Original Research Article

COMPARISON OF THE MEDIAL LONGITUDINAL ARCH OF THE HILLY AND PLAIN GARHWALIS OF THE UTTARAKHAND

Sunita¹, Sadakat Ali², Anju Partap³

¹SR/Tutor Specialist, Department of Anatomy, IGMC Shimla, Himachal Pradesh, India.
²Professor and Head, Department of Anatomy, SGRR Institute of Medical and Health Sciences Dehradun. India.
³Professor and Head, Department of Anatomy, IGMC Shimla, Himachal Pradesh, India.

A B S T R A C T

Background: The human foot is an extremely robust and intricate anatomical system, that provides an effective flexible surface necessary for weight transfer, shock absorption, ground plane adaptation, and mobility. The normal, pes planus, and pes cavus three types of foot have been suggested based on the structure of the Medial Longitudinal Arch. **Aim:** Comparison of the Medial Longitudinal Arch of the hilly and plain Garhwalis of the Uttarakhand.
Materials and Methods: This study includes 400 individuals. 100 male and 100 female from each region of hilly and Plain Garhwal. The distance from the floor to the navicular tuberosity is measured and marked on the custom-made index card on a non-weight-bearing and weight-bearing individual and then noted with the help of the digital vernier calliper for the Navicular Drop Test. For measuring the Medial Longitudinal Arch Angle, the digital goniometer is placed on the foot with having its one limb placed on the head of the 1st metatarsal other limb is placed on the medial malleolus and the body is placed on the Navicular tuberosity.
Results: The flat foot was maximum seen in hilly Garhwali's in comparison to Plain Garhwali's according to the Navicular Drop test. According to the Medial Longitudinal Arch Angle, Plain Garhwalis were found with a maximum number of flat feet.
Conclusion: The present study follows the hypothesis as it states hilly individuals have flat feet in comparison to plain region individuals according to Navicular Drop. The right foot has the max % of flat feet than the left foot.
Keywords: Medial longitudinal arch angle, Navicular height, Navicular drop, Body mass Index, Right foot, Left foot.

INTRODUCTION

The human foot is an extremely robust and intricate anatomical system, that provides an effective flexible surface that is necessary for weight transfer, shock absorption, ground plane adaptation, and mobility.[1] It is a very strong and complex anatomical structure, consisting of a total 26 bones; 33 joints; 42 muscles; and more than 50 tendons and ligaments and other surrounding soft tissues. The foot's main functions are to bear the body weight and to allow bipedal locomotion. According to its function, the foot can be divided into forefoot, midfoot and Hindfoot in three functional segments. The hindfoot is the most posterior segment of the foot and is composed of the talus and the calcaneus. The midfoot is the middle segment of the foot consisting of the cuboid, navicular and the three cuneiform bones. The forefoot is the most anterior segment of the foot and is composed of the 14 phalanges and the corresponding five metatarsal bones.[2] The human foot is uniquely designed with two springs like longitudinal arches and two transverse arches which acts as an effective flexible surface essential for adapting to ground planes, shock absorption, weight transfer and locomotion. The morphology of these arches determines the normal biomechanics of foot and entire lower extremity.

Based on the structure of the medial longitudinal arch the Normal foot, Low arched foot or pes planus or pronated foot and high arched or pes cavus or supinated foot three types of foot have been suggested.[1] The arch function depends on the foot shape, structure of the bones, strength of ligaments, and muscular fatigue while factors like race, foot wear, age and gender are found to impact the arrangement of MLA.[1,2,4]

The longitudinal arch consists of a medial and a lateral part. Its medial part, i.e., the medial longitudinal arch (MLA) is made up by the calcaneus, the talus, the navicular, the three cuneiform bones (medial, intermediate, and lateral), and the first three metatarsal bones. It is higher than the lateral arch and called foot arch normally. The lateral part, i.e., the lateral longitudinal arch (LLA) is composed of the calcaneus, the cuboid, and the fourth and fifth metatarsals.[1,3,4]

As per previous studies and according to the lifestyles there will be a difference in the MLA in the plain region individuals and MLA of hilly region individuals, there will be the difference in MLA of different age groups and of different gender as well. This study is to generate a comprehensive database in young Indian adults of three different age groups of hilly and plain regions on finding different morphology by observing their MLA. The database reported by this study will be of great significance to orthopaedic surgeons, podiatrists, and industries related to foot prosthetics & orthotics. The purpose of this study is to explore the possibility of high arched/pes cavus, flat foot/pes planus foot and the early detection of it.

