RESEARCH PAPER

Correlation of Medial Longitudinal Arch Height with Dynamic Balance, Single-Leg Hop Distance, And Agility in Recreational Athletes: A Cross-Sectional Study

Nibha Kumari [1], Saikat Mandal* [2], Brijesh Prajapati [2], Ajit Kumar Gupta [2], Chandni Bhattacharjee [2] and Sahil Pawaria [2]

[1]BPT student, Department of Physiotherapy, Galgotias University, Greater Noida, Gautam Buddh Nagar, Uttar Pradesh, India, PIN-203201
[2]Assistant Professor, Department of Physiotherapy, Galgotias University, Greater Noida, Gautam Buddh Nagar, Uttar Pradesh, India, PIN-203201
https://orcid.org/0009-0000-3025-6291.
***Corresponding author:** m.saikat.mandal@gmail.com*

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ABSTRACT

Background: The medial longitudinal arch (MLA) is a key structural component of the foot during physical activity, contributing to stability, shock absorption, and lower-limb biomechanics. Alterations in MLA mobility may influence agility, functional performance, and dynamic balance; however, evidence on these relationships in recreational athletes remains limited.

Objective: This cross-sectional correlational study aimed to examine the relationship between MLA mobility and dynamic balance, single-leg hop distance, and agility in recreational athletes.

Methods: Sixty-seven healthy young adults (39 males, 28 females) aged 18–28 years participated. MLA mobility was assessed using the navicular drop test (NDT). Dynamic balance in the anterior, posteromedial, and posterolateral directions was assessed using the Y-balance test (YBT). Lower-limb functional performance was evaluated using the single-leg hop test, and agility was assessed using the zig-zag agility test. Relationships between variables were analyzed using Spearman's rank correlation coefficient, with significance set at $p < 0.05$.

Results: Right and left NDT values were moderately positively correlated ($r = 0.593$, $p < 0.001$). Left NDT showed weak positive correlations with right posteromedial ($r = 0.277$, $p = 0.012$) and right posterolateral ($r = 0.283$, $p = 0.010$) YBT reach distances. Strong positive correlations were observed between posteromedial and posterolateral reach directions on the left ($r = 0.922$, $p < 0.001$) and right ($r = 0.804$, $p < 0.001$) sides. Right and left single-leg hop distances were strongly correlated ($r = 0.769$, $p < 0.001$). Agility time was moderately negatively correlated with right ($r = -0.367$, $p = 0.001$) and left ($r = -0.402$, $p < 0.001$) single-leg hop distance. No significant correlations were found between NDT and single-leg hop distance or agility performance.

Conclusion: MLA mobility is weakly associated with select dynamic balance measures but does not appear to significantly influence single-leg hop performance or agility. Functional performance and agility in recreational athletes are likely governed by factors beyond arch mobility alone.

Keywords: Medial longitudinal arch, navicular drop test, dynamic balance, Y-balance test, single-leg hop test, agility, recreational athletes, foot biomechanics.

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INTRODUCTION

The medial longitudinal arch (MLA) is a key structural component of the foot that provides functional stability, absorbs impact loads, and contributes to energy transfer during physical activity. Altered arch structure, particularly flatfoot, has been associated with reduced mobility and diminished functional performance in physically active individuals [1,2]. Changes in foot posture have also been shown to affect balance and postural control, underscoring the importance of arch structure for maintaining stability [3]. Because functional balance is critical to athletic performance and injury prevention [4], its relationship with foot structure has drawn increasing research interest. Individuals with flatfeet demonstrate significantly lower Y-balance test performance than those with normally arched feet [5], and

**Author for Correspondence: m.saikat.mandal@gmail.com*

foot form has similarly been shown to affect functional balance in healthy university students [3].

Arch height has also been linked to dynamic balance and neuromuscular control in athletic populations such as dancers [6], and MLA mobility has been shown to correlate with postural control, with altered arch motion associated with poorer balance [7]. Differences in postural balance across athletes with varying arch types further highlight the role of foot shape in athletic performance [8].

