might experience structural damage. Various elements influence the landing method. Age, gender, and level of fitness are some of the key risk factors for serious knee injuries.

In addition, they may be affected by physiological factors such as fatigue, increased knee valgus angle, and decreased knee flexion on landing. The superior leg is stronger than the non-superior limb. When doing a drop landing task, those with a low flexion landing pattern experience increased frontal plane loading at the knee. The low flexion landing pattern increases knee loading in both the sagittal and frontal planes.

This is relevant to ACL damage because in vitro studies have demonstrated that the combination of anterior shear and knee valgus loading causes stronger quadriceps contraction at modest knee flexion degrees as well as increased ACL strain. When 3D analysis is unavailable, 2D video assessments of human movement are a legitimate and reliable alternative for quantifying dynamic movement activities. [11]

The SL-LESS demonstrated fair interrater reliability and good test-retest reliability. Individual item per cent agreement between raters ranged from 75.0–100% and the kappa statistics indicated significant fair to perfect agreement. Between sessions, the percentage agreement ranged from 78.6% to 100% and the kappa statistics indicated significant moderate to perfect agreement.[12]

Unfortunately, there is a notable research gap linking drop jump landing mechanics to badminton players' agility and balance.

AIM AND OBJECTIVE

AIM AND OBJECTIVE

To determine the correlation between the landing mechanism and balance and agility among badminton players

Primary objective

Investigate the relation between the landing mechanism and agility among badminton players.

Secondary objective

Investigate the relation between the landing mechanism and balance among badminton players.

REVIEW OF LITERATURE

Methodology of the literature review :

1. Bishop et al. (2019) examined 16 adult female soccer players to explore the link between inter-limb asymmetry and performance. Unilateral countermovement jumps (CMJ) and drop jumps (DJ) were used to assess asymmetry, while sprint (10 m, 30 m) and 505 change-of-direction speed (CODS) tests measured performance. Findings showed DJ asymmetry (~9%) significantly correlated with slower sprint and CODS performance, whereas CMJ asymmetry (~8.6%) showed no relationship. No associations were found between asymmetry across tests, highlighting test specificity. Overall, unilateral DJ appears to be a sensitive indicator of performance-relevant asymmetry in female soccer, though results are limited by small sample size.

2. This study by Earl-Boehm et al. (2023) evaluated the **reliability and construct validity** of the **Single-Leg Landing Error Scoring System (SL-LESS)** for assessing single-leg landing biomechanics in physically active females. Twenty-eight healthy women performed single-leg landings on two occasions, recorded with 2D video and 3D motion capture. Two raters scored each trial using the SL-LESS rubric. Inter- and intra-rater reliability were **moderate** (total score ICC ≈ 0.50–0.56; κ-values low to moderate). Construct validity was supported: "good" landers exhibited greater hip and trunk flexion, lower knee abduction moment, and smaller vertical ground reaction forces compared to "poor" landers.

3. Maloney et al. (2017). This study addressed whether lower-limb stiffness (vertical,

ankle, knee, hip) and inter-limb asymmetry influence change-of-direction speed (CODS). **Eighteen healthy young men** performed unilateral drop jumps to assess stiffness and CODS cutting tests, with ground reaction force data recorded. A **stepwise regression** revealed that **mean vertical stiffness** and **drop-jump height asymmetry** together explained **63%** of CODS variance ($R^2 = 0.63$, $p = 0.001$). **Faster performers** exhibited greater stiffness ($p = 0.001$) and lower asymmetry ($p = 0.026$). The findings suggest that vertical stiffness and symmetrical drop-jump performance are key predictors of CODS in non-athletic individuals.

4. This study by Kishi et al (2021) investigated dynamic balance in junior female athletes with a history of shin splints (MTSS). Using a single-leg drop jump landing task on a force plate, balance was assessed via centre of pressure sway and time to stabilisation. Results showed athletes with prior shin splints demonstrated significantly poorer dynamic balance and delayed stabilisation compared to healthy controls, indicating persistent neuromuscular deficits despite clinical recovery. The authors suggest that impaired landing balance may increase reinjury risk and highlight the importance of incorporating dynamic balance training into preventive and rehabilitative programs for young female athletes.

5. Duncan P. Fransz, et al investigated whether the static phase following a single-leg drop-jump (DJ) on a force plate could stand in for a traditional single-leg stance (SLS) balance task. They measured three postural stability outcomes—COP speed, COP sway, and horizontal ground reaction force (Horizontal GRF)—during both tasks.

Results showed that SLS demonstrated a learning effect (4.6–6.1%; $p < 0.03$), while DJ did not ($p > 0.27$). Precision was superior for SLS in COP speed and Horizontal GRF. Although not interchangeable, DJ may serve as a proxy for static postural stability, provided more than three trials are used.

6. Brice Picot et al present an updated review of the Star Excursion Balance Test (SEBT) along with practical guidelines. The SEBT—measuring dynamic postural control of the lower limb via normalised reach distances in multiple directions—is highlighted as a reliable, responsive, and clinically relevant outcome measure. However, significant methodological variation across studies limits comparability. To improve standardisation, the authors propose practical recommendations, including adopting the modified SEBT (mSEBT) with three core reach directions, standardising instructions, and capturing normative data. These steps aim to enhance consistency and interpretation in clinical and research applications.

7. The study Marleen G. T et.al aimed to systematically review and evaluate agility tests in racquet sports, identify effective tests, and suggest areas for future research to improve agility assessment in tennis, badminton, and squash. This review could give some useful information about the content of agility testing, needed for monitoring agility performance. The Badcamp and BSST are both suitable for use in practice for agility monitoring in badminton. For both tennis and squash, no sport-specific agility tests were identified showing reliable and valid results.

8. Guo et al sixteen elite male badminton players volunteered to participate and were

randomly assigned to a balance-plyometric group (BP: n = 8) and plyometric group (PL: n = 8). The BP group performed balance combined with plyometric training three times a week over 6 weeks, while the PL group undertook only plyometric training three times a week during the same period. All participants were tested to assess the COD ability before and after the training period: Southeast Missouri (SEMO) test and 5-0-5 test, dynamic balance ability (Y-Balance test, YBT), and reactive strength index (RSI). Repeated-measure ANOVA revealed that after the intervention there was a significant time × group interaction for 5-0-5 COD test, YBT of both legs and RSI ($p < 0.05$, partial $\eta2 = 0.26–0.58$) due to the better performance observed at post-test compared with a pre-test for the BP group [effect size (ES) = 1.20–1.76], and the improvement was higher than that of the PL group. The change in SEMO test did not differ between BP and PL ($p < 0.159$, partial $\eta2 = 0.137$), but the magnitude of the within-group improvement for BP (ES = 1.55) was higher than that of PL (ES = 0.81). These findings suggest that combined training could further improve the COD performance of badminton athletes than plyometric training alone and might provide fitness trainers with a more efficient COD training alternative.

9. Stanislav Dimitri Siegel et al.2025 studied the acute effects of minimalist shoes, standard sport shoes, and barefoot conditions on sports-specific performance in forty-eight team and racket sports athletes over three testing sessions. Jump tests and 90° cutting manoeuvres (90°COD) were among the biomechanical laboratory assessments.Single-leg drop jump performance (DJ). O'Connor49 reports that participants completed three valid trials with each leg of the DJ. Participants in DJ stood in a single-leg stance on a 20 cm box, then jumped from a distance of 25% of their height and landed on a force plate using the same leg. This distance was chosen

to standardise the horizontal component of the drop jump across participants based on their individual anthropometrics, as suggested by O'Connor50, to ensure biomechanical comparability and consistency. Following landing, the participant executed a single-leg maximum vertical jump with freely moving arms. A trial was deemed invalid if the participant did not jump off with one foot, did not jump off the box vertically, did not land with the entire foot on the force plate, touched the ground with the swing leg, lost/fell off balance, or did not complete the task in a fluid motion. Significant footwear effects were found for 90°COD, MS, and LS, with minimalist and barefoot conditions reducing performance by up to 9% when compared to standard sport shoes. Footwear did not affect jumping performance. Surface conditions were a major effect on the performances of LS and MS, with tartan and synthetic turf improving performance by up to 9% over indoor surfaces. Except for the 90°COD test, all tests revealed significant sex differences. These findings indicate that the effects of footwear are context-dependent and should not be interpreted without taking into consideration specific surfaces, movements, and individual factors. Future research should look into whether long-term habituation can influence these outcomes.

10. Maximiliano Ezequiel Arlettaz et al 2024 studied that the Landing Error Scoring System (LESS) is a movement analysis tool designed to predict the risk of anterior cruciate ligament injuries and is extremely useful for injury prevention. The purpose of this study is to examine the LESS variants, their normative scores, and the differences based on gender and sport practice.Twenty of the 360 articles identified were included in a full analysis (18,093 participants, age range: 8-30 years, 70.6% male). The military population was the most commonly examined (7 studies, n = 16,603). The results showed six variations of the LESS, with average values ranging

from 2.56 to 7.1. Males and females had different landing patterns, with errors in different planes. Our findings highlight the need for more field research on LESS reference scores, particularly among females and basketball or hockey players. More research is needed before conducting a systematic review and meta-analysis.

11. Christiane Wilke et al. (2017) studied that despite successful rehabilitation, many high-performance athletes sustain additional damage or recurrent injuries. This is frequently caused by insufficient movement quality, which is rarely assessed by test protocols that determine the point of reintegration into high-performance sports (Return-to-Play, RTP). There are objective and subjective test protocols for assessing movement quality. Objective methods, such as 3D motion analysis, are regarded as the international gold standard, but they are not the most practical solutions for daily training routines. This study aims to review the available literature on the reliability and validity of existing subjective test protocols. Their application in high-performance sports is also being evaluated. Subjective methods have not previously demonstrated sufficient validity. However, some practical methods for assessing movement quality after injury are known. First, based on selected criteria, recommendations for the use of various subjective screening test methods are made. In summary, more research on the validity of subjective tests is required. To identify additional risk factors, subjective testing methods should be used in conjunction with other tests (e.g., strength testing). To improve injury prevention, pre-injury movement quality screenings should be repeated regularly.

12. Florian Giesche et al. (2018 studied participants who had undergone ACL

reconstruction and uninjured controls who performed countermovement jumps with single-leg landings. Two Different conditions are to be completed: anticipated (n=35) and unanticipated(n=35) successful landings. Before the jump, participants are shown a visual representation of their desired landing leg. In unanticipated conditions, this information will be provided approximately 400 milliseconds before landing. Electroencephalography will be used to measure neural correlates for motor planning. This study will examine movement-related cortical potentials, frequency spectral power, and functional connectivity. A capacitive force plate will be used to measure biomechanical landing quality. A capacitive force plate will be used to measure biomechanical landing quality. Calculated parameters include time to stabilization.Measure the vertical peak ground reaction force and the length of the centre of pressure path. Interference statistics will be used to identify potential systematic differences between ACL-reconstructed individuals and controls based on jumping conditions (anticipated/unanticipated, injured/uninjured leg and controls). Correlation analysis will be used to identify potential associations between cortical and biomechanical measures. For statistical significance ($\alpha < 0.05$), additional confounders (cofactors) will be considered.