Aim: The Comparison of the Medial Longitudinal Arch of the hilly and plain Garhwalis of the Uttarakhand"

Objectives: - The objectives are
1. Arch Height/ Navicular height of RF and LF without weight.
2. Arch Height/ Navicular height of weight-bearing RF and LF.
3. Left Navicular Drop and Right Navicular Drop in a single report.
4. Medial Longitudinal Arch Angle for the right foot and the left foot.
5. Height, Weight, and BMI are also calculated for 20-30, 30-40 and 40-50 three age groups for the whole study population.

MATERIAL AND METHODS

The present study is cross-sectional and is a qualitative research design done in the Shri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun. It took 2 years from January 2022 to January 2024 for the data collection and the observations. The sample size is 400. The Institutional ethical clearance certificate is provided by the institution for the observation. Before the observation, the individual was provided with the proper guidance, and then a consent form was signed by each individual.

Inclusion Criteria: All the healthy individuals between 20-50 years of age from plain and hilly Garhwal of Uttarakhand in which the following sample number was collected: -
1. 100 males and 100 females from hilly Garhwal
2. 100 males and 100 females from Terai/Plain Garhwal

It includes migrated individuals staying in these particular regions ancestrally and for more than 20 years.

Exclusion Criteria: Post-surgery patients, accident cases, patients with burns, patients with fracture, patients with paralysis, patients with CTEV, patients below 20 years of age, patients above 50 years of age, disabled patients, Obese cases, patients with history of external radiotherapy of the foot, patients having any foot diseases and migrated individuals staying in this particular region for less than 20 years.

Statical Analysis: All the data is analyzed by the standard protocol. IBM" SPSS version 26.0 was used for analyzing the data. The normality of the data was tested using the Shapiro-Wilk test. The mean, median, standard deviation, p-value, and Inter Quartile Range (IQR) were calculated for all the parameters. The variance for the Navicular Drop among the hilly and plain Garhwalis was compared using the Mann - Whitney U test. Navicular Drop >10mm indicates overpronation (flat foot). Navicular Drop <5mm indicates over supination (high arch)/Pes Cavus). Between 5mm-10mm Navicular Drop was considered normal in the present study. To account for the variance for the Medial Longitudinal Arch Angle, the normal values are set to be between 131 degrees and 152 degrees. Values lower than 131 degrees signify a lower foot arch (flat feet), and values higher than 152 degrees signify a higher foot arch (high-arched feet). A p-value of less than 0.05 was considered statistically significant.

Study tools include 1. Custom-made Index card 2. Digital Vernier Calliper 3. Colour marker 4. Pencil 5. Digital Goniometer 6. Digital Weight Machine.

The navicular tuberosity was located and its distance from the ground was marked on the custom-made index card to calculate the Navicular/ Arch Height in a non-weight-bearing individual in a sitting (on a chair) position then the same was measured and marked on custom - made index card for a weight-bearing individual (own body weight) in standing position, now the height of the medial longitudinal arch is measured by the digital vernier calliper to calculate the navicular drop (ND) for both. The difference between the navicular heights of both measurements is called Navicular Drop. If the ND drop is greater than 10 mm, the foot is overpronated and would be deemed pathological, a value lower than 5mm is considered supinated and values between 5mm-10mm are neutral.
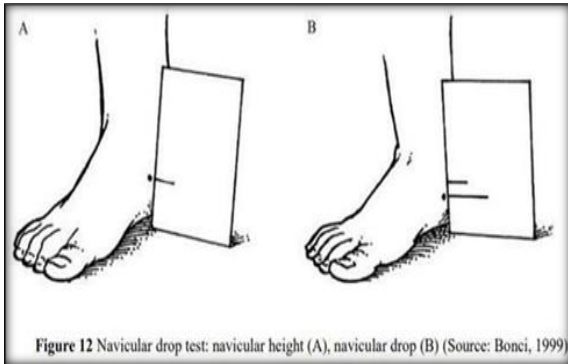
Figure 12 Navicular drop test: navicular height (A), navicular drop (B) (Source: Bonci, 1999)

- **Navicular drop test: - A. Navicular height. B. Navicular drop.**

Figure 1: Navicular height, B. Navicular drop

The Medial longitudinal Arch Angle for the right and left foot is measured of the individual standing on his body weight as follows: -