The navicular drop test (NDT) is a widely used clinical measure of MLA mobility and pronation-related foot function. Asymmetry in navicular drop height has been identified as an internal risk factor for lower-limb injury in recreational athletes [9,10], and strengthening of proximal and distal lower-limb musculature has been shown to improve navicular drop, balance, and foot posture index in individuals with overpronated feet [11].

Functional tasks such as the single-leg hop require adequate lower-limb balance, strength, and neuromuscular coordination [12], while repeated agility tests—incorporating rapid changes in direction and dynamic stability—are commonly used to assess agility in athletes [13]. Foot arch type has similarly been linked to differences in agility and speed performance, particularly in running [14].

Foot arch abnormalities have been associated with reduced physical performance, functional capacity, and quality of life [2], and flatfoot-related changes in foot function have been linked to poorer physical performance and functional movement economy [1]. These findings suggest that MLA characteristics may have relevance to foot function beyond balance alone [7].

A comprehensive assessment of foot posture and arch mobility is needed to clarify their relationship with balance and functional performance [9]. Both questionnaire-based and functional assessment methods have demonstrated adequate validity and reliability for evaluating foot-related functional limitations in clinical and research settings [15], and reliable outcome measures are therefore essential when examining the relationship between arch height and dynamic performance [4].

Most prior research has compared performance across different foot types [14], and while balance differences based on foot posture have been reported among students and athletes [3], few studies have examined multiple performance domains—balance, hop distance, and agility—in combination. Although existing evidence supports an association between MLA characteristics and balance, postural control, and functional performance, its relationship with dynamic performance measures such as hop distance and agility remains unclear, with most studies focusing on isolated outcomes or comparisons between foot types rather than combined relationships. Clarifying these relationships may help inform strategies to enhance athletic performance and reduce injury risk.

Accordingly, the aim of this cross-sectional study was to determine the association between MLA height, measured using the navicular drop test, and dynamic balance, single-leg hop performance, and agility in recreational athletes, in order to generate evidence relevant to physiotherapy assessment and treatment planning [1].

MATERIALS AND METHODS

Study Design

This was a cross-sectional correlational study.

Participants

Participants were recruited and screened for eligibility between August 2025 and June 2026 according to predefined inclusion and exclusion criteria. Written informed consent, provided in each participant's preferred language, was obtained prior to enrollment. Inclusion criteria comprised healthy individuals of either sex aged 18–28 years, recruited using a convenience sampling method. Sample size was calculated using G*Power software based on correlation coefficients reported by Ghorbani et al. [1], assuming a one-tailed test with $r = 0.4$, $\alpha = 0.05$, and power = 80%; the minimum required sample size was 67. Of 77 individuals initially screened, 67 met the eligibility criteria and were enrolled (see Results and Figure 3).

Ethical Considerations

Institutional ethical approval was obtained prior to the commencement of the study, and written informed consent was obtained from each participant from the Galgotias University with reference no. SRC/PT/UG/25-26/206/086. Demographic data, including age, sex, height, weight, and BMI, were recorded for all participants.

Outcome Measures

Navicular Drop Test (Brody's Method)

The navicular drop test was performed on all participants in both non-weight-bearing and weight-bearing positions. For the non-weight-bearing measurement, participants were seated with the hip and knee flexed to 90° and the foot flat on the floor; the navicular tuberosity was palpated and marked, and the vertical distance from the navicular tuberosity to the supporting surface was measured using a vernier caliper. The same landmark was then re-measured in relaxed bilateral standing to obtain the weight-bearing value, with navicular drop calculated as the difference between the two measurements [16].

Y-Balance Test

Prior to testing, participants received a demonstration of the test procedure and completed six practice trials in each of the three reach directions (anterior, posteromedial, posterolateral) on each limb. During testing, participants stood barefoot with the stance foot centered on the platform and aligned with the start line, and were instructed to maintain single-limb stance while reaching maximally with the contralateral limb in each direction (Figure 1) [16].

