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Assessment of foot type and comparison of anthropometric foot dimension between foot types of Indian population: A pilot study

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Abstract: *Background:* Human foot morphology is essential for enhancing the fit and comfort of foot-related products in fields like orthopedics, orthotic design, and sports sciences. *Objectives:* This study aims to collect foot anthropometric dimensions, categorize foot types, and compare these dimensions among the Indian population. *Materials and Methods:* A total of 162 male volunteers (average age: 28.20 ± 12.95 years, height: 165.62 ± 6.27 cm, weight: 63.33 ± 6.70 kg) participated. Measurements were taken using a 3D foot scanner, and data analysis was performed using SPSS version 26. *Results:* The study found that 53.08% of participants had the Egyptian foot type, followed by 46.91% with the square foot type. Square foot measurements were generally higher than Egyptian feet, except for foot arch height. Significant differences ($p<0.05$) were observed in waist circumference, toe circumference, and heel center width between the two-foot types. The Egyptian foot type showed lower values in all dimensions compared to the square foot type. However, all foot parameters for the square foot type were higher than the pooled data, except for foot arch height. *Conclusion:* The most prevalent foot shapes among Indian males are the square and Egyptian types. The study recommends designing adult-specific shoes based on these foot types.

Keywords: Foot type, Foot Dimension, Indian Adults, Footwear Design, Orthosis-prothesis Design.

Introduction

The human foot is the lowest part of the leg, and due to its structure and the body's natural ability to maintain balance, people can run, climb, and engage in various physical activities besides walking. The foot is a complex anatomical structure composed of movable bones, joints, muscles, and soft tissues [1]. The development and changes in human foot shape begin during the postnatal developmental stage. Human feet consist of 52 bones, with 25% of the bones located in the ankle [2].

Foot anthropometry involves measuring both the size and dimensions of the foot. The human foot bears the body's weight and serves as the foundation for bipedal mobility [3]. Anthropometric data is vital for product design and development in global markets. Using appropriate anthropometric measures can enhance well-being, health, and comfort, particularly in footwear design. These measurements are used in shoe manufacturing to assist with construction operations. When creating shoes and boots, anthropometric measurements of the leg area are taken. Foot anthropometric measures that are used to design shoes and socks should be representative of specific groups, such as children, teenagers, and the elderly [4].

The use of 3D foot scanning has the potential to play a significant role in developing customized products. It is hypothesized that gender, age, and body mass are influencing factors on foot morphology, as well as on the differences between static and dynamic foot morphology. Identifying these influences is important to determine if footwear should account for these influencing variables, potentially improving the dynamic fit of footwear for maturing feet [5]. There are 3 most common types of foot, and these are

Egyptian foot, Greek foot, and square foot. The Egyptian foot is the most common foot shape found among the largest population across India. The Egyptian foot is a type of foot distinguished by a long, big toe, followed by the other toes tapering at a 45-degree angle. The entire foot is at an incline, and usually longer and narrower than other shapes [6-7].

The Greek foot is referred to as the flame foot or fire foot. This foot type is characterized by a protruding second toe longer than the big toe. They are energetic and they have the trait of natural leaders but can be impulsive and a bit stressed head. The square foot is characterized by the first three toes being of the same height, with the other two in descending order. Individuals with this toe type often have a balanced body shape and a personality that is inherently outgoing, energetic, and adventurous [8].

Orthosis and prostheses are devices that help people with disabilities. Orthosis, commonly known as braces, supports and modifies the structural and functional characteristics of the human neuromuscular and musculoskeletal systems. The prosthesis is a device designed to replace a missing body part such as an arm, hand, foot, or leg, to improve body function. Furthermore, foot anthropometric data can be used by podiatrists, footwear producers, and orthopedic equipment manufacturers to enhance product design to meet specific patient needs, improving comfort and performance. Incorporating anthropometric measurements into the design of orthopedic devices has been demonstrated to enhance walking patterns and reduce leg pain in individuals with knee osteoarthritis [9].

Shoes should provide daily protection for our feet, especially during movement. Proper shoe fit is crucial for developing feet to avoid affecting physiological maturation [10]. It's important to wear proper footwear to reduce the risk of foot problems such as hallux valgus, corns, ankle injuries, chronic pain, and blisters. The shape of the shoe 'last' is crucial for creating well-fitting shoes that match the characteristics of the human foot. Designing footwear based on anthropometric data can improve fit and help prevent foot deformities in the long term [11-12]. Unfortunately, there is limited and insufficient data available on the foot dimensions of the adult Indian population. Understanding foot dimensions is essential for designing footwear, orthoses, prostheses, and other foot-related products. Therefore, this study aims to measure the anthropometric foot dimensions, categorize foot types (e.g., Egyptian, Square foot), and analyze the variations in foot dimensions among the Indian adult population.

Material and Methods

Participants: The cross-sectional study aimed to collect foot anthropometric data from individuals aged between 18 and 50 years. This study took place at the Footwear Design and Development Institute (FDDI) in North India. One hundred and sixty-two healthy male participants were randomly selected for the experiment, and their mean ± standard deviation values were as follows: Age (27.28 ± 9.02) years, Height (165.62 ± 6.27) cm, Weight (63.33 ± 6.70) kg.

Inclusion criteria: The healthy subjects with no foot deformities and no musculoskeletal disorders in the lower extremities.

Instrumentation: In this study, all foot parameters were captured by a 3D foot scanner (model: LSF-350-A) from Shenzhen 3doe Technology Co., Ltd., China, which offers high measuring precision with a standard error of less than 0.5mm.