1. First of all, the head of the first metatarsal is marked with the marker.
2. The medal malleolus is marked.
3. The navicular tuberosity is marked.
4. Now the center or the body of the digital goniometer is placed on the navicular tuberosity, one arm of the digital goniometer is placed on the 1st metatarsal and other arm is placed on the medial malleolus.
5. The medial longitudinal arch angle (MLAA) is measured for both, the right and the left foot one after another. [Figure2. A. B].
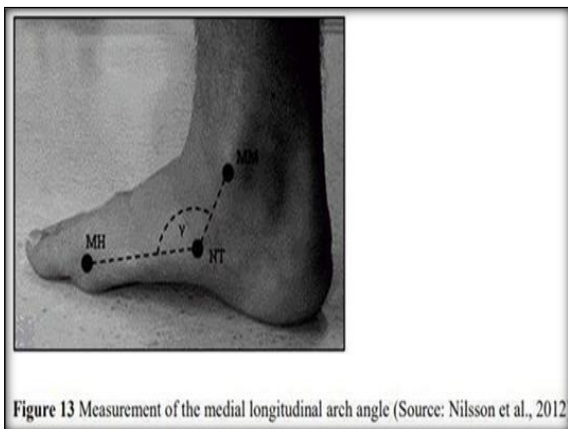

Figure 13 Measurement of the medial longitudinal arch angle (Source: Nilsson et al., 2012)

- **Measurements of the MLAA.**

**Figure 2: A. 1st metatarsal, navicular tuberosity & medial malleolus.**

Figure 2: B. Measurements of the Medial Longitudinal Arch Angle.

Figure 3: A. Digital vernier calliper, B. Digital Goniometer

RESULTS

In the present study presented in Table 1. among the 200 hilly individuals of Garhwalis of the Uttarakhand, according to the Navicular drop (ND) test the highest number of the pes planus/ flat feet were found in RF, which was 84 and in left foot was 68, the pes cavus right feet were 27 and left feet were 32. According to MLAA measured with the help of the digital goniometer the highest number of the pes planus/ flat feet were found in LF which was 144 and in RF was 110, the pes cavus feet were not found.
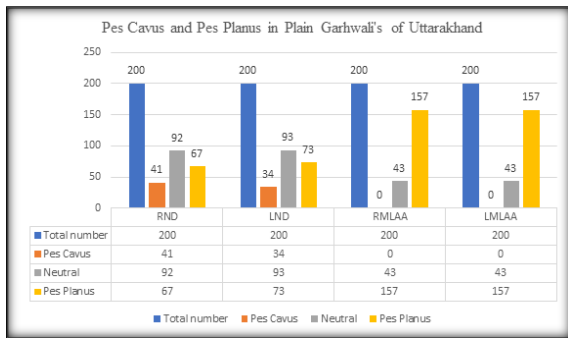
**Figure 4: Pes Cavus and Pes Planus in Plain Garhwali's of Uttarakhand.**

In the present study presented in Figure 4. shows that after observing the 200 Plain Garhwalis of the Uttarakhand, according to the Navicular drop (ND) test the highest number of pes planus/ flat feet were found in LF, which was 73 and in RF was 67, the pes cavus RF was 41 and LF were 34. According to MLAA the RF and LF were found with equal numbers 157 and the pes cavus feet were not found. The present study states that in Table 2. & figure. 5 according to the ND test the RF had max number of pes planus/ flat feet and it was 151 RF among 400 individuals while 68 individuals had pes cavus RF. 181 RF were seen as normal/ neutral. 141 LF were found low arched, 66 LF were high arched with 193 LF normal according to the ND test. On the other hand, according to MLAA tested with the help of the digital goniometer among the whole study population LF had the highest number of pes planus or flat feet which was 301 in number, 99 LF were seen as normal while no pes cavus feet or high arched feet were observed according to it. 267 RF were found Pes planus or low-arched or flat feet with 99 RF normal and no pes cavus RF were observed in the present study according to MLAA. [Table 2]
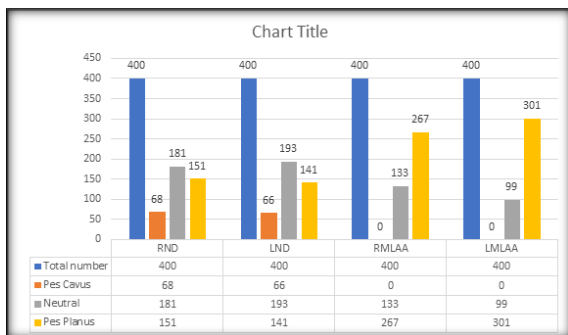
**Figure 5: Pes Cavus and Pes Planus in total population.**