Single-Leg Hop Test

The distance from the toe at the starting position to the heel at landing was measured in centimeters. A trial was considered successful only if the participant-maintained balance on the landing leg, without additional hops, until the landing position was recorded; unsuccessful trials were repeated. Participants were randomly assigned to begin with either leg and completed two practice trials before testing, which continued until three successful trials were recorded for each leg [12].

Zig-Zag Agility Test

Participants completed a course marked by cones arranged in a zig-zag pattern at predetermined distances. On the command "Go," participants ran through the course as quickly as possible while maintaining control and avoiding contact with the cones (Figure 2). Timing began at the starting command and stopped when participants crossed the finish line. Two to three trials were performed with adequate rest between attempts, and the fastest time was recorded for analysis [13].

Statistical Analysis

Data were analyzed using SPSS version 25 (IBM Corp., Chicago, IL, USA). Descriptive statistics were used to summarize participant age, height, weight, and BMI. Normality of data distribution was assessed using the one-sample Kolmogorov–Smirnov test. As the data were not normally distributed, Spearman's rank correlation coefficient was used to examine relationships between navicular drop, Y-balance test, single-leg hop test, and zig-zag agility test scores. Statistical significance was set at $p \leq 0.05$, with a 95% confidence interval.

RESULTS

Of 77 individuals initially screened, 67 (39 males, 28 females) met the eligibility criteria and were included in the final analysis. Ten participants were excluded: six declined to provide consent, two had a history of femur fracture, and two had a recent lower-limb injury (Figure 3). Demographic characteristics of the study sample are presented in Table 1.

Descriptive statistics for NDT, Y-balance test, single-leg hop test, and agility test scores, stratified by sex, are presented in Table 2. On average, male participants demonstrated slightly higher NDT values, greater Y-balance reach distances, longer single-leg hop distances, and faster agility times than female participants.

Spearman's correlation analysis revealed several significant relationships among the study variables (Table 3). Right and left NDT values were moderately positively correlated ($r = 0.593$, $p < 0.001$), indicating that participants with greater navicular drop on one side tended to show greater navicular drop on the opposite side. Left NDT showed weak positive correlations with right posteromedial ($r = 0.277$, $p = 0.012$) and right posterolateral ($r = 0.283$, $p = 0.010$) YBT reach distances.

Among Y-balance test directions, strong positive correlations were observed between posteromedial and posterolateral reach on the right ($r = 0.804$, $p < 0.001$) and left ($r = 0.922$, $p < 0.001$) sides, indicating that participants who performed well in one directional reach tended to perform well in the related direction. Weaker inter-limb associations were also observed, including right and left anterior reach ($r = 0.297$, $p = 0.007$), right and left posteromedial reach ($r = 0.204$, $p = 0.049$), right posterolateral and left posteromedial reach ($r = 0.284$, $p = 0.010$), and right and left posterolateral reach ($r = 0.275$, $p = 0.012$), reflecting bilateral consistency in dynamic balance performance.

Right and left single-leg hop distances were strongly positively correlated ($r = 0.769$, $p < 0.001$), indicating consistent bilateral lower-limb functional performance. Agility time was weakly negatively correlated with left anterior YBT reach ($r = -0.233$, $p = 0.029$), and moderately negatively correlated with right ($r = -0.367$, $p = 0.001$) and left ($r = -0.402$, $p < 0.001$) single-leg hop distance, indicating that better hop and balance performance was associated with faster agility times.

No significant correlations were found between NDT and single-leg hop distance or agility performance (right NDT vs. right anterior YBT reach: $r = 0.051$; right NDT vs. agility time: $r = 0.017$, $p = 0.446$; left NDT vs. agility time: $r = 0.053$, $p = 0.336$; left NDT vs. left single-leg hop distance: $r = 0.027$).

DISCUSSION

This study examined the relationship between MLA height, measured using the navicular drop test, and dynamic balance, single-leg hop performance, and agility in recreational athletes. Contrary to the hypothesis of a broad relationship across all measures, MLA mobility was significantly associated with select measures of dynamic balance but not with single-leg hop performance or agility.

