# Correlation between abductor hallucis muscle strength , ankle dorsiflexion range of motion and dynamic balance in young females with flexible flatfoot: A pilot study

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**Abstract** : Flexible flatfoot is a foot posture in which the medial longitudinal arch and may be associated with alterations in intrinsic foot muscle function, ankle mobility, and dynamic balance. The present study aimed to determine the relationship between abductor hallucis muscle strength, ankle dorsiflexion ROM and dynamic balance young females in flexible flatfoot. A pilot study was conducted among 12 young females with flexible flatfoot. Navicular Drop Test, abductor hallucis muscle strength, ankle dorsiflexion ROM, and dynamic balance were assessed using the respective outcome measures. Descriptive statistics were calculated, for normality assessed Shapiro–Wilk test. Pearson's correlation coefficient is used to determine the relationships of the study variables. Statistical significance was $p < 0.05$. Correlation analysis showed significant positive correlation of abductor hallucis muscle strength and ankle dorsiflexion range of motion ($r = 0.818$, $p = 0.001$). No relations between Navicular Drop Test and abductor hallucis muscle strength ($r = 0.141$, $p = 0.661$), Navicular Drop Test and ankle dorsiflexion range of motion ($r = -0.020$, $p = 0.952$), or between the study variables and dynamic balance. These findings indicate that greater abductor hallucis muscle strength was associated with greater ankle dorsiflexion range of motion in young females with flexible flatfoot. However, no significant relationship was observed between flatfoot severity, ankle mobility, abductor hallucis strength, and dynamic balance.

**Keywords:** Flexible Flatfoot, Abductor Hallucis, Muscle Strength, Ankle Dorsiflexion, Dynamic Balance, Navicular Drop Test, Y-Balance Test

## INTRODUCTION

Flatfoot is a common foot condition in which the medial longitudinal arch is lower than normal, resulting in a greater area of the sole coming into contact with the ground[1,2]. It associated with inward tilting of the heel and outward displacement of the forefoot. The medial longitudinal arch is normally higher than the lateral longitudinal arch that leads to flatten to some extent during weight bearing. These foot arches play an important role in absorbing shock, distributing body weight, and providing a stablility for forward movement during walking and locomotion[3].

foot muscles are supports the medial longitudinal arch, and foot weight and balance[4]. muscle thicknesses and cross-sectional areas of the abductor hallucis ,Flexor Hallucis Brevis (FHB), Flexor Hallucis Longus (FHL), and Flexor Digitorum Longus (FDL) change in feet with reduced MLA[5]. Intrinsic muscles are neeed for postural control and postural stability. Abductor Hallucis muscle (AbH), are supporting the medial longitudinal arch of the foot. one of primary intrinsic foot muscles that provides dynamic support to the arch during standing, walking, and balance activities[6].

Ankle dorsiflexion ROM refers to movement in which foot moves upward toward the tibia. It is an essential component of normal lower limb biomechanics and is required during gait, stair climbing, squatting, running, and balance-related activities. Adequate dorsiflexion allows smooth forward progression of the tibia over the foot during stance phase and helps maintain proper alignment of the ankle, subtalar, knee, and hip joints. Restriction in dorsiflexion can alter movement patterns and lead to compensatory strategies throughout the kinetic chain [7].

Balance refers to the ability of the body to keep its center of gravity within the base of support.. Many musculoskeletal and nervous system condition affect balance control[8]. Dynamic balance involves maintaining body stability while the body or center of gravity is moving. It requires the coordinated functioning of the neuromuscular, musculoskeletal, sensory, and cognitive systems[9]. Dynamic balance is essential for everyday activities such as walking, running, climbing stairs, reaching, and participating in sports. [10]. more foot pronation influence balance by changing sensory input from the foot, joint movement, and the area of contact with the ground. Therefore more pronation increase demand on the neuromuscular system to stabilize foot and maintain an upright posture. So, balance assessment is an important part of evaluating foot dysfunction.[11].

## RESEARCH METHODOLOGY

A pilot correlational is evaluate relation of abductor hallucis muscle strength, ankle dorsiflexion range , and dynamic balance on young females among flexible flatfoot.

### Participants

cross-sectional pilot study carried out among young females with flexible flatfoot aged 18-25 years. Participants were recruited using a convenience sampling method predefined Eligibility Criteria**.** participants was assessed for navicular displacement, abductor hallucis muscle strength, ankle dorsiflexion range, and moving balance.