13. Zacharias Flore et al.'s 2024 study was to generate baseline values for uninjured elite youth football players for a multifactorial RTP assessment and compare with previously published data. A secondary aim was to investigate the use of the Limb Symmetry Index (LSI) as a method to determine whether an athlete passes a performance test or not. Study Design Observational Cohort study Methods Baseline data of performance tests (Y-Balance [YBT-LQ], Heel Rise [HRT]; Singe Leg Squat [SLST]; Single Leg Drop Jump [SLDJ]; Side Hop [SHT]; Figure of 8 Hop [F-8];

Modified Agility T-Test [MAT]) were assessed in 20 elite youth football players, aged 16-21 years. Additionally, the traditional LSI (dividing the result of the non-dominant leg by the result of the dominant leg and multiplying by 100) and directionally corrected LSI (the worst value is divided by the better value and multiplied by 100) were calculated. The test values were compared to previously reported study results. LSI and side-to-side comparisons between dominant and non-dominant leg sides were analysed using the Wilcoxon test. Results Male elite youth football players achieved better results in the dynamic performance tests (SHT, F-8, and MAT) compared to reference values of the cohorts previously described in the literature: YBT-LQ total score (cm), dominant (dom) 99.3±8.3, non-dominant (ND) 99.5±10.4; HRT (average number) dom. 27.1±5.4, ND 25.2±5.1); SLDJ height (cm) dom 15±5, ND 15±5 and contact time (sec) dom 0.29±0.08, ND 0.29±0.07, Reactive Strength Index (RSI) dom 0.52±0.12, ND 0.50±0.13); SHT (sec) dom 7.12±0.73, ND 7.39±0.93; F-8 (sec) dom 10.52±1.02, ND 10.37±1.04; and MAT (sec) 5.82±0.22. Directionally corrected LSI differed significantly from the traditional calculated LSI ($p<0.05$)

14. Florian Giesche et al. (2018 studied participants who had undergone ACL reconstruction and uninjured controls who performed countermovement jumps with single-leg landings. Two Different conditions are to be completed: anticipated (n=35) and unanticipated (n=35) successful landings. Before the jump, participants are shown a visual representation of their desired landing leg. In unanticipated conditions, this information will be provided approximately 400 milliseconds before landing. Electroencephalography will be used to measure neural correlates for motor planning. This study will examine movement-related cortical potentials, frequency spectral power, and functional connectivity. A capacitive force plate will be used to measure

biomechanical landing quality.A capacitive force plate will be used to measure biomechanical landing quality. Calculated parameters include time to stabilisation,. Measure the vertical peak ground reaction force and the length of the centre of pressure path. Interference statistics will be used to identify potential systematic differences between ACL-reconstructed individuals and controls based on jumping conditions (anticipated/unanticipated, injured/uninjured leg and controls). Correlation analysis will be used to identify potential associations between cortical and biomechanical measures. For statistical significance ($\alpha < 0.05$), additional confounders (cofactors) will be considered.

15. Oren Schwartz et al, 2015, to determine the value of the Landing Error Score System - real-time test as a predictor of knee injuries among Israeli Defence Forces combat soldiers. All 2474 Israeli Defence Forces combat soldiers enrolled in the Israeli Defence Forces Injury Prevention and Rehabilitation Centre were considered. A retrospective cohort study was performed. The landing error score system - real-time score was used to determine the predictive variable. The three main outcome variables were overuse knee injuries, meniscal injuries, and anterior cruciate ligament injuries. Receiver operator characteristic analysis was used to assess the test's predictive potential and to determine the best cutoff score.The area under the curve of the receiver operation curves revealed that the landing error score system - in real time evaluation had little predictive value for all three outcome variables (knee injuries: area under the curve 0.526, 95% confidence interval 0.498, 0.554; anterior cruciate ligament injuries: area under the curve 0.496, 95% confidence interval 0.337, 0.656; meniscus injuries: area under the curve 0.515, 95% confidence interval 0.454, 0.576).

METHODOLOGY

1. **Study design:** Observational study
2. **Study setting**: SAI Badminton Academy.
3. **Sampling method**: Convenience sampling.
4. **Sample size:** 69 athletes. The sample size was calculated using G-Power software using a compromise analysis with alpha (80%) and power (0.92).
5. **Period of study:** 1 study
6. **Participant characteristics**
    a. **Inclusion criteria**
        i. Badminton player
        ii. Gender: Male and Female
        iii. Age: 15-18 years
    b. **Exclusion criteria**
        i. Recent fracture or any musculoskeletal condition, strain, sprain, or dislocation in less than 6 months.
7. **Outcome measure: 2D motion analysis.**

Kinovea (version 0.8.24) is reliable (inter and intra–rater) and valid 2D movement analysis software, which is free, used to analyse angles, distance, coordinates and spatiotemporal parameters.

PROCEDURE

Procedure

Approval from the IEC of Abhinav Bindra Sports Medicine and Research Institute (Annexure –C.1) was obtained. For data retrieval, Players were accessed and recorded in the Sports analysis in Google Drive.

Phase 1

Between January 2024 and May 2024, data was collected. A total of 90 players were assessed, and 70 participants' video was taken to analyse.

Phase 2

Movement analysis was done during this phase.

- **Sequence:**

Phase I. Six markers were placed on each right and left ASIS, the centre of the patella, and between the malleoli. The individual is then asked to perform both tests. The video will be recorded from the beginning to the end.

Phase II. Individuals performed the single-leg drop jump test from a 20cm box with 3 repetitions and 3.

Phase III. Individuals performed the Modified Star Excursion test for both the dominant and non-dominant leg.

Phase IV. Individuals performed the Badminton Agility test

Phase 3

- **Standardization**

Standardisation was done on 60 individuals using Kinovea software for further analysis.

Patient preparation:

1. Patient clothing:

   Men: Tight-fit pants/shorts and t-shirts.

   Women: Tight-fitting pants/shorts and a t-shirt.

2. Bony landmarks: ASIS, centre of patella, between two malleoli.
3. Surface: Badminton court and even surface.
4. Material required: Camera, digital camera tripods, skin markers.
5. Distance of camera: Frontal and Lateral view: 3 meters.
6. Height of camera: Level of ASIS to the floor

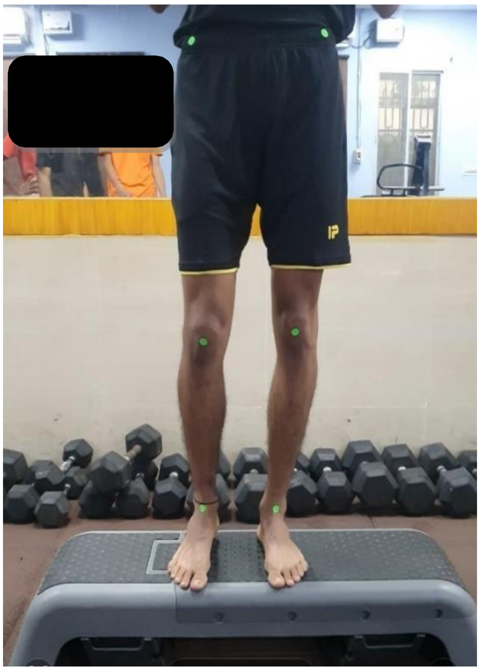


Figure 1: Frontal view of anatomical landmark placement for SLDJ

Phase 4

All participants were screened for inclusion and exclusion criteria by the principal investigator of the study, and 60 participants were recruited. After thoroughly explaining the procedure, informed consent was obtained from all the participants. Participants who met the inclusion criteria, including gender, age, height, and weight, were collected. Following this, the patient was asked to change into suitable clothing, and reflective skin markers were applied over ASIS, the centre of the patella, and between the two malleoli.

Participants were instructed to perform the forward step-down test and later the modified star excursion test and badminton agility test on a cue to start, which was recorded using a camera.

Adverse event: There was no adverse event while performing the test

Phase 5

- **Data Analysis: Drop Jump Landing**

"Data was captured using a camera. Data processing was done in 2D software Kinovea (version 0.8.24). Descriptive analysis was done for the demographic characteristics of participants.
Drop landing was using the scale of single-leg landing error scoring system criteria related to movement patterns not often observed during bilateral tasks, but may become apparent during single-leg tasks, were also added. In total, 11 items were included in the final revision of the SL-LESS.

Dichotomous ratings were given for each of the items, with "1" indicating the error was present in two or more of the trials and "0" representing acceptable movement patterns in two or more of the trials. The total number of errors was added together to give a score ranging from 0 to 11."

Figure 2: SLDJ analysis

SL-LESS Itemized Description

Plane		Item	Error (1)	Good (0)
SAGITTAL PLANE	1	Forward Trunk Flexion at IC	At IC the trunk is vertical or extended on the hips	The trunk is flexed on the hips
	2	Knee Flexion at IC	At IC the knee is flexed more than 30º	The knee is not flexed more than 30º
	3	Ankle Plantarflexion at IC	The foot lands heel to toe or with a flat foot	The foot of the test leg lands toe to heel
	4	Forward Trunk Flexion Displacement	Between IC and MKF there is no additional trunk flexion	There is additional trunk flexion
	5	Knee Flexion Displacement	Between IC to MKF the knee does not flex an additional 30º	The knee flexes an additional 30º
	6	Ankle Dorsiflexion Displacement	Between IC and MKF the heel does not touch the ground or the ankle does not move into a dorsiflexed position during landing	The heel touches the ground and the ankle becomes dorsiflexed during landing
FRONTAL PLANE	7	Knee Valgus at IC	At IC, a line drawn straight down from the center of the patella is medial to the midfoot	The line goes through the midfoot
	8	Lateral Trunk Flexion at IC	At IC, the midline of the trunk is flexed to the left or the right side of the body	The trunk is not flexed to the left or right side of the body
	9	Knee Valgus Displacement	At MKV a line drawn straight down from the center of the patella runs through the great toe or is medial to the great toe	The line is lateral to the great toe
	10	Pelvic Drop	During landing the contralateral pelvis positioned lower than the ipsilateral pelvis	Both sides of the pelvis remain level
	11	Tibial Rotation (toe pointed in/out)	Between IC and MKF the foot is internally/ externally rotated more than 30º	If the foot is not internally/ externally rotated more than 30º

IC, initial contact; ROM, range of motion; MKF, maximum knee flexion; MKV, maximum knee valgus

- **Balance**

"The Star Excursion Balance Test (SEBT) is a reliable, responsive, and clinically relevant functional assessment of lower limbs' dynamic postural control."