A weak negative correlation between left anterior YBT reach and agility time indicated that participants with greater anterior reach distances tended to complete the agility test more quickly. The anterior reach component of the YBT requires lower-extremity stability, proprioception, and neuromuscular control—qualities also important for rapid directional changes during agility tasks. **Butler et al.** (2013) reported that YBT performance reflects dynamic postural control and lower-extremity functional capacity, while **Pereira et al.** (2023) identified balance and neuromuscular characteristics as key determinants of change-of-direction performance. Better dynamic balance may therefore support more effective body control during directional changes, contributing to faster agility performance; however, the weak magnitude of this correlation suggests that agility is also shaped by muscular strength, power, coordination, and reaction speed [24,28].

Moderate negative correlations between single-leg hop distance and agility time indicated that athletes capable of greater hop distances tended to perform agility drills more quickly. This is consistent with **Sonesson et al.** (2021), who reported moderate-to-strong correlations between hop performance and agility in young football players, suggesting that lower-limb power is a key determinant of agility performance [18].

MLA mobility showed weak positive correlations with right posteromedial and posterolateral YBT reach distances, suggesting that greater arch mobility is associated with modestly better performance in specific balance directions. Similar associations have been reported by **Sojitra and Patel** (2023), **Parekh and Sudhakar** (2021), **Kim et al.** (2016), and **Seyedahmadi et al.** (2024) [3,5,16,17]. The MLA contributes to shock absorption, load distribution, force transmission, and proprioceptive feedback during weight-bearing activity, which may support postural control during multidirectional movement.

However, NDT was not significantly correlated with anterior reach or most other YBT directions, suggesting that arch mobility alone is not a primary determinant of dynamic balance. Dynamic balance is a complex function shaped by muscle strength, proprioception, neuromuscular control, coordination, and training status. Consistent with this, **Gribble et al.** (2012) proposed that dynamic postural control depends on the integrated function of sensory, motor, and neuromuscular systems, suggesting that arch mobility contributes to, but does not independently predict, performance across all balance tasks [19].

No significant correlation was found between NDT and single-leg hop distance, indicating that MLA mobility was not meaningfully associated with lower-limb functional power in this sample. This is consistent with **Cairns et al.** (2024), who found that arch height and navicular drop were not reliable predictors of athletic movement characteristics, suggesting that foot anatomy alone may not substantially influence functional performance outcomes [20]. Single-leg hop performance likely depends primarily on lower-limb muscle strength, power, coordination, and neuromuscular control rather than arch mobility; recreational athletes may also develop compensatory strategies that preserve functional performance despite variation in arch mobility. **Maniar et al.** (2022) similarly demonstrated that single-leg tasks require coordinated activation of multiple lower-extremity muscles, underscoring the role of neuromuscular control in functional performance [21].

NDT was also not significantly correlated with agility performance (right NDT: $r = 0.017$, $p = 0.446$; left NDT: $r = 0.053$, $p = 0.336$), suggesting that MLA mobility is not a meaningful predictor of agility in recreational athletes. This is consistent with **Dominguez-Navarro et al.** (2023), who found that dynamic balance and explosive strength had a stronger influence on athletic performance than foot structure [22]. Agility is a multifactorial skill shaped by lower-limb power, neuromuscular control, coordination, reaction time, and change-of-direction ability; regular sports participation may help recreational athletes compensate for variation in arch mobility through improved strength and neuromuscular adaptation. **Young et al.** (2015) similarly concluded that agility depends on multiple factors, such that foot arch mobility alone is unlikely to substantially affect performance [23].

Several significant positive correlations were also observed among YBT reach directions, reflecting bilateral consistency in dynamic balance performance. Strong correlations between posteromedial and posterolateral reach on both sides, together with weaker inter-limb correlations across directions, suggest that participants with better neuromuscular control in one direction tended to perform well in related directions. These associations likely reflect shared demands for balance, strength, flexibility, and postural control across similar movement patterns, and support the reliability of the YBT as a measure of dynamic balance, consistent with **Alshehre et al.** (2021) [4].