### Outcome Measures

- Flexible flatfoot: Assessed using the Navicular Drop Test (NDT).
- Abductor hallucis muscle strength: Assessed using a hand-held dynamometer.
- Ankle dorsiflexion range : using Weight-Bearing Lunge Test (WBLT).
- moving balance: Assessed using Y-Balance , composite score used for analysis.

### Statistical Analysis

Descriptive statistics values are calculated for all study variables. Normality were assessed Shapiro–Wilk test and Q–Q plots. As all components demonstrated normal pattern with $p > 0.05$, Pearson's correlation coefficient determine relationship of the study variables. Data were analysed SPSS and Jamovi.

### Results

Descriptive analysis are assessed for Navicular Drop Measure ,abductor hallucis (AH) muscle strength, ankle DF ROM, moving balance (Y-Balance composite score) in 12 young females with flexible flatfoot. Pearson's correlation coefficient is then check relationships among AH strength, DF ROM, and dynamic balance, and their association with NDT. Analysis are $p < 0.05$, and figures are generated in SPSS and Jamovi.

### DESCRIPTIVE ANALYSIS THE STUDY

**Table 1: Descriptive Analysis and Normality assesment**

| Variable | Mean | Median | SD | Min | Max | Skewness | Kurtosis | Shapiro–Wilk W | p |
|---|---|---|---|---|---|---|---|---|---|
| NDT | 11.42 | 11.38 | 0.504 | 10.5 | 12 | -0.172 | -0.948 | 0.892 | 0.124 |
| AH strength | 3.45 | 3.4 | 0.484 | 2.75 | 4.15 | 0.173 | -1.039 | 0.932 | 0.397 |
| DF ROM | 10.17 | 10.1 | 0.955 | 8.7 | 11.3 | -0.303 | -1.428 | 0.894 | 0.134 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Y-Balance composite | 83.17 | 82.5 | 4.891 | 76.5 | 90 | 0.255 | -1.076 | 0.908 | 0.201 |

The descriptive statistics showed that the mean NDT value was 11.42 ± 0.504, with a median of 11.38 and values ranging from 10.50 to 12.00. skewness amount−0.172 thats negative skew, while kurtosis value of −0.948 indicates a relatively flatter distribution

The mean AH muscle strength was 3.45 ± 0.484, with a median of 3.40 and a range of 2.75–4.15. The skewness value of 0.173 indicates that the distribution was approximately symmetrical, while the kurtosis value of −1.039 flat arrangement.

DF ROM was 10.17 ± 0.955, with a median of 10.10 and values ranging from 8.70 to 11.30. skewness −0.303 shows small negative skew, and kurtosis value of −1.428 indicates a relatively platykurtic distribution.

The Y-Balance composite score had a mean of 83.17 ± 4.891, with a median of 82.50 and a range of 76.50–90.00. skewness is 0.255 shows positive skew, while kurtosis value of −1.076 indicates a relatively flat distribution.

**Test of Normality**

Shapiro–Wilk results confirmed normal distributions across all four variables: NDT (W = 0.892, p = 0.124), AH muscle strength (W = 0.932, p = 0.397), DF ROM (W = 0.894, p = 0.134), and Y-Balance composite score (W = 0.908, p = 0.201). All p-values exceeded 0.05, supporting the use of Pearson's correlation for subsequent analyses.

**To determine the correlation between abductor hallucis muscle strength, ankle DFROM and moving balance in young females of flexible flatfoot.**

**Hypothesis:**

Null Hypothesis ($H_0$): no relation of abductor hallucis muscle strength, ankle DFROM and moving balance in young females in flexible flatfoot.

Alternative Hypothesis ($H_1$): There is a significant correlation between abductor hallucis muscle strength, ankle DFROM and moving balance on young females of flexible flatfoot.