The median is 53.41 for RFNH, 52.08 for LFNH, 44.54 for RFNHW, 43.80 for LFNHW, 9.26 for RND, and 8.92 for LND, 130.50 for RMLAA, 128.10 FOR LMLAA. The IQR is 7.58 for RFNH, 9.54 for LFNH, 7.46 for RFNHW, 7.18 for LFNHW, 5.99 for RND, and 4.72 for LND, 10.67for RMLAA, 7.17 for LMLAA. The p-value for RFNH and LFNH is 0.07 (not significant), for RFNHW and LFNHW it is 0.21(not significant), for RND and LND it is 0.84 (not significant), p- value is 0.015 significant for

RMLAA and LMLAA. The Mann-Whitney U test is not significant for the whole hilly Garhwali female group. [Table 3]
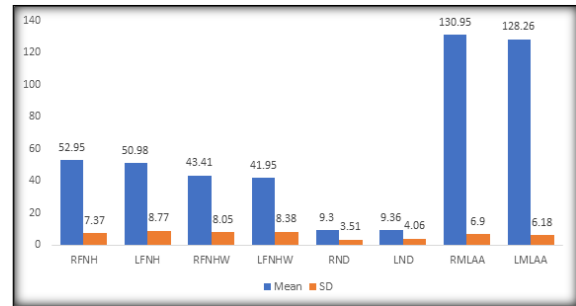
Figure 6: Comparison of RF and LF in hilly Garhwal Female group.

Figure 6. Shows that in comparison of RF and LF of the 100 females of hilly Garhwal of the Uttarakhand, the mean±SD of RFNH is 52.95±7.37, LFNH is 50.98±8.77, RFNHW is 43.41±8.05, LFNHW is 41.95±8.38, RND is 9.31±3.51, LND is 9.36±4.06 and RMLAA is 130.95±6.9, LMAA is 128.26±6.18. In the present study Table 5. states that the median is 56.09 for RFNH, 54.32 for LFNH, 46.37 for RFNHW, 46.47 for LFNHW, 9.04 for RND, and 8.25 for LND, 129.30 for RMLAA, 128.20 for LMLAA. The IQR is 12.94 for RFNH, 14.05 for LFNH, 13.02 for RFNHW, 14.50 for LFNHW, 6.46 for RND, and 4.83 for LND, 4.97 for RMLAA, and 5.47 for LMLAA. The p-value for RFNH and LFNH is 0.23 (not significant, for RFNHW and LFNHW it is 0.59(not significant), for RND and LND it is 0.41 (not significant), 0.06 for RMLAA and LMLAA. The Mann-Whitney U test is not significant for the whole hilly Garhwali male group. [Table 4]
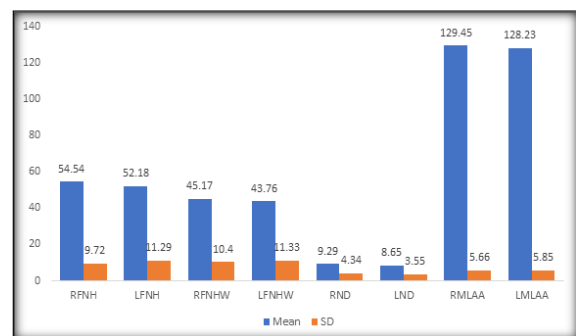
Figure 7: Comparison of RF and LF in hilly Garhwal male group.

Table 4. & Figure 7. Shows that in comparison of RF and LF of the 100 males of hilly Garhwal of the Uttarakhand, the mean±SD of RFNH is 54.54±9.72, LFNH is 52.18±11.29, RFNHW is 45.17±10.4, LFNHW is 43.76±11.33, RND is 9.29±4.34, LND is 8.65±3.55 and RMLAA is 129.45±5.66, LMAA is 128.23±5.85.

Table 5. presents that the median is 48.32 for RFNH, 43.54 for LFNH, 37.08 for RFNHW, 33.81 for LFNHW, 9.30 for RND, and 9.19 for LND,127.75 for RMLAA, 124 FOR THE LMLAA. The IQR is

11.76 for RFNH, 15.11 for LFNH, 11.79 for RFNHW, 15.46 for LFNHW, 3.92 for RND, and 5.44 for LND,5.92 for RMLAA and 8.74 for LMLAA. The p-value for RFNH and LFNH is 0.03 (significant, for RFNHW and LFNHW it is 0.02(significant), for RND and LND it is 0.66(not significant) and 0.003(highly significant) for RMLAA and LMLAA. The Mann-Whitney U test was significant for only RMLAA and LMLAA nut not significant for all the other parameters. [Table 5]