Collectively, these findings suggest that dynamic balance, hop performance, and agility are multifactorial abilities shaped by numerous physical and neuromuscular factors. Although the MLA contributes to foot stability and biomechanics, performance on the YBT, single-leg hop test, and agility test also depends on lower-limb muscle strength, core stability, proprioception, neuromuscular control, coordination, training experience, and reaction speed [19,20,22,24]. Recreational athletes may compensate for altered arch mobility through neuromuscular adaptations developed during regular training, consistent with the Preferred Movement Path Theory proposed by **Nigg et al.** (2017), which posits that individuals adapt to anatomical variation to preserve functional performance [25]. **Schmitt et al.** (2015) similarly reported that movement strategies developed through sports participation can offset biomechanical differences to maintain functional outcomes [26]. In a related study of elite female basketball players, **Cairns et al.** (2024) found that foot anthropometric measures were not strong predictors of lower-extremity movement characteristics, potentially owing to relatively homogeneous arch characteristics within athletic populations [20].

The present findings further suggest that MLA mobility may influence some balance directions more than others. Significant associations were observed between NDT and posteromedial/posterolateral reach but not anterior reach, which may reflect the greater demand for rotational stability and multi-planar neuromuscular coordination in posteromedial and posterolateral reaching compared with anterior reaching [19].

Because single-leg hop performance is primarily determined by lower-limb power generation—including quadriceps strength, gluteal power, and ankle plantar-flexor strength—arch mobility alone appears insufficient to meaningfully influence hop distance. **Dominguez-Navarro et al.** (2023) similarly identified explosive strength as a primary predictor of single-leg hop performance [22].

Given that agility depends on multiple higher-order neuromuscular and physical qualities—including lower-limb strength, power, sprint speed, coordination, reaction time, and change-of-direction ability—the relative contribution of MLA mobility to agility performance appears minor. **Pereira et al.** (2023) similarly identified lower-body strength, power, and neuromuscular characteristics as key predictors of change-of-direction performance [24].

Several NDT correlations demonstrated near-zero coefficients (e.g., right NDT vs. right anterior YBT reach, r = 0.051; right NDT vs. agility, r = 0.017; left NDT vs. left single-leg hop, r = 0.027), which, per **Schober et al.** (2018), hold limited practical significance despite an adequate sample size (n = 67) [27]. These findings suggest that MLA mobility plays a limited role in determining dynamic balance, hop performance, or agility in recreational athletes, with neuromuscular control, muscular strength, and training-related factors likely playing a greater role.

Limitations

This study has several limitations. The use of convenience sampling may limit the generalizability of the findings. In addition, variables such as lower-limb muscle strength, training intensity, sport type, and footwear were not assessed, despite their potential influence on dynamic balance, single-leg hop performance, and agility.

Future Research

Future studies should include a broader age range and more diverse athletic backgrounds, along with larger sample sizes, to improve external validity. Prospective or longitudinal designs are recommended to clarify the relationship between MLA mobility and functional performance over time.

CONCLUSION

MLA mobility demonstrated weak positive correlations with select measures of dynamic balance but was not significantly associated with single-leg hop performance or agility in recreational athletes. These findings suggest that, while arch mobility may contribute modestly to balance performance, other neuromuscular and physical factors play a greater role in functional performance and agility. This information may assist physiotherapists and sports professionals in the assessment of foot function and the development of training and injury-prevention strategies.

Declaration of patient's consent

The authors certify that they have obtained informed consent from all the subjects who agreed to participate. In the form the subject(s) has/have given his/her consent for his/her images and other clinical information to be reported in the journal.

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Conflict of interest

The authors declare no conflicts of interests.