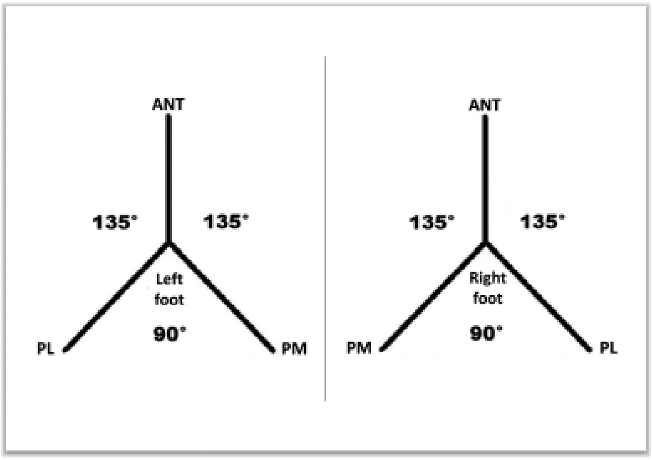


Figure 3: Setup of mSEBT grid

ANT = anterior; PL = posterolateral; PM = posteromedial; mSEBT = modified Star Excursion Balance Test; SEBT = Star Excursion Balance Test

Figure 4: Performing the mSEBT

2021 Updated Recommendation for the SEBT Procedure

Important criteria	Recommendations
Number of directions	Three (ANT, PM, and PL) representing a "Y" instead of eight.[13,16,31] See the proposed compact versions (Figure 3).
Setup of the test	Demonstration prior to the test by the experimenter (or video).[7,17]
Number of familiarization trials	Four in each direction for both limbs, until familiarization with procedure.[7,17]
Number of recorded trials	Three per direction.[7,17] *Performances should be stabilized*. Switch from one leg to the other between each direction to avoid fatigue.[18]
Hand position	Hands should remain on the hips to target lower limb performance. [14,21]
Foot placement	Barefoot (or socks), the most distal aspect of the great toe on 0 (crossroad of three lines) during the entire procedure. Need to be standardized across studies. This method avoids possible foot placement errors.[14]
Failure criteria	(a) Subject falls or loses his/her balance (the reaching foot touch the ground). (b) Subject shifts his/her weight on the reach limb when contacting the floor or contacts the floor at multiple times or miss the tape measure. (c) Stance foot moves or heel rises or any part of the foot lifts from the ground. (d) Hands are removed from the hips.
Parameter	(a) Mean of the three trials for each direction and limb.[46] (b) Calculation of the composite score (mean of three directions) for normalized (in percentage) and nonnormalized (in centimeters) scores. (c) Qualitative analysis of the movement.[56,57]
Limb length normalization	Scores are expressed as a percentage of the tested lower limb length (*from ASIS to medial malleolus preferably*, or lateral malleolus).[21]

Note. ASIS = anterior and superior iliac spine; ANT = anterior; PL = posterolateral; PM = posteromedial; SEBT = Star Excursion Balance Test.

- **Agility:**

"Specific Speed Test (On-court Agility Test)

Players must move from a central base at maximal speed to the extremities of the court using Badminton movements and simulating shots at set positions as detailed below.

Equipment

Tape measure. Masking tape (or similar) to mark out the court as specified.

Four shuttles. Three shuttle tubes (for 12 shuttles) taped end to end.

To prepare the court, mark the following onto a singles court (see figure 1).

- *Place a line at the rear court (forehand side) 75 cm from the sideline to complete a box also formed by the outside of a singles court and the doubles service line (labelled '1').*
- *Fix (with tape) the three shuttle tubes on the forehand sideline at a point 150 cm from the front service line (labelled '2').*
- *Place a shuttle on the net cord 50 cm in court from the backhand sideline (labelled '3'). This point is best marked by a small piece of tape for ease of replacement.*
- *Place a shuttle on the backhand side 150 cm from the short service line (labelled '4'). This point is also best marked by a small piece of tape for ease of replacement.*
- *Mark a rectangle (the 'central base') 150 cm back from the short service line, centred on the mid-line. The box must be 75 cm wide (side to side) and 50 cm deep (front to back)."*

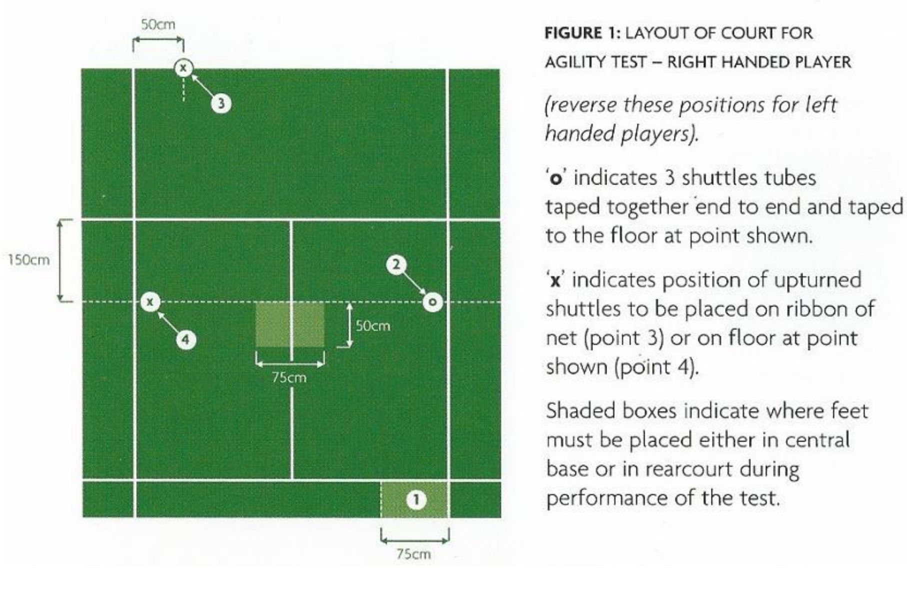


Figure 5: Layout of court for agility test (RT handed)

METHODOLOGY FLOW CHART

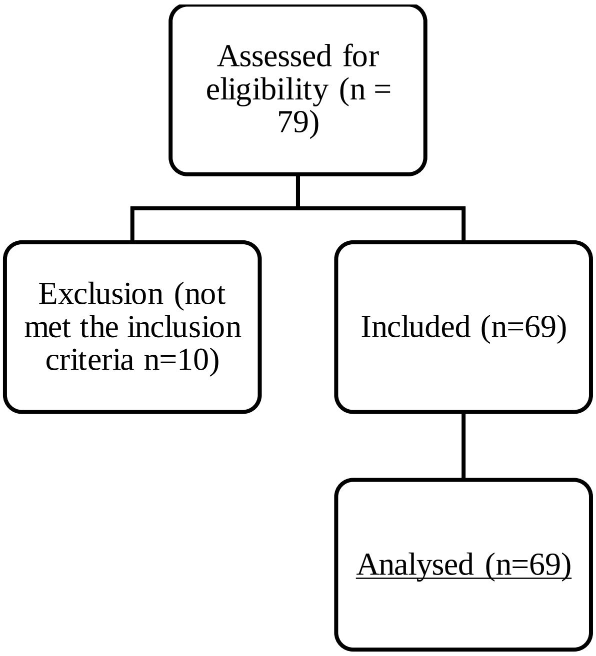


Figure 6: Methodology Flow Chart

STATISTICAL ANALYSIS

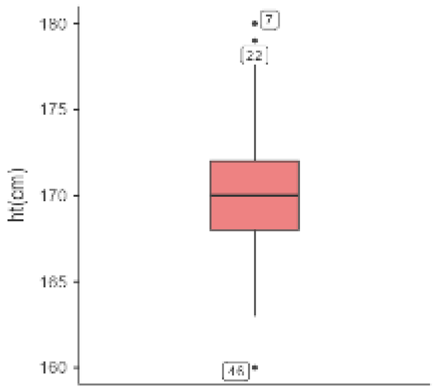
STATISTICAL ANALYSIS

The study included 69 under-18 Indian badminton players, with a mean age of 17.7 ± 0.78 years. The majority were males (92.8%) and right-leg dominant (63.8%). Mean anthropometric values were height 170.1 ± 4.23 cm and weight 61.6 ± 5.95 kg.

Table 1 presents the descriptives statistics of the study participants. The mean age was 17.7± 5.5 years. The mean height and weight values are also shown.

	Mean	SD
Age	17.7	0.783
ht(cm)	170.1	4.23
wt	61.6	5.951

Table 1: Descriptive statistics



The mean height was 170.1 ± 4.23 cm, and the boxplot shows a symmetric distribution centred on the median (\~170 cm). The majority of values fell within the interquartile range (165-175 cm), but there were three outliers: two participants (IDs 7 and 22) who were taller than the average, and one participant (ID 46) who was shorter. The average body weight was 61.6 ± 5.95 kg, with slightly more variation compared to height.

Gender	% of Total
female	7.20%
male	92.80%

Table 2: Frequency of gender

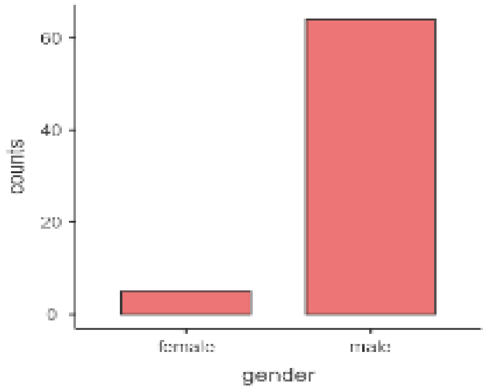


Figure 7: Gender distribution

The gender distribution of the study showed a significant predominance of males (92.8%) over females (7.2%). The boxplot further demonstrates this imbalance, with the majority of data points representing male participants and only a few outliers representing females.

Dominance	Counts	% of Total	Cumulative %
left	25	36.20%	36.20%
right	44	63.80%	100.00%

Table 3: Frequencies of Dominance

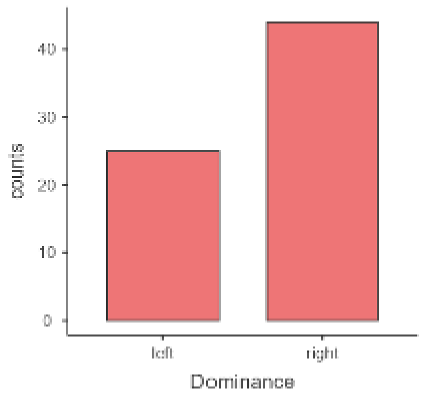


Figure 8: Frequency of Dominance

The dominance analysis for the 69 participants shows a clear right-handed bias. The frequency table shows 44 people who are right-handed, accounting for 63.8% of the total sample. In contrast, 25 people—or 36.2% of the sample—are left-handed. The bar chart depicts this distribution visually, with a taller bar for "right" dominance and a shorter bar for "left" dominance, based on the numerical findings.

This finding is consistent with general population trends, as most people are right-handed. The data also clearly depicts a cumulative percentage, demonstrating that right-handed people account for the remaining percentage after subtracting left-handed people, bringing the total to 100%.

	N	Mean	Median	SD	Minimum	Maximum	Shapiro-Wilk	
							W	p
Leg Length R	69	86.2	86	3.44	80	92	0.953	0.011
Leg Length L	69	86.1	86	3.39	80	92	0.952	0.01

Table 4: Limb length distribution

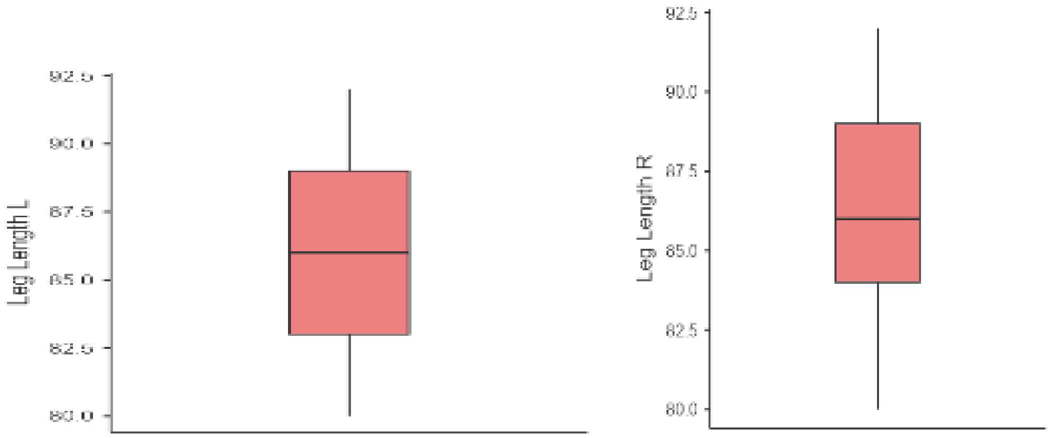


Figure 9: Limb Length distribution (i) Left, (ii) Right

In 69 participants, the distribution of right (R) and left (L) leg lengths was found to be very similar. The mean length of the right leg was 86.2 cm (SD = 3.44), and the left leg was 86.1 cm (SD = 3.39), with a median of 86 cm and a range of 80 cm to 92 cm. The box plots visually demonstrate this similarity, with nearly identical central tendencies and spreads. However, the Shapiro-Wilk test revealed that the data for both leg lengths are not normally distributed, with p-values of 0.011 for the right leg and 0.010 for the left, both of which are less than the 0.05 significance level. This implies that, while the lengths are nearly identical, their distribution deviates from a bell-shaped curve.