**Table 2: Pearson's Correlation between Study Variables**

| | | NDT | AH strength | DF ROM | Y balance |
|---|---|---|---|---|---|
| **NDT** | Pearson's r | | | | |
| | df | | | | |
| | p-value | | | | |
| **AH strength** | Pearson's r | 0.141 | — | | |
| | df | 10 | — | | |
| | p-value | 0.661 | — | | |
| **DF ROM** | Pearson's r | -0.020 | 0.818** | — | |
| | df | 10 | 10 | — | |
| | p-value | 0.952 | 0.001 | — | |
| **Y balance** | Pearson's r | -0.487 | -0.081 | 0.090 | — |
| | df | 10 | 10 | 10 | — |
| | p-value | 0.108 | 0.803 | 0.782 | — |
| *Note.* * p < .05, ** p < .01, *** p < .001 | | | | | |

The Relationship identified only one relationship among the study variables: a strong positive correlation between abductor hallucis muscle strength and ankle dorsiflexion range of motion

The relation of NDT , AH strength, NDT and DF ROM, NDT and Y-Balance, AH strength and Y-Balance, and DF ROM and Y-Balance were not statistically significant (p > 0.05).

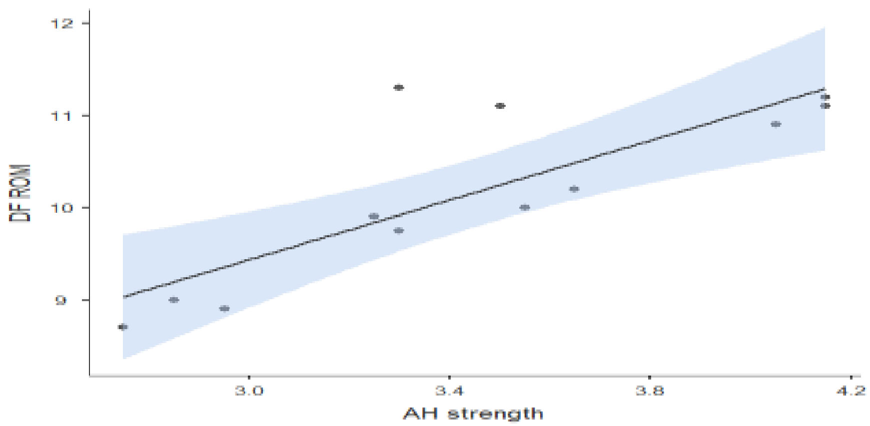


**Figure 1: Scatter plot illustrating the relationship between abductor hallucis muscle strength and ankle dorsiflexion range of motion (DF ROM)**

Scatter plot shows a positive linear relationship between abductor hallucis muscle strength and ankle dorsiflexion ROM. Individuals with higher muscle strength tend to have greater ankle mobility.

## DISCUSSION

The present pilot correlational study investigated the relationship between abductor hallucis strength, ankle DFROM , dynamic balance on young females with flexible flatfoot. The major finding of the study was a strong positive correlation between abductor hallucis muscle strength and ankle dorsiflexion range of motion That indicates more abductor hallucis muscle strength tended to demonstrate greater ankle dorsiflexion range of motion.

The significant association between abductor hallucis strength and ankle dorsiflexion ROM may be explained by the functional interaction between intrinsic foot muscle activity and foot-ankle mechanics. foot muscles gives dynamic stability to the medial longitudinal arch and contribute to foot stability during weight-bearing activities.[12,13] Previous literature has demonstrated that the abductor hallucis is active during gait and contributes to stabilization of the foot during the stance and propulsion phases. In individuals with flatfoot, alterations in foot posture may influence the mechanical demands placed on the intrinsic foot musculature.

The present finding is also consistent with previous evidence demonstrating an interaction between ankle position and abductor hallucis activity. Research has shown that performing short-foot exercise with the ankle positioned in dorsiflexion produces greater abductor hallucis activation compared with the exercise performed in a neutral ankle position.[14] This suggests that ankle position and intrinsic foot muscle function may be mechanically interrelated. However, the present study was correlational in design; therefore, the significant relationship between abductor hallucis strength and dorsiflexion ROM should not be interpreted as evidence that greater muscle strength causes an increase in ankle dorsiflexion.

The study found no significant correlation between Navicular Drop Test and abductor hallucis muscle strength Similarly, no significant relationship was observed between Navicular Drop Test and ankle dorsiflexion ROM . findings says degree on navicular displacement in this sample was not significantly associated with either intrinsic foot muscle strength or ankle dorsiflexion mobility. Previous research indicates that foot muscles helps dynamic stability of arch, although foot posture is influenced by multiple passive and active structures rather than by a single muscle.