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Figures

Figure 1: Y-balance test

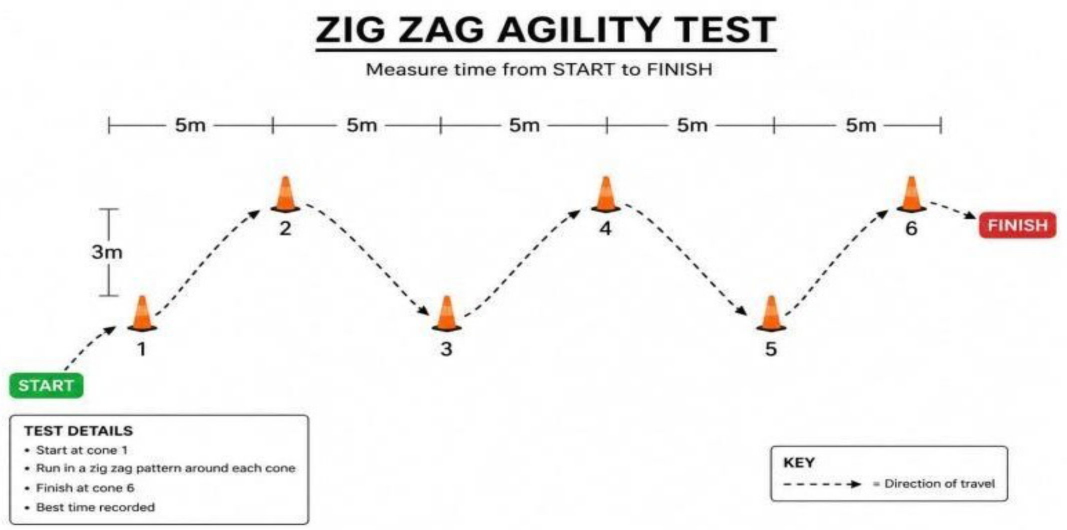

Figure 2: Zig-zag agility test

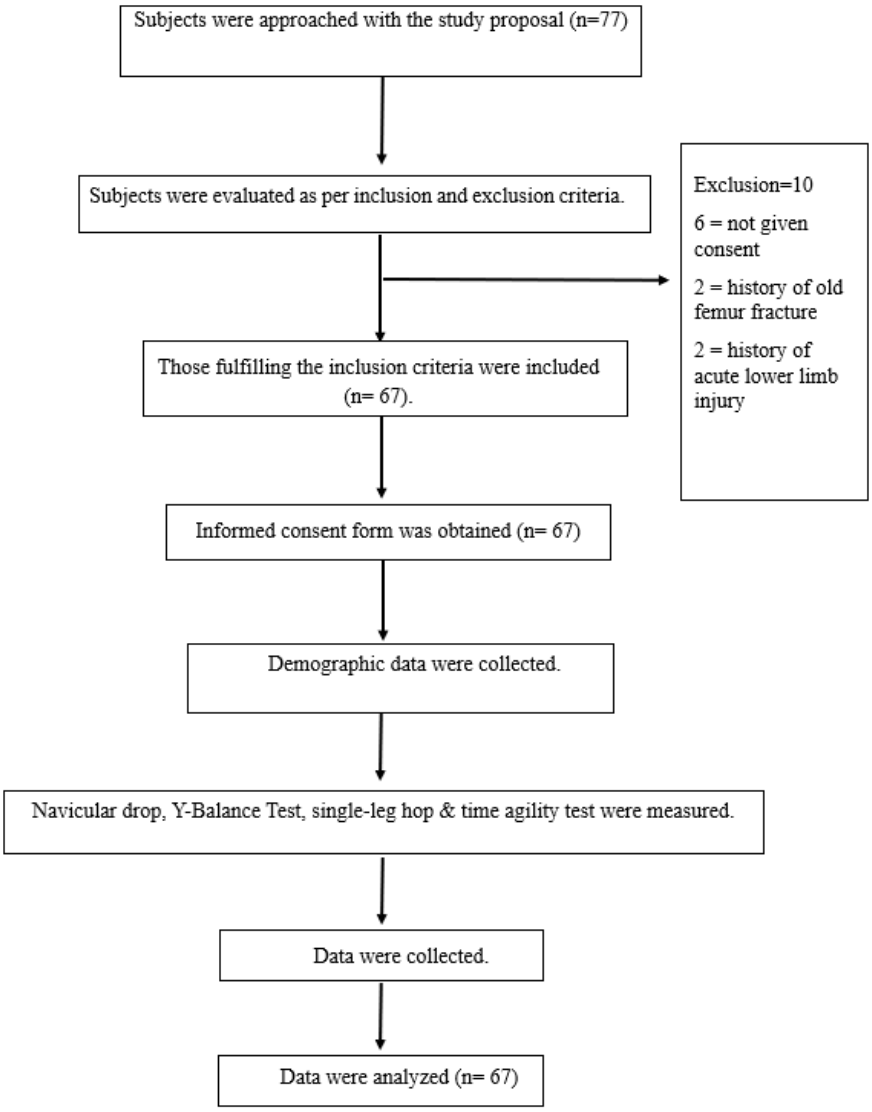

Figure 3: CONSORT flow chart

Table 1: Demographic Characteristics of Study Participants

Variable	Male (n=39) Mean±SD	Female (n=28) Mean±SD	Total (n=67) Mean±SD
Age (years)	21.31±1.67	21.00±1.49	21.18±1.59
Height (m)	1.74±0.06	1.60±0.07	1.68±0.09
Weight (kg)	69.49±12.00	53.18±7.37	62.67±13.08
BMI (kg/m²)	23.02±3.96	20.82±2.97	22.10±3.72

Table 2: Descriptive Statistics of Outcome Measures

Group	Right NDT	Left NDT	YBT_ANT_R	YBT_PM_R	YBT_PL_R	YBT_ANT_L	YBT_PM_L	YBT_PL_L	SL Hop R	SL Hop L	Agility (s)
Male	4.99±2.54	4.79±2.78	68.18±8.77	51.41±5.13	54.62±5.11	69.52±6.56	50.91±6.60	53.55±6.09	81.28±8.19	80.59±9.73	12.82±1.67
Female	4.02±2.69	4.09±1.79	66.69±8.75	50.29±5.54	53.55±5.56	65.66±8.18	51.05±5.70	54.29±5.95	75.77±14.05	74.40±13.21	14.44±2.00