RESULTS

RESULT

Variable	Mean ± SD	(p)
Age (years)	17.7 ± 0.78	0.783
Height (cm)	170.1 ± 4.23	4.23
Weight (kg)	61.6 ± 5.95	5.951
Leg Length R (cm)	86.2 ± 3.44	0.011
Leg Length L (cm)	86.1 ± 3.39	0.010
Gender Distribution: 64 males (92.8%), 5 females (7.2%)		
Dominance: Right – 63.8%, Left – 36.2%		

Table 5: Descriptive Characteristics of Participants (N = 69)

The participants were mostly late adolescents, with an average age of 17.7 ± 0.78 years, indicating a uniform age distribution. Anthropometric measurements showed a mean height of 170.1 ± 4.23 cm and a mean weight of 61.6 ± 5.95 kg, indicating similar body profiles across the study. The mean leg length was similar between the right (86.2 ± 3.44 cm) and left (86.1 ± 3.39 cm) limbs, but statistically significant differences were noted ($p = 0.011$ and $p = 0.010$, respectively), indicating subtle asymmetries. The gender distribution was skewed, with 92.8% males ($n = 64$) and 7.2% females ($n = 5$), which may limit the applicability of the findings to female athletes. In terms of dominance, the majority of participants were right-leg dominant (63.8%), and 36.2% were left-leg dominant.

Variable Pair	Spearman's ρ	p-value	Interpretation
SLDJ vs Agility (sec)	0.828	0.000	Significant correlation

Table 6: Correlation Between Landing Mechanics (SLDJ) and Agility

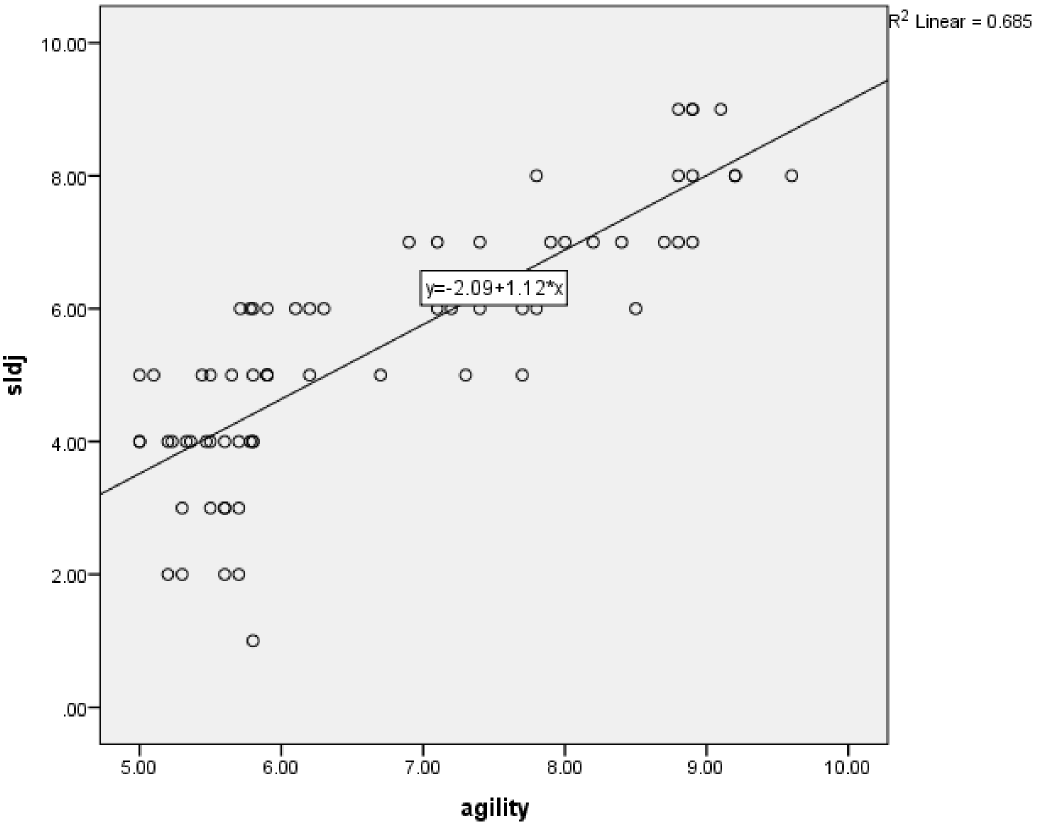


Figure 10: Landing Mechanics and Agility

Analysis revealed significant correlation between single-leg drop jump (SLDJ) scores and agility performance (Spearman's $\rho = 0.828$, $p< 0.05$). This indicates that the quality of landing mechanics does directly influence agility times in badminton players.

Balance Variable	Spearman's ρ	p-value	Interpretation
SLDJ vs L Composite %	0.253	0.036	Correlated
SLDJ vs R Composite	-.022	0.856	No correlation
SLDJ vs L Post-Lateral	0.146	0.231	No correlation
SLDJ vs R Post-Medial	-.038	0.759	No Correlation
SLDJ vs L Post-Medial	0.094	0.441	No Correlation
SLDJ vs R Post-Lateral	0.031	0.803	No Correlation
SLDJ vs L Anterior	0.076	0.534	No Correlation
SLDJ vs R Anterior	-.016	0.899	No Correlation

Table 7: Correlation Between Landing Mechanics (SLDJ) and Balance Scores

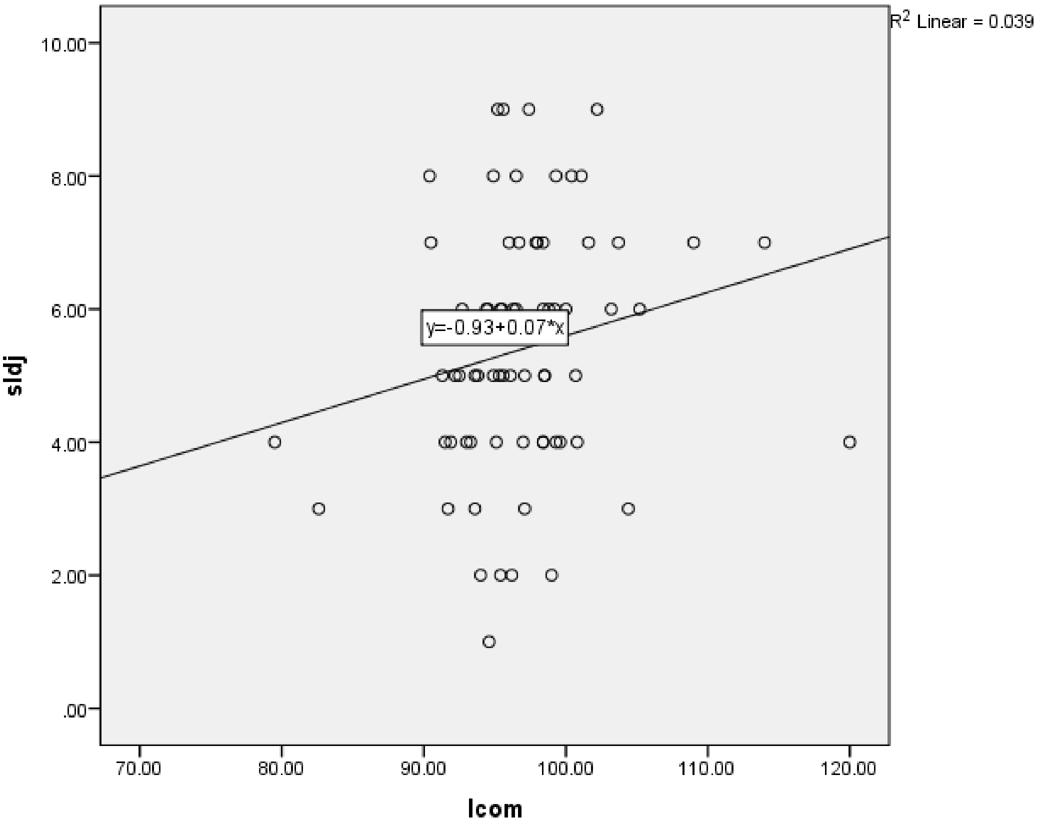


Figure 11: Left composite score and landing score

Weak correlation was observed between SLDJ and left composite balance score (Spearman's $\rho = 0.253$, $p = 0.036$).

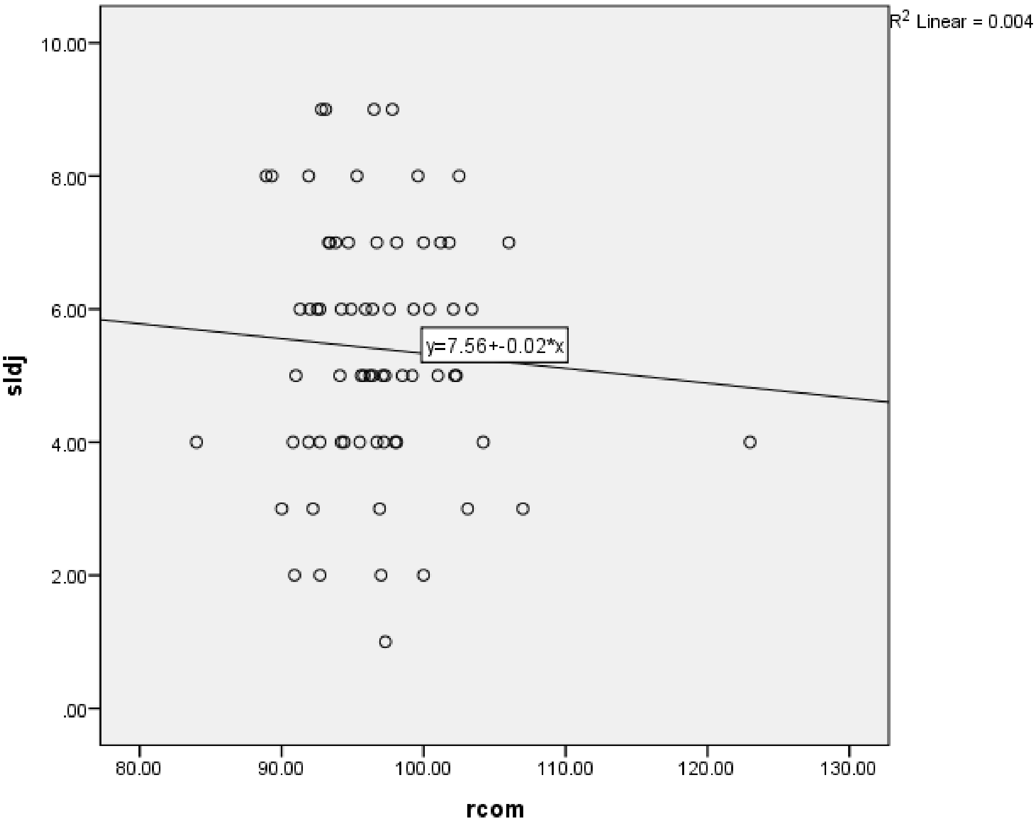


Figure 12: Right composite score and landing score

No Significant correlation was observed between SLDJ and right composite balance score (Spearman's ρ = -.022, p = 0.856).