RFNHW, 40.38 for LFNHW, 8.25 for RND, and 8.01 for LND,126.35 for RMLAA, 125.35 for LMLAA. The IQR is 19.09 for RFNH, 13.9 for LFNH, 17.64 for RFNHW, 15.25 for LFNHW, 4.02 for RND, and 4.8 for LND, 7.67 for RMLAA and 8.62 for LMLAA. The p-value for RFNH and LFNH is 0.10(not significant, for RFNHW and LFNHW it is 0.13(not significant), for RND and LND it is 0.28 (not significant) and 0.10 (not significant) for RMLAA and LMLAA. The Mann-Whitney U test was not significant for whole plain male Garhwali group. [Table 6]

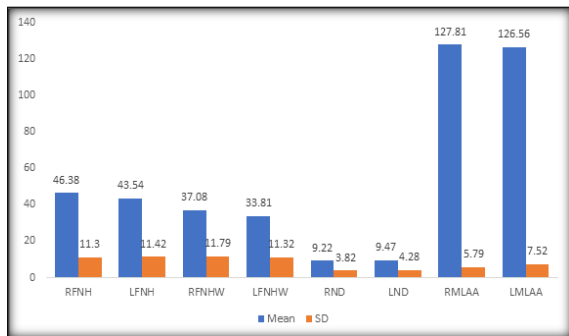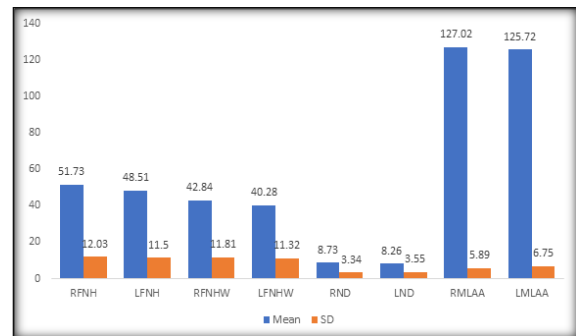**Figure 8: Comparison of left foot and right foot in Plain Garhwal Female group.**

Table 5. & Figure 8. Shows that in comparison of RF and LF of the 100 females of Plain Garhwal of the Uttarakhand, the mean±SD of RFNH is 46.38±11.3, LFNH is 43.54±11.42, RFNHW is 37.08±11.79, LFNHW is 33.81±11.32, RND is 9.22±3.82, LND is 9.47±4.28 and RMLAA is 127.81±5.79, LMAA is 126.56±7.52.

Table 6: represents that in comparison of RF and LF of the Plain male group of Garhwal the median is 50.48 for RFNH, 49.20 for LFNH, 42.39 for

Figure 9: Comparison of left foot and right foot in Plain Garhwal male group.

Table 6. & Figure 9. Shows that in comparison of RF and LF of the 100 females of Plain Garhwal of the Uttarakhand, the mean±SD of RFNH is 51.73±12.03, LFNH is 48.51±11.5, RFNHW is 42.84±11.81, LFNHW is 40.28±11.32, RND is 8.73±3.34, LND is 8.26±3.55 and RMLAA is 127.02±5.89, LMAA is 125.72±6.75.

Table 1: Pes Cavus and Pes Planus in hilly Garhwalis of Uttarakhand.

Measures	Total number	Pes Cavus	Neutral	Pes Planus
RND	200	27	89	84
LND	200	32	100	68
RMLAA	200	0	90	110
LMLAA	200	0	56	144

Table 2: Pes Cavus and Pes Planus in total population.

Measures	Total number	Pes Cavus	Neutral	Pes Planus
RND	400	68	181	151
LND	400	66	193	141
RMLAA	400	0	133	267
LMLAA	400	0	99	301

Table 3: Comparison of LF and RF in the hilly Garhwal Female group.

Variables	Garhwali Females					
	Mean	SD	Median	Mann Whitney U-test	p-Value	Interquartile Range
Right Foot Navicular Height	52.95	7.37	53.41	4402	0.07	7.58
Left Foot Navicular Height	50.98	8.77	52.08			9.54
Right Foot Navicular Height with weight	43.41	8.05	44.54	4486	0.21	7.46
Left Foot Navicular Height with weight	41.95	8.38	43.80			7.18
Right Navicular Drop	9.30	3.51	9.26	4916.5	0.84	5.99
Left Navicular Drop	9.36	4.06	8.92			4.72
Right Medial Longitudinal Arch Angle	130.95	6.90	130.50	4015	0.015	10.67

Left Medial Longitudinal Arch Angle	128.26	6.18	128.10			7.17

Table 4: Comparison of left foot and right foot in hilly Garhwal male group.