Absence of relationship among Navicular Drop Test , abductor hallucis strength may also be related to the relatively narrow range of NDT values in the present sample. The NDT values ranged from 10.50 to 12.00 mm, with a mean of 11.42 ± 0.504 mm.  A restricted range of scores may reduce the ability of correlation analysis to detect relationships between variables.

No significant correlation was found between abductor hallucis muscle strength and dynamic balance ($r = -0.081$, $p = 0.803$). Similarly, ankle dorsiflexion ROM showed no significant relationship with Y-Balance composite score ($r = 0.090$, $p = 0.782$).  Although intrinsic foot muscles contribute to foot stability and may influence balance, dynamic balance is a complex neuromuscular task involving multiple factors, including proprioception, lower-limb strength, joint mobility, sensory information, and postural control. Therefore, isolated abductor hallucis strength or ankle dorsiflexion ROM may not be sufficient to explain individual differences in dynamic balance.

The mean Y-Balance composite score in the present study was 83.17 ± 4.891, with values ranging from 76.50 to 90.00.   Y-Balance considered reliable assessment on moving neuromuscular control in healthy adults. However, Y-Balance performance can be influenced by several participant characteristics and testing factors, and therefore the no correlation of this does not necessarily indicate that foot muscle function has no role in dynamic balance.

Previous intervention studies provide evidence that intrinsic foot muscle exercises can influence foot function and balance. [15] These findings differ from the present correlational results because intervention studies evaluate changes following a specific treatment, whereas the current study only examined associations between variables at a single point in time.

This study also shows no significant relation of NDT , dynamic balance ($r = -0.487$, $p = 0.108$). Although the correlation coefficient indicated a moderate negative trend, the association did not reach statistical significance.  This may indicate that greater navicular displacement was not necessarily accompanied by poorer dynamic balance in this group. Dynamic postural control is multifactorial, and a single measure of foot posture may not adequately represent the complete neuromuscular mechanisms involved in balance.

An important consideration in interpreting the present findings is the small sample size of 12 participants.  As this was a pilot study, the sample provides preliminary information regarding the relationships between the variables but limits the generalizability of the findings. The nonsignificant correlations should therefore be interpreted cautiously, as the study had less idea to identify moderate relations.

Overall, findings demonstrate a significant strong positive relationship between abductor hallucis strength ,ankle DFROM young females of flexible flatfoot. No significant relationships were observed between Navicular Drop Test and the other variables or between abductor hallucis strength, ankle dorsiflexion ROM, and dynamic balance. Futurely more samples or longitudinal -based designs is recommended to determine whether improving abductor hallucis strength can produce changes in ankle dorsiflexion and whether such changes have an effect on dynamic balance and foot posture.

## CONCLUSION

This study found a significant positive relationship between abductor hallucis muscle , ankle DFROM young females were flexible flatfoot ($r = 0.818$, $p = 0.001$), supporting rejection of the null hypothesis for that specific relationship. No significant correlations were found between NDT and any other variable, nor between either AH strength or DF ROM and dynamic balance.

These findings suggest that foot muscle strength , ankle motions closely linked this population, and that abductor hallucis strengthening may be a relevant component of interventions targeting ankle mobility in individuals with flexible flatfoot. No relations of flatfoot severity (NDT) and the other variables — and between AH strength/DF ROM and dynamic balance — suggests that other components are larger value on postural stability .

## DECLARATIONS

### Study Limitations

The study included a relatively small sample of 12 young females with flexible flatfoot, which has reduced identify important associations. Second, participants were limited to young females with flexible flatfoot. This restrict generalisability ,different age , or individuals with different types of foot posture. Third, the cross-sectional correlational design does not allow causal relationships to be established between abductor hallucis muscle strength, ankle DFROM, moving balance. Finally, other factors such as physical activity level, previous lower-limb injury, muscle strength of other lower-limb muscles, proprioception, and individual variations in balance control were not assessed or controlled and may have influenced the observed relationships.

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Nil

**Competing Interests**

There are no financial or charitable organization to carry out.

**Ethical Approval**

The study was approved by the Institutional Ethics Committee, A. J. Institute of Medical Sciences & Research Centre, Mangaluru, Karnataka, India. Ethical approval was granted under Reference No. AJEC/REV/207/2025 on 24 June 2025. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

**Consent from Participants**

subjects give consent prior to study.

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