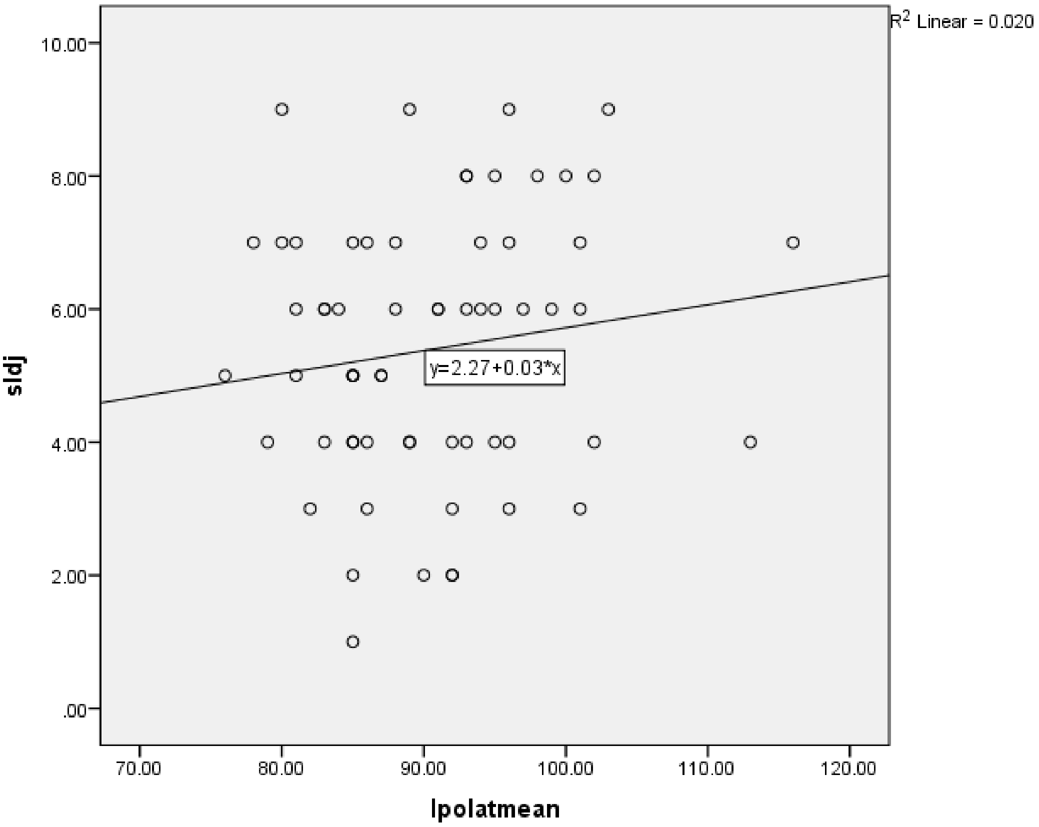


Figure 13: Left posterior lateral and landing score

Weak correlation, not significant was observed between SLDJ and Left posterior lateral balance score (Spearman's $\rho = 0.146$, $p = 0.231$).

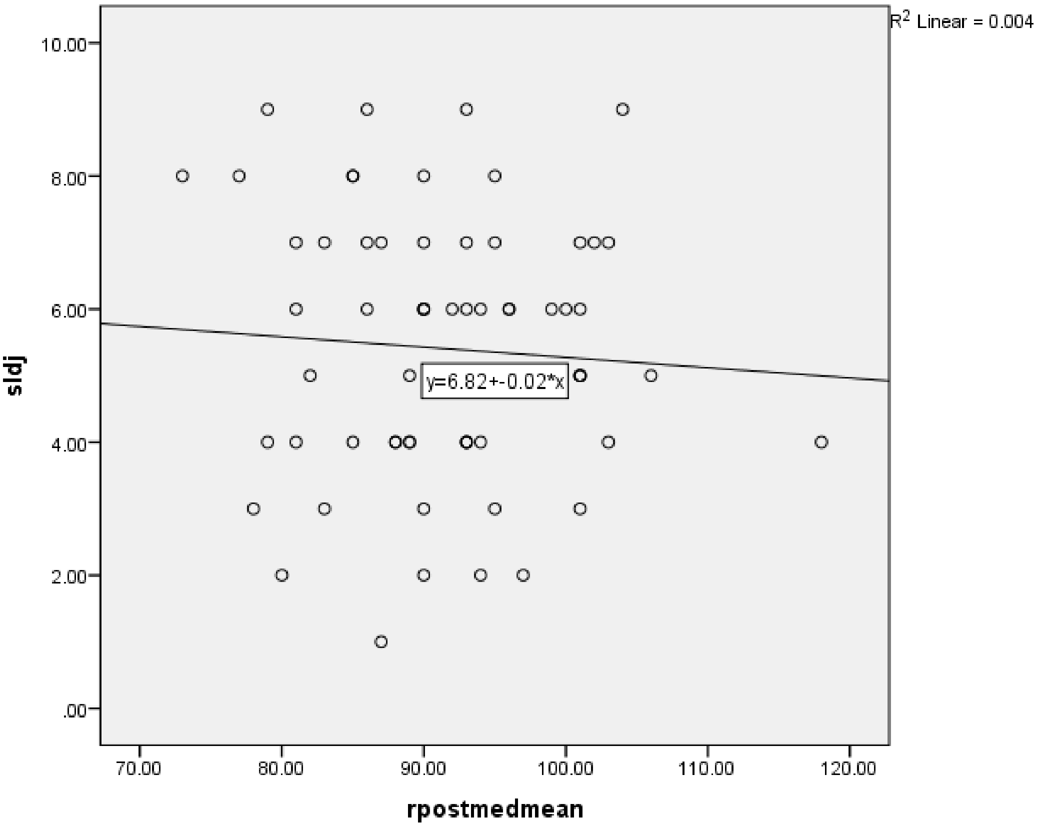


Figure 14: Right posterior medial and Landing score:

No Significant correlation was observed between SLDJ and Right posterior medial balance score (Spearman's ρ = -.038, p = 0.759).

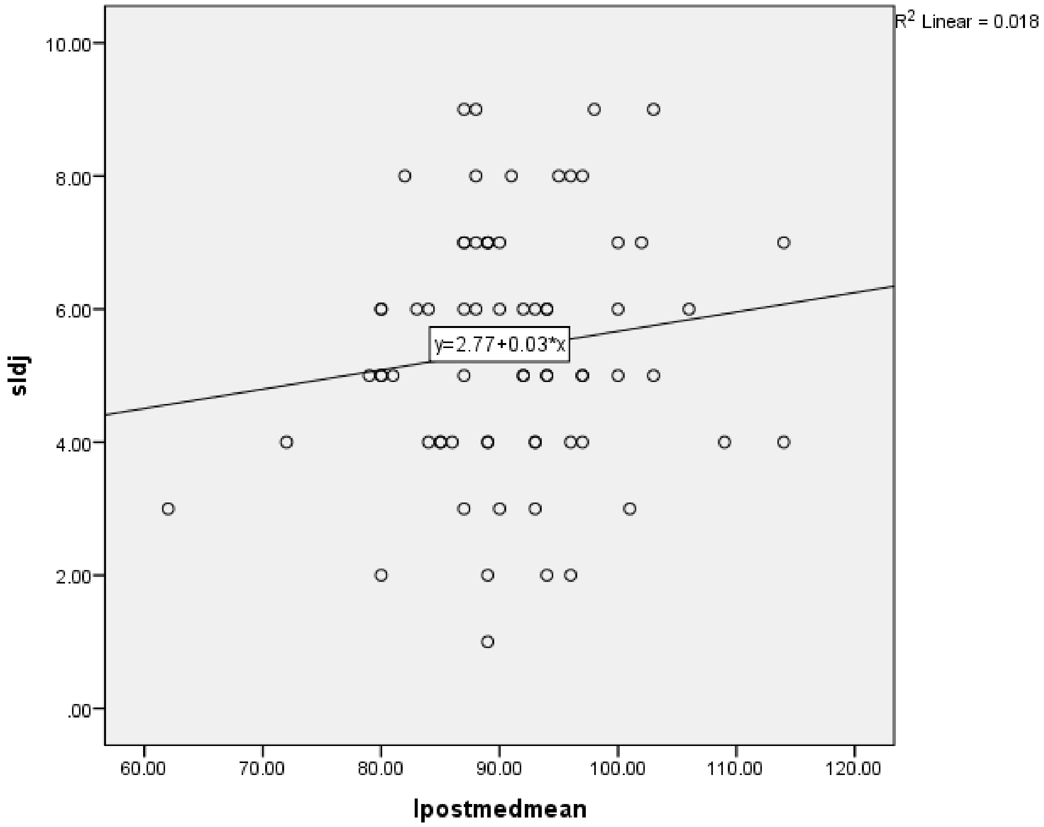


Figure 15: Left posterior medial and landing score

No Significant correlation was observed between SLDJ and Left posterior medial balance score (Spearman's ρ = 0.094, p = 0.441).

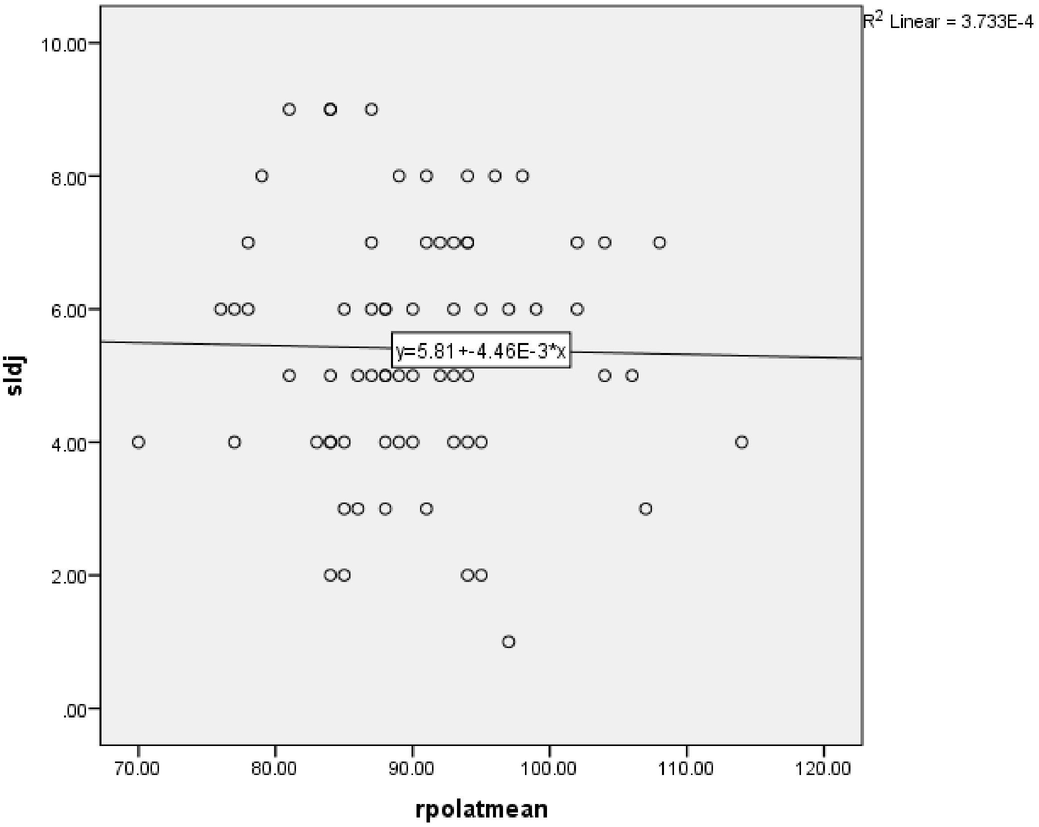


Figure 16: Right posterior lateral and landing score

No Significant correlation was observed between SLDJ and Right posterior lateral balance score (Spearman's ρ = 0.031, p = 0.803).