Variables	Garhwali Males					
	Mean	SD	Median	Mann Whitney U-test	p-value	Interquartile Range
Right Foot Navicular Height	54.54	9.72	56.09	4515.5	0.23	12.94
Left Foot Navicular Height	52.18	11.29	54.32			14.05
Right Foot Navicular Height with weight	45.17	10.40	46.37	4783	0.59	13.02
Left Foot Navicular Height with weight	43.76	11.33	46.47			14.50
Right Navicular Drop	9.29	4.34	9.04	4662	0.41	6.46
Left Navicular Drop	8.65	3.55	8.25			4.83
Right Medial Longitudinal Arch Angle	129.45	5.66	129.30	4238	0.06	4.97
Left Medial Longitudinal Arch Angle	128.23	5.85	128.20			5.47

Table 5: Comparison of left foot and right foot in Plain Garhwal Female group.

Variables	Plain Females					
	Mean	SD	Median	Mann Whitney U-test	p-value	Interquartile Range
Right Foot Navicular Height	46.38	11.30	48.32	4114	0.03	11.76
Left Foot Navicular Height	43.54	11.42	43.54			15.11
Right Foot Navicular Height with weight	37.08	11.79	37.08	4074	0.02	11.79
Left Foot Navicular Height with weight	33.81	11.32	33.81			15.46
Right Navicular Drop	9.22	3.82	9.30	4823.5	0.66	3.92
Left Navicular Drop	9.47	4.28	9.19			5.44
Right Medial Longitudinal Arch Angle	127.81	5.79	127.75	3816.5	0.003	5.92
Left Medial Longitudinal Arch Angle	126.56	7.52	124			8.74

Table 6: Comparison of left foot and right foot in Plain Garhwal male group.

Variables	Plain Males					
	Mean	SD	Median	Mann Whitney U-test	P-value	Interquartile Range
Right Foot Navicular Height	51.73	12.03	50.48	4346	0.10	19.09
Left Foot Navicular Height	48.51	11.50	49.20			13.9
Right Foot Navicular Height with weight	42.84	11.81	42.39	4391	0.13	17.64
Left Foot Navicular Height with weight	40.28	11.32	40.38			15.25
Right Navicular Drop	8.73	3.34	8.25	4561	0.28	4.02
Left Navicular Drop	8.26	3.55	8.01			4.8
Right Medial Longitudinal Arch Angle	127.02	5.89	126.35	4390	0.10	7.67
Left Medial Longitudinal Arch Angle	125.72	6.75	125.35			8.62

DISCUSSION

Aenumulapalli A. et. al. in 2017 stated on their study that the prevalence of flexible flat foot was 13.6% (for males-12.8%; for females-14.4%). The median with Inter Quartile Range (IQR) for ND among males was 6 mm (4-8) and 6 mm (4-9) for right and left foot respectively. The median with IQR for ND among females was 6mm (4-10) and 7mm (3-8) for right & left respectively. The correlation of Right-Side Navicular Drop (RND) with height and weight was significant, but insignificant correlation was found between RND and BMI. The correlation of Left Side Navicular Drop (LND) with height, weight and BMI of individuals was statistically not significant. The difference between the ND of males and female group was statistically not significant.[1]

Reddy et. al. in 2021 stated that the prevalence of bilateral flat foot as 11.6% (8.3% were females and 3.3% were males). Unilateral as 3% (2% were females and 1% were males) and the correlation of ND, AI, and FPI with gender, age was not significant and with BMI, weight was highly significant and they observed that the flat foot affected the quality of life and functionality of the students whose BMI is more.[8]

According to López, D.L et. al. in 2018 observed in their study that the FHSQ comparison between the three groups within the sample population did not show any statistically significant difference (p > 0.05) for any domains of the specific foot (pain,

function, general health, and footwear) and general (general health, physical activity, social function, and vigor) health-related QoL. Specific foot and general health-related QoL did not seem to be influenced by the foot arch height between high, normal, and low foot arches heights. Nevertheless, further studies with higher sample sizes and matched-paired groups should be carried out.[9]

Kevin A. Kirby in 2017 stated in his study that the active tension load-bearing elements, the plantar intrinsic and plantar extrinsic muscles, are under direct central nervous system control and serve to increase or decrease the stiffness of the medial and lateral longitudinal arches depending on the type and intensity of the prevailing weight-bearing activity of the individual. Together, the elements of the longitudinal arch load-sharing system ensure that proper weight-bearing function of the longitudinal arch, and the foot and lower extremity, can still occur even when a failure of one of these tension load-bearing elements occurs due to injury.[10]