Total	4.58±2.63	4.50±2.42	67.55±8.73	50.94±5.29	54.18±5.29	67.91±7.47	50.97±6.19	53.85±6.00	78.98±11.26	78.00±11.63	13.50±1.97

NDT = Navicular Drop Test; YBT_ANT/PM/PL_R/L = Y-Balance Test Anterior/Posteromedial/Posterolateral Right/Left; SL = Single Leg.

Table 3: Significant Spearman Correlation Analysis

S.No.	Variables	Spearman's rho (r)	p-value
1	Right NDT vs. Left NDT	0.593**	<0.001
2	Left NDT vs. YBT_PM_R	0.277*	0.012
3	Left NDT vs. YBT_PL_R	0.283*	0.010
4	YBT_ANT_R vs. YBT_ANT_L	0.297**	0.007
5	YBT_PM_R vs. YBT_PL_R	0.804**	<0.001
6	YBT_PM_R vs. YBT_PM_L	0.204*	0.049
7	YBT_PL_R vs. YBT_PM_L	0.284*	0.010
8	YBT_PL_R vs. YBT_PL_L	0.275*	0.012
9	YBT_PM_L vs. YBT_PL_L	0.922**	<0.001
10	SL Hop Right vs. SL Hop Left	0.769**	<0.001
11	YBT_ANT_L vs. Time Agility	-0.233*	0.029
12	SL Hop Right vs. Time Agility	-0.367**	0.001
13	SL Hop Left vs. Time Agility	-0.402**	<0.001

**p < 0.05, **p < 0.01 (1-tailed). NDT = Navicular Drop Test; YBT_ANT/PM/PL_R/L = Y-Balance Test Anterior/Posteromedial/Posterolateral Right/Left; SL = Single Leg.*