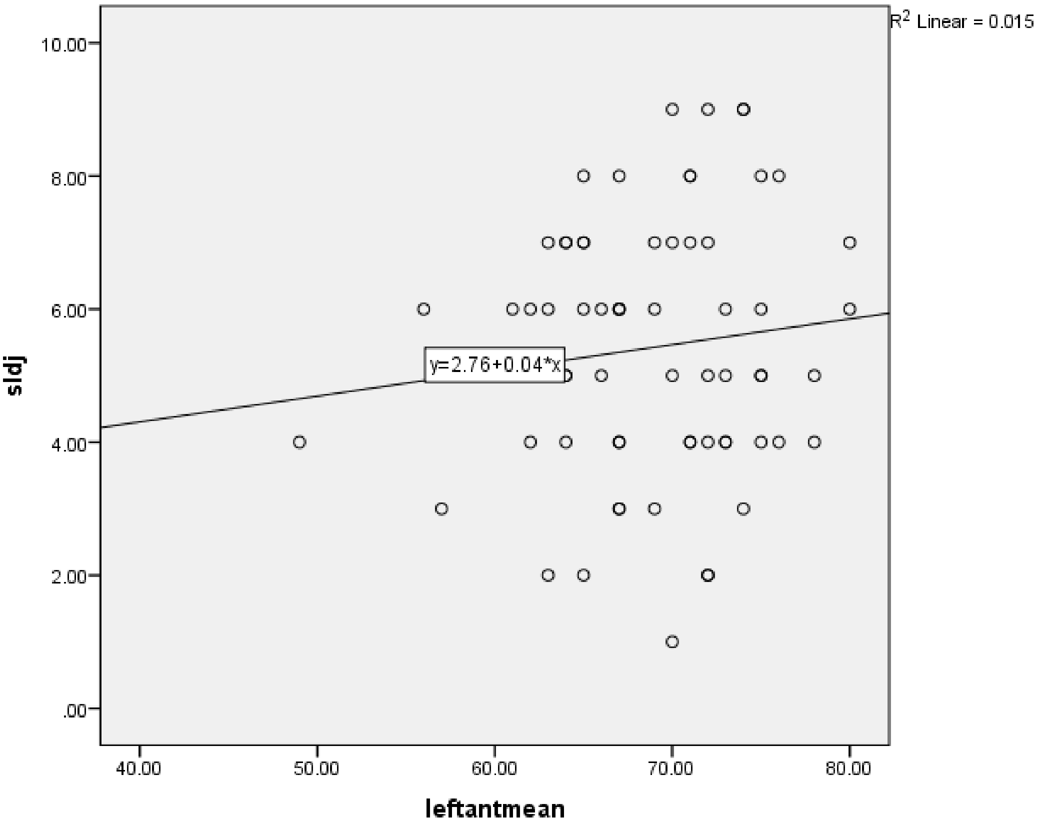


Figure 17: Left anterior and landing score

No Significant correlation was observed between SLDJ and left anterior balance score (Spearman's ρ = 0.076, p = 0.534).

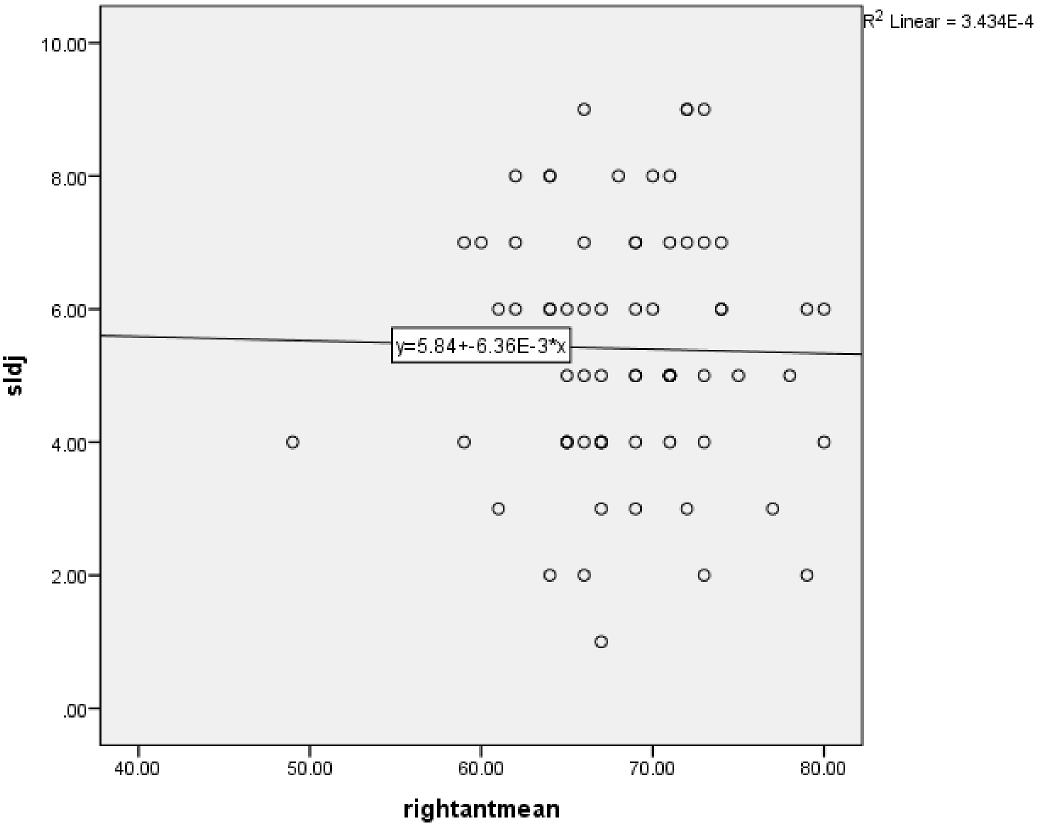


Figure 18: Right anterior and landing score

No Significant correlation was observed between SLDJ and Right anterior balance score (Spearman's ρ = -.016, p = 0.899).

Thus, poor landing mechanics appear to be modestly associated with deficits in balance control, specifically in the left composite measure and with agility performance

SL.NO	Outcome measure	R value	P value
1	Right composite score with right dominance	0.023	0.882
2	Right composite score with left dominance	-.100	0.634
3	Left composite score with right dominance	0.384	0.010
4	Left composite score with left dominance	-.022	0.915

Table 8: Correlation between Landing score and balance with dominant and non-dominant leg

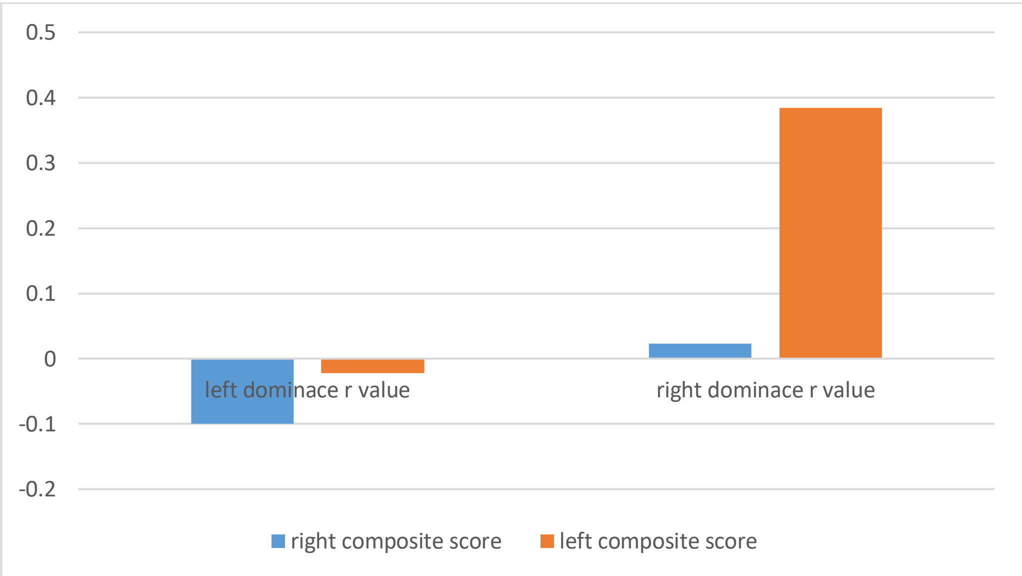


Figure 19: Dominance

1. Right composite score with right dominance ($r = 0.023$, $p = 0.882$):
   - There is no significant correlation
   - This means right composite score has no meaningful relationship with athletes who are right-dominant.
2. Right composite score with left dominance ($r = -0.100$, $p = 0.634$):
   - Very weak negative correlation.
   - Statistically not significant ($p > 0.05$).
   - Right-side balance does not appear to be a determining factor for left-handed players.
3. Left composite score with right dominance ($r = 0.384$, $p = 0.010$):
   - Moderate positive correlation and statistically significant.
   - Indicates that right-dominant athletes have better balance performance on their non-dominant (left) side.
   - This could be due to cross-limb balance adaptation, in which dominant-side control promotes stability on the opposing side.
4. Left composite score with left dominance ($r = -0.022$, $p = 0.915$):
   - Suggests left-dominant athletes' left-side balance is not related to their dominance.
   - no significant correlation

DISCUSSION

DISCUSSION

This study aimed to examine the relationship between landing mechanics, balance, and agility among under-18 badminton players. The findings partially supported the hypothesis:

Landing mechanics and agility: A significant relationship was observed. This suggests that agility in badminton, which relies heavily on quick directional changes, reactive speed, and neuromuscular coordination, may be strongly influenced by vertical landing quality. Previous studies in other sports have shown that agility is often more dependent on anticipation, cognitive processing, and footwork efficiency rather than landing stability alone.

Landing mechanics and balance: A weak but significant correlation with left composite balance scores suggests that asymmetries or errors in landing mechanics may affect certain aspects of balance. Since badminton are very well trained athletes involves repetitive unilateral landings and push-offs, they train the jump landings from years of practice this could be a major comeback for varied results.

The present study investigated the association between landing mechanics, agility, and dynamic balance among under-18 Indian badminton players. The findings provide nuanced insights into how neuromuscular control, postural stability, and sport-specific agility interact in adolescent athletes.