A cross-sectional study (n = 86; 59.3% women; 27.8 years, standard deviation: 4.8 years) was carried out by Juan Carlos Zuil-Escobar et. al. and on their study the navicular drop test was evaluated and footprint parameters using a plantar pressure platform were recorded in the dominant foot. Both intrarater and interrater reliability were excellent for all the parameters evaluated (intraclass correlation coefficients > 0.880). Statistically significant correlations existed between the navicular drop test and footprints parameters (arch angle = 0,643; Staheli index = 0.633; Chippaux-Smirak index = 0.614). The footprint parameters had excellent correlation with each other (0.838-0.881). The navicular drop test and the footprint parameters studied were reproducible and thus had excellent reliability.[11]

According to Asok et. al. the median (with IQR) for Truncated Foot Length (TFL), Fore Foot Length (FFL), Hind Foot Length (HFL), Arch Height (AH), Arch Spread (AS), and Navicular Drop (ND) were found to be 17.6(16.8-18.7), 8.6(8.1-9.2), 9.0(8.5-9.7), 4.5(4- 5.1), 0.5(0.3-0.6) & 0.6(0.4-0.9) on right side respectively and 17.6(16.8-18.7), 8.7(8-9.3), 9.0(8.5-9.7), 4.6(4-5.1), 0.5(0.3-0.6) & 0.6(0.4-0.9) on left side respectively. Truncated Foot Length (TFL) showed a strong positive correlation with both height and weight of the individual. Arch Height (AH) showed a moderately positive and weak positive correlation with the Height and weight of the individual. The gender differences in the morphology of MLA were statistically insignificant.[12]

According to Andreas Stotz et. al. the comparisons between clinical rating and diagnostic systems, receiver operating characteristic (ROC) curves and ordinal logistic regression were calculated. The combined kappa score for all three arch types (0.422, 32.8%) shows borderline moderate agreement between raters. Area under the curves (AUC) values of the ROC curves ranging from 0.48 to 0.68 show poor relationship between quantitative and qualitative arch height measurements. The highest agreement was found for the dynamic arch index and foot experts' ratings for low arched vs non-low arched feet (AUC = 0.68) and normal vs low arched feet (AUC = 0.67). The results of this study showed borderline moderate agreement among clinical experts in the clinical assessment of the medial longitudinal plantar arch in children. Also, only a poor relationship between the clinical foot arch assessments and the static and dynamic foot measurements was revealed.[13]

Katsuhito Nagano et. al. studied 36 participants, the mean value of the arch height ratio, and values of the six parameters potentially influencing MLA height show the correlation analysis. The ratio of arch height in males was significantly positively correlated with TPM strength (r=0.42, p<0.01) and TPM strength relative to body weight (r=0.35, p<0.05). No significant correlations were found between the ratio of arch height and any of the other parameters. In contrast, correlation analysis in female subjects showed that ratio of arch height was significantly positively correlated with TPM strength (r=0.36, p<0.05) and toe-gripping strength (r=0.38, p<0.05) and was significantly negatively correlated with the hallux valgus angle (r=0.37, p<0.05) and the LHA (r=0.47, p<0.01). No significant correlations were found between the ratio of arch height and any of the other parameters. [14]

According to Guenka et. al. in dorsiflexion at 60 °/s, the phase where the velocicty is sustained (load range phase) was higher in the planus group (Mean Difference=10.9 %; $\omega 2$ p = 0.06) when compared with the pes cavus group. Deficits in the peak torque/body mass in dorsiflexion at 60 °/s (cavus feet: MD=-3 N.m/kg; $\omega 2$ p = 0.06; and planus feet: MD=-1.1 N.m/kg; $\omega 2$ p = 0.06) were also observed as well as in the 3D surface maps, when compared with the normal group. The flexibility of MLA had a negative correlation of PT at 30 °/s in pes cavus group. The height of MLA had a positive correlation with the PT for the pes cavus and pes planus group ate 60 °/s. All other results did not show differences between the groups. The planus groups showed a better capacity to attain and sustain the velocity in dorsiflexion than the cavus group. The cavus and planus group had deficits in torque about the normal. The correlations were weak between the measures of MLA and PT. Thereby, in general, the differences between foot types showed a small effect on isokinetic muscle performance measures of the plantar and dorsi flexors.[15]