The study included 69 adolescent badminton players (mean age 17.7 ± 0.78 years; height 170.1 ± 4.23 cm; weight 61.6 ± 5.95 kg), predominantly male (92.8%) with right-leg dominance

(63.8%). Given the narrow anthropometric range, variations in landing and balance are likely due to neuromuscular and technical rather than structural factors.[13]

The analysis revealed significant correlation between single-leg landing error scores and agility as measured by the badminton-specific speed test ($\rho = 0.828$, p = 0.00). This association corelates with previous research, where poor landing mechanics were linked to reduced agility performance and predictive of slower sprint times and impaired change-of-direction ability in sports such as soccer and basketball [14]. The lack of association in badminton may be explained by the multidimensional nature of agility in this sport. Badminton agility is not purely mechanical but heavily dependent on perceptual and cognitive skills, such as reading the opponent's shot, anticipation, and decision-making speed[15]. The agility test used in this study, which incorporates shuttle striking and directional footwork, captures these broader demands.

The weak association in the present study was observed between landing mechanics and Left composite score on the Modified Star Excursion Balance Test (mSEBT) performed on the left limb ($\rho = 0.253$, $p < 0.001$). Athletes with higher landing error scores tended to demonstrate reduced reach, indicating a direct link between faulty landing mechanics and impaired dynamic stability. This relationship is biomechanically plausible because both tasks require effective ankle dorsiflexion, quadriceps eccentric control, and trunk stability. Inadequate dorsiflexion range or eccentric quadriceps strength leads to stiffer landings and limited forward reach[16]. Comparable findings have been reported in adolescent basketball players, where reduced anterior reach was associated with higher injury risk and impaired jump-landing control[17]. For badminton players, diminished anterior balance may reduce the ability to control forward lunges, which are among the most frequently executed movements during rallies.

Players with poor neuromuscular control during landing are likely to exhibit deficits in this plane as well, leading to reduced reach distances. This finding aligns with work by Maloney et al., who demonstrated that asymmetries in multidirectional balance performance predicted poorer change-of-direction speed in youth athletes[18]. In badminton, posteromedial stability is critical when performing defensive lunges and recovery steps following wide forehand or backhand shots. Poor control in this direction not only reduces the efficiency of recovery but may also predispose players to knee valgus collapse, a known risk factor for anterior cruciate ligament injuries[19].

The left posterolateral reach also showed a significant but weaker correlation with landing mechanics ($\rho = 0.146$ $p = 0.231$). This association suggests that posterior-lateral stability plays a supporting role in maintaining safe and efficient landings. The posterolateral component of the SEBT requires strong activation of the gluteus medius and external rotators to control hip abduction and prevent medial collapse. Although the correlation was weaker compared to anterior and posteromedial directions, it remains meaningful as it indicates that athletes with poor landing mechanics may also have difficulty controlling multiplanar postural tasks. Prior research has shown that deficits in posterolateral reach are associated with higher re-injury rates in athletes returning to sport after lower-limb injuries[20].

Interestingly, there is a significant positive correlation ($r = 0.384$, $p = 0.010$) between left-leg balance and right-leg dominance, implying that right-leg dominant players may develop superior contralateral (non-dominant) leg stability. This could be explained by the nature of badminton footwork, which involves frequent lunges, lateral shuffles, and single-leg landings that require strong support from the non-dominant leg during stroke execution and recovery.In contrast, no significant correlations were found for other combinations, indicating that dominant-leg balance is not always superior to non-dominant-leg balance, and performance may be influenced more by sport-specific demands than by pure dominance. This is consistent with previous findings in racket sports, where functional asymmetry and cross-dominance adaptations help with agility and landing control.

As most athletes were right-dominant, their left limb functioned more frequently as the stabilising leg during overhead strokes and defensive lunges. Repeated use of the non-dominant limb for stabilising tasks may expose deficits in neuromuscular control more clearly than the dominant limb, which is primarily employed for explosive strokes and directional push-offs. Fransz et al. reported similar asymmetries in single-leg postural stability following drop jump tasks, noting that non-dominant limbs were more strongly associated with balance deficits[20]. This asymmetry highlights the importance of bilateral assessment and targeted training of the stabilising limb in unilateral sports like badminton.

The consistent associations between landing mechanics and balance measures can be mechanistically explained by their shared reliance on neuromuscular control, proprioception, and eccentric strength. Faulty landings reflect insufficient force attenuation strategies, such as inadequate hip and knee flexion, poor trunk positioning, or delayed muscle activation. These same deficits impair performance in dynamic balance tests, where rapid joint adjustments are required to maintain stability during reach tasks. Adolescents may be particularly vulnerable due to mismatched growth in skeletal and neuromuscular systems during puberty, leading to temporary declines in coordination and control[10]. Thus, the findings of this study are consistent with theoretical models of motor development and neuromuscular adaptation.

Identifying poor landing mechanics is essential because they may not immediately impair agility but could compromise balance and lead to increased risk of ankle sprains, knee injuries, and overuse syndromes. This highlights the importance of integrating neuromuscular training, proprioceptive drills, and unilateral stability exercises in the conditioning programs of young badminton players.

The present results are supported by Hung et al., who highlighted the prevalence of lower limb injuries following single-leg landings in badminton[17], and by Guo et al., who demonstrated that combined balance and plyometric training enhanced agility through improved postural control[18]. They also resonate with studies in broader youth populations, such as Read et al., who documented maturational effects on landing mechanics[19], and Rudd et al., who found that motor competence explained a significant proportion of landing error variance in boys aged 10–13[20]. However, the correlation with agility similarity with Bishop et al., who linked drop-jump asymmetries to slower sprint and agility performance[14]. This discrepancy likely reflects the cognitive-perceptual nature of badminton agility tests, which incorporate reaction and anticipation demands not present in linear sprint tasks.

From a practical standpoint, the findings underscore the need to incorporate dynamic balance and landing control exercises into youth badminton training programs. Screening with landing error scoring and SEBT can identify at-risk athletes early. Coaches should incorporate eccentric strength training for the quadriceps and gluteal muscles, as well as ankle dorsiflexion mobility exercises and proprioceptive drills, to improve both landing mechanics and balance. Given the observed asymmetry, targeted training of the non-dominant (often stabilising) leg is crucial. Additionally, agility development should not be limited to physical drills but should include perceptual-cognitive elements such as opponent anticipation and reaction to unpredictable stimuli.

CONCLUSION

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CONCLUSION

In conclusion, the present study demonstrated that poor landing mechanics were weakly associated with deficits in dynamic balance, particularly in left posteromedial directions on the non-dominant limb and strong relationship with agility . These results highlight the central role of neuromuscular control and proprioceptive capacity in adolescent badminton players. Coaches and practitioners should prioritise the training and assessment of landing strategies and dynamic balance to enhance performance and reduce injury risk in this population

LIMITATIONS AND FUTURE SCOPE

LIMITATIONS AND FUTURE SCOPE

The strengths of this study include its use of validated outcome measures, focus on a sport-specific adolescent population, and integration of both mechanical and functional assessments. However, limitations include the cross-sectional design, which precludes causal inference, and the absence of sex-specific analyses despite known gender differences in adolescent landing biomechanics[10]. The reliance on two-dimensional video analysis may also have reduced the precision of kinematic assessments compared with three-dimensional motion capture.

Future research should adopt longitudinal designs to track neuromuscular development across puberty and explore the causal pathways between landing mechanics, balance, and agility. Intervention studies examining the impact of targeted neuromuscular and proprioceptive training on reducing landing errors and enhancing sport-specific performance are warranted. Inclusion of sex-specific analyses and reactive agility tests that better simulate in-game demands would also strengthen the evidence base.

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ANNEXTURE

ANNEXURE A: IEC Certificate

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE, BHUBANESWAR, ODISHA

CDSCO Reg. No.: ECR/1981/Inst/OD/24

Prof. (Dr.) E. Venkata Rao Chairperson	Mr. Chinmaya Kumar Patra Member Secretary

Ref. No. ABSMARI/ IEC/2025/094 Date 10-01-2025

APPENDIX – XV

IEC ACKNOWLEDGEMENT RECEIPT

Proposal ID: **ABS-IEC-2025-PHY-053**

Title Correlation Between Poor Landing Mechanics, Balance and Agility Among Under 18 Indian Badminton Players- A Cross Sectional Study.

Submitted on: Date 06/01/2025 Time:

Submitted by: **Internal**

Proposal Type: Academic proposal without funding

Investigator's (s) Name:

Dear Dr./ Mr./ Ms. **NAVYA R**

The undersigned do hereby acknowledge that your proposal for the Ethical Review has been received by the I.E.C Secretariat of ABSMARI as on date and time stated above. The Secretariat shall keep you inform about its progress, schedule of the review meeting for presentation as well as the proponent on the result of evaluation as per the SOP.

With best regards,

Member Secretary,
ABSMARI Ethics Committee

Member Secretary
ABSMARI ETHICS COMMITTEE

ABSMARI ETHICS COMMITTEE BHUBANESWAR Dt.................

Utkal Signature, Plot No.-273, Ground Floor, Pahal, Bhubaneswar-752101 +91-63707-03654 iec@absmari.com

ABSMARI

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA

CDSCO Reg. No.: ECR/1981/Inst/OD/24

Ref. No. ABSMARI/IEC/2025/165

Date: 09/05/2025

APPROVAL LETTER
APPENDIX- VIII

To,

NAVYA R
ABSMARI
273, PAHAL, BHUBANEWAR-752101

Protocol Title: Correlation between Poor landing mechanics, balance and agility among under 18 Indian Badminton Players- A Cross sectional Study

Protocol ID.: ABS-IEC-2025-PHY-053

Subject: Approval for the conduct of the above referenced study

Dear Mr./Ms./Dr **NAVYA R**
With reference to your Submission letter dated 06/01/2025 the ABSMARI IEC has reviewed and discussed your application for conduct of the study on dated 25/04/2025.

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	25/04/2025
2	Informed Consent Form	25/04/2025
3	Undertaking form PI	25/04/2025
4	CRF	25/04/2025
5	COI from the Investigators	25/04/2025

The following members were present at meeting held on 25-04-2025

ABSMARI ETHICS COMMITTEE Dt. 9/5/25 BHUBANESWAR

Utkal Signature, Plot No.-273, Ground Floor, Pahal, Bhubaneswar-752101 +91-63707-03654 iec@absmari.com

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA

CDSCO Reg. No.: ECR/1981/Inst/OD/24

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/165

Date: 09/05/2025

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the Institution (Y/N)
1	Prof. Dr. E. Venkata Rao	Professor (MBBS, MD, Dept. of Community Med.) IMS & Sum Hospital, BBSR	Chair Person	M	N
2	Dr. Smaraki Mohanty	Asst. Prof-IMS & Sum Hospital/MBBS, MD (Community Med)	Clinician	F	N
3	Mr. Shiba Sankar Mohanty	Junior Counsel-Lt. Ramachandra Sarangi's Chamber / BA LLB	Legal Expert	M	N
4	Mr. Chinmaya Kumar Patra	Principal-ABSMARI, MPT	Member Secretary	M	Y
5	Ms. Annie Hans	Disability Inclusive Development Co-Ordinator in Humanity and Inclusion (India/Nepal/Srilanka). /MA in Social Work	Social Scientist	F	N
6	Ms. Subhashree Samal	Ret. Reader-Pol Sc.	Lay Person	F	N
7	Mr. Deepak Kumar Pradhan	Asst. Prof-ABSMARI, MPT	Scientific Member	M	Y

This is to confirm that only members who are independent of the Investigator and the Sponsor of the trial have voted/ provided opinion on the trial.

This Committee approves the documents and the conduct for the study in the presented form with necessary recommendation.

The ABSMARI IEC must be informed about the progress of the study in the prescribed format attached, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent/assent and request to provide a copy of the final report.

The ABSMARI IEC follows procedures that are in compliance with the requirements of ICH (International Conference on Harmonization) guidance related to GCP (Good Clinical Practice) and applicable Indian regulations.

Yours sincerely

Mr. Chinmaya Kumar Patra
Member Secretary
ABSMARI Ethics Committee

MEMBER SECRETARY
ABSMARI ETHICS COMMITTEE

ABSMARI ETHICS COMMITTEE
Dt. 9/5/25
BHUBANESWAR

Utkal Signature, Plot No.-273, Ground Floor, Pahal, Bhubaneswar-752101 | +91-63707-03654 | iec@absmari.com

ANNEXURE B: Informed consent form

ASSENT FORM

Study Title: Correlation between Poor landing mechanics, balance and agility among under 18 Indian badminton players

Study Number: ABS-IEC-2025-PHY-048

Investigator's Name: Navya R

Details of the participant subject -

Subject's Name: Subject's Initials:

Date of Birth/Age:

Address of the Subject:

Qualification:

Occupation: (If any)

Part 1:

1. Introduction

I am going to give you information and invite you to be part of a research study. You can choose whether you want to participate. We have discussed this research with your parent(s)/legal guardian, and they know that we are also asking you for your agreement. If you are going to participate in the research, your parent(s)/guardian also must agree. But if you do not wish to take part in the research, you do not have to, even if your parents have agreed.

You may discuss anything in this form with your parents or friends or anyone else you feel comfortable talking to. You can decide whether to participate or not after you have talked it over. You do not have to decide immediately.

There may be some words you don't understand or things that you want me to explain more about because you are interested or concerned. Please ask me to stop at any time and I will take time to explain).

2. The purpose of this study is to assess your badminton landing mechanics, balance and agility.
3. You are being asked because your input is valued and relevant to my study.
4. Participation is voluntary.

5. Procedure has been explained.
6. There are no risks involved in this study.
7. The intervention will not hurt any of the participants.
8. Your badminton landing technique will be assessed and corrected if required.
9. As the study is not funded there will be no reimbursements.
10. Confidentiality of each participant is maintained.
11. If in case you get hurt, appropriate measures will be taken to address the situation.
12. The final findings will be shared with each participant.
13. You have the right to choose not to participate in the research, and you may withdraw at any time without penalty.
14. You can contact me (Navya R) for any doubt or clarification.

Navya R

Signature

Date: _______

Part 2:

Certificate of Assent

I/ my parent or legal guardian has read the previous page(s) of the consent form, and the investigator has explained the details of the study.

I/my parent or legal guardian understands that I am free to ask additional questions.

I/my parent or guardian understands that participation in this study is voluntary

1/my parent or legal guardian may refuse to participate or may discontinue participation at any time without penalty, loss of benefits, or prejudice to the quality of care which I will receive.

I/my parent or legal guardian, acknowledge that no guarantees have been made to me regarding the results of the treatment involved in this study, and I agree to participate in the study.

Statement by the Child

Name of child:

Signature of child: ___________________ Date: ___________

Parent's or legal guardian's Name:

Signature or legal guardian: __________________ Date: ____________

If illiterate:

A literate witness must sign (if possible, this person should be selected by the participant, not be a parent, and should have no connection to the research team). Participants who are illiterate should include their thumb print as well.

I have witnessed the accurate reading of the assent form to the child, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Name of impartial witness (not a parent): ________________ Thumb print of participant

Signature of witness: ________________

Date: _________________

Statement by the researcher/person taking assent

I confirm that the child and respective parents or legal guardian were given an opportunity to ask questions about the study, and all the questions asked by him/her have been answered correctly and to the best of my ability. I confirm that they have not been forced into giving assent, and the assent has been given freely and voluntarily.

Navya R

INFORMED CONSENT

Study Title: Correlation between Poor landing mechanics, balance and agility among under 18 Indian badminton players

Study Number: ABS-IEC-2025-PHY-048

Subject 's Name: ______________ Subject 's Initials: _________

Date of Birth / Age: _______

Address of the Subject______________

Qualification ______________________

Occupation: Student/Self-Employed/ Service/Housewife/Others (Please tick as appropriate)

Annual Income of the subject __________________ if applicable

Name and address of the nominee(s) and his relation to the subject ___________________________________ (for the purpose of compensation in case of trial related death).]

(i) I confirm that I have read and understood the information sheet dated _______ for the above study and have had the opportunity to ask questions.

(ii) I understand that my participation in the study is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected.

(iii) I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s) (iv) I agree to take part in the above study

Signature (or Thumb impression) of the Subject/Legally Acceptable Representative:

____

Date: _____/ ____/ _____

Signatory 's Name: ____

Signature of the Investigator:

Date:

Study Investigator 's Name: Navya R

Signature of the Witness: ________________

Date: ________/ _________/ __________

Name of the Witness: ____

ANNEXURE C: Case record form

CASE REPORT

NAME:

AGE:

GENDER:

HEIGHT:

WEIGHT:

BMI:

OUTCOME MEASURE	VALUE
2D ANALYSIS (ERROR)	
BADMINTON SPECIFIC AGILITY TEST (TIME)	
MODIFIED STAR EXCURSION BALANCE TEST (COMP.SCORE)	

ANNEXURE D: Master Chart

Name	Age	Gender	Ht (cm)	Wt (kg)	SLDJ	Agility (secs)	Leg Length R	Leg Length L	Dominance	R Composite score %	L Composite score %
athele1	15	male	168	60	6	5.71	88	88	right	97.6	100
athele2	17	male	170	64	3	5.3	82	82	left	107	104.4
athele3	18	male	170	58	2	5.3	85	85	left	100	99
athele4	15	male	165	50	5	5.65	86	86	right	101	92.5
athele5	18	male	168	60	7	8.9	87	87	right	100	114
athele6	17	male	170	65	7	8.8	83	83	right	106	109
athele7	18	male	180	64	4	5.47	84	84	right	123	120
athele8	18	male	169	65	3	5.7	85	85	left	90	82.6
athele9	18	male	169	85	4	5.23	86	86	right	84	79.5
athele10	18	male	170	60	4	5.33	81	91	left	94.2	91.9
athele11	17	male	175	64	5	5.44	90	89	right	94.1	100.7
athele12	16	female	177	69	6	7.1	88	84	right	92	103.2
athele13	18	male	165	50	5	5	85	92	left	97.3	91.3
athele14	17	male	166	58	6	7.4	85	85	left	94.9	96.5
athele15	18	male	170	65	2	5.2	91	84	right	92.7	94
athele16	18	male	172	64	8	9.2	81	91	right	102.5	94.9
athele17	18	male	168	70	9	8.9	89	84	right	97.8	95.6
athele18	18	male	169	61	7	7.1	82	80	right	94.7	97.9
athele19	18	female	172	62	7	6.9	81	86	right	96.7	101.6
athele20	18	male	170	60	5	5.9	86	90	right	102.3	92.2
athele21	18	male	177	67	7	8.2	92	82	right	93.8	103.7
athele22	18	male	179	66	4	5.78	89	86	left	94.4	99.6
athele23	18	male	174	70	4	5.5	89	81	right	98.1	98.4
athele24	18	male	177	62	6	6.2	89	88	right	103.4	99.2
athele25	18	male	176	66	5	5.9	90	86	right	95.6	95.3
athele26	18	male	166	60	6	6.3	86	84	right	94.2	98.4
athele27	18	female	167	55	6	5.9	81	82	left	102.1	92.7
athele28	18	male	163	60	2	5.6	90	87	right	97	96.2
athele29	18	male	172	62	3	5.5	85	88	left	92.2	91.7
athele30	18	male	174	60	3	5.6	86	92	left	103.1	97.1
athele31	18	male	170	69	6	5.8	84	85	right	96.4	94.5
athele32	18	male	163	64	4	5.8	82	82	left	96.7	98.4
athele33	18	male	166	66	5	5.9	92	90	right	97.1	98.5
athele34	18	male	169	67	8	8.8	90	88	right	89.3	100.4

Name	Age	Gender	Ht (cm)	Wt (kg)	SLDJ	Agility (secs)	Leg Length R	Leg Length L	Dominance	R Composite score %	L Composite score %
athele35	18	male	164	58	9	9.1	88	89	right	92.8	102.2
athele36	18	male	168	55	6	8.5	85	81	left	92.5	96.3
athele37	18	male	170	62	6	5.78	90	84	right	95.9	94.4
athele38	18	male	176	66	3	5.6	87	89	right	96.9	93.6
athele39	18	male	165	54	4	5	85	90	right	98	93.3
athele40	18	male	172	55	5	5.1	85	85	right	99.2	94.9
athele41	18	male	177	59	9	8.9	82	90	left	93.1	95.2
athele42	18	male	173	51	8	9.2	81	90	right	88.9	101.1
athele43	18	male	170	60	5	6.2	87	85	right	95.8	96.1
athele44	18	male	169	66	4	5	91	91	right	91.9	99.3
athele45	18	male	166	63	7	8.7	80	83	left	101.2	98
athele46	18	male	160	64	7	8.4	91	83	right	101.8	96
athele47	18	male	170	68	6	7.7	90	88	right	100.4	95.5
athele48	18	male	173	62	5	6.7	83	88	right	96.4	98.5
athele49	18	male	177	66	5	5.5	88	81	left	96.2	97.1
athele50	18	male	170	67	8	9.6	82	90	left	99.6	99.3
athele51	18	male	165	66	7	7.4	89	82	left	93.3	96.7
athele52	18	male	166	69	4	5.6	89	90	right	95.5	91.5
athele53	18	male	168	66	6	7.2	84	80	left	91.3	95.4
athele54	18	male	170	67	4	5.8	80	90	left	104.2	93
athele55	18	male	171	61	8	8.9	92	90	left	95.3	90.4
athele56	18	male	164	62	9	8.8	85	90	right	96.5	97.4
athele57	16	male	172	64	7	7.9	91	88	right	93.4	90.5
athele58	17	male	173	66	7	8	88	86	right	98.1	98.4
athele59	18	male	170	58	6	7.8	90	89	left	99.3	105.2
athele60	16	female	168	54	5	5.8	89	83	right	91	93.6
athele61	18	male	169	57	4	5.2	82	90	right	92.7	97
athele62	18	male	167	52	2	5.7	84	87	right	90.9	95.4
athele63	17	male	166	59	8	7.8	86	85	right	91.9	96.5
athele64	15	female	170	55	1	5.8	86	86	right	97.3	94.6
athele65	18	male	170	58	4	5.7	80	87	left	90.8	100.8
athele66	18	male	178	53	6	6.1	87	80	left	92.7	98.8
athele67	18	male	176	51	4	5.36	82	81	left	97.2	95.1
athele68	16	male	171	56	5	7.7	89	83	right	102.2	95.6
athele69	17	male	170	55	5	7.3	88	81	left	98.5	93.8

Navya R

CORRELATION BETWEEN POOR LANDING MECHANICS, BALANCE AND AGILITY AMONG UNDER-18 INDIAN BADMIN...

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