A total of 500 adults aged 18 years to 25 years normal healthy individuals had participated in the study done by Azhagiri, et. al. and there were 168 (34%) males and 332 (66%) females) revealed the prevalence of normal foot arch as 71% (355 out of 500) among participants, with a higher prevalence in females (240 out of 355, 68%) than in males (115 out of 355, 32%). The prevalence of pes planus was 29% (145 out of 500) among participants, with a higher prevalence in females (92 out of 145, 63%) than in males (53 out of 145, 37%). Pes planus analysis was done by footprint

screening test. The highest prevalence and pattern of age-wise distribution of pes planus were observed in 20 years (24%), 18 years (16%), 19 & 21years (14%), 23 years (13%), and followed by 22, 24 & 25 years (10%,6%,3%). In general, studies on the prevalence of pes planus in young adults, especially girls are limited, because of the low research conducted in this field, it endured as the best motivation to study it. Hence this study was performed on young healthy adults.[16]

Statistically significant correlations were obtained between the Navicular Drop Test and the footprint parameters, with r absolute values ranging from 0.722 to 0.788. The Navicular Drop Test and the Foot Posture Index-6 showed an excellent correlation (Spearman correlation coefficient = 0.8), and good correlations (Spearman correlation coefficient = |0.663–0.703|) were obtained between the footprint parameters and the Foot Posture Index-6. Excellent intrarater reliability and interrater reliability were obtained for all of the parameters according to Zuil-Escobar JC et. al..[17]

Robin M. Queen et. al. all of the linear measurements (navicular height and foot length) obtained from the MFPB demonstrated good inter-rater and between-day reliability. Footprint measurements obtained from the MFPB also demonstrated excellent reliability. Inter-rater reliability ranged from 0.807 to 0.970, with the arch angle being the least reliable. The most reliable footprint measurement was the footprint index (0.970), followed by the Staheli index (0.963), Chippaux Smirak index (0.961), arch index (0.957), truncated arch index (0.933), and arch length index (0.818). Similar to the linear measurements, the inter-rater reliability for the footprint measurements was higher than between-day reliability. The between-day reliabilities ranged from 0.638 to 0.924; however, all of the variables except the arch length index (0.755) and arch angle (0.638) were greater than 0.890.[18]

CONCLUSION

Based on the results and the methodology used, on 400 individuals, 100 males and 100 females from each hilly Garhwal and from Plain Garhwal of Uttarakhand we have concluded that in the present study between the age group of 20-50 years, the finding indicated that the flat feet were maximum found in hilly Garhwalis in comparison to Plain Garhwalis and it follows the hypothesis according to ND test, some pes cavus feet were also observed according to it. On the other hand, Garhwalis living in the plain were found with a maximum number of flat feet and there were no number of pes cavus feet found among the whole study population according to MLAA.

The RF was found with max % of flat feet and RF had max % of pes cavus feet as well according to ND test among the whole study population. However, according to MLAA, LF was found more pes planus than RF and there were none of the pes cavus RF or LF according to MLAA.

Among the 200 hilly individuals of Garhwalis of Uttarakhand, according to the Navicular drop (ND) test the highest % of the pes planus/ flat feet were found in RF, which was 84, and in the LF was 68, the pes cavus right feet were 27 and left feet were 32. According to MLAA measured with the help of the digital goniometer the highest % of the pes planus/ flat feet was found in LF which was 144 and in RF was 110, the pes cavus feet were not found. And after observing the 200 Plain Garhwali of the Uttarakhand, according to the Navicular drop (ND) test the highest % of the pes planus/ flat feet were found in LF, which was, and in RF was 67, the pes cavus RF were 41 and LF was 34. According to MLAA the RF and LF were found with equal numbers 157 and the pes cavus feet were not found.

According to the ND test the RF had max number of pes planus/ flat feet and it was 151 RF among 400 individuals while 68 individuals had pes cavus RF. 181 RF were seen as normal/ neutral. 141 LF were found low arched, 66 LF were high arched with 193 LF normal according to the ND test. On the other hand, according to MLAA tested with the help of the digital goniometer among the whole study population LF had the highest number of pes planus or flat feet which was 301 in number, 99 LF were seen normal while no pes cavus feet or high arched feet were observed according to it. 267 RF were found in Pes planus or low arched or flat feet with 99 RF normal and no pes cavus RF were observed in the present study according to MLAA.

There is a dearth of prior research in this area; not many studies have been conducted. As a result, preventive measures including appropriate shoe selection, physiotherapy, compensatory exercises, and good foot care should be encouraged more. Our study generates comprehensive database on the morphology of the MLA utilizing the ND test and MLAA for young Indian individuals aged 20 to 50. Garhwali people who live in Uttarakhand's hilly and plain regions have not had their RF and LF compared in previous studies on this topic. Podiatrists, orthopedic surgeons, and companies that manufacture foot prosthetics and orthotics will find great value in the database that this study reports.

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