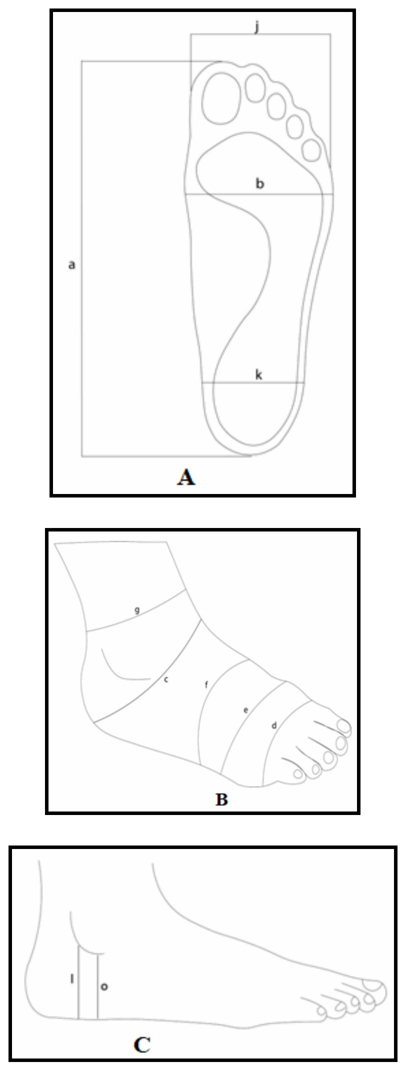
Measurement procedure: Before the start of the study, each participant provided informed consent. They were then informed about how the study would be conducted and its purpose was explained to them. The participants were asked to either remove their shoes and socks or to go barefoot. Their height and weight were then measured using an anthropometric rod and a standard weighing machine. Following this, participants underwent a foot scanning process, ensuring equal distribution of body weight between both feet (right and left). The scanning process took 5-10 seconds to capture both feet. Upon successful completion of the scan, measurements of both feet were displayed to the participants and recorded using a 3D foot scanner instrument. Subsequently, 15-foot parameters were obtained from the reported foot anthropometry data (Fig-1).

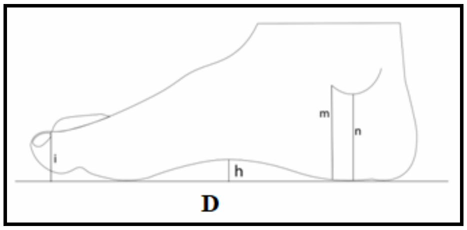
Fig-1: Foot scanning process of participants.

The foot morphology measurements were conducted according to their foot and anatomical landmarks points were (Fig-2);

a) Foot Length (mm) - Distance from the pterion point to the most anterior point of the longest toe (first and second) measured parallel to the foot axis.
b) Feet Width (mm) - Distance between the metatarsal tibiale point and the metatarsal fibulare point.
c) Heel girth / Circumference (mm) - The measurement around the widest part of the heel.
d) Toe girth/ Circumference (mm) - Distance between the metatarsal tibiale point and metatarsal fibulare.
e) Waist girth /Circumference (mm) - The measurement is taken around the narrowest part of the foot, typically just above the instep and below the ankle bone.
f) Instep girth /Circumference (mm) - The measurement is taken around the arch of the foot, specifically the highest point of the foot where it meets the leg.
g) Ankle girth /Circumference (mm) - The measurement is taken around the ankle, typically taken just above the ankle bone.
h) Foot Arch Height (mm) - Distance between the ground and the highest point of the arch.
i) Thumb Height (mm)-The position of the big toe.
j) Toe Width (mm)-Distance between the medial and lateral borders of toes.
k) Heel center Width (mm) - Distance between the medial and lateral heel point.
l) Lateral Malleolus Length (mm)- The vertical distance from the most lateral point of the lateral malleolus to the supporting surface of the foot.
m) Medial Malleolus Length (mm) - The vertical distance from the most medial point of the medial malleolus to the supporting surface of the foot.
n) Spherion Height (mm) - The measurement is taken from the ground to the most prominent point on the lateral malleolus height when the individual stands erect with feet together.
o) Spherion Fibulae Height (mm) - The measurement is taken from the ground to the highest point of the head when the individual stands erect with feet together.

Fig-2 (A, B, C, D): Foot anthropometric landmarks points.





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Ethical clearance: The present study protocol on human use as an experimental subject and the entire principles of the experiment outlined by the Declaration of Helsinki Protocol, 1964, and as per approved ethical clearance No HMC/ IEC/ FDDI/ 01, dated 18.04.2024.

Statistical Analysis: The collected data was summarized as Mean ± SD. The Shapiro-Wilk Normality test indicated that the parameters were not normally distributed. In this study, descriptive statistics were used to evaluate the frequency distribution of different foot types (Egyptian and Square), which were presented as percentages (%), and 5th and 95th percentile values were calculated for both Egyptian and square foot types. Therefore, the Mann-Whitney U test was conducted to determine the statistically significant differences in foot anthropometric parameters between the pooled data vs. Egyptian foot type, pooled data vs. square foot type, and Egyptian vs. square foot type. The significance level was set at 0.05. The collected data was analyzed using SPSS software version 26.

Results

In this study, Fifteen-foot anthropometric parameters were selected and their Mean ± SD were Feet length (248.01±16.002)mm, Feet width (92.81± 6.190) mm, Heel girth (309.93± 20.917) mm, Toe girth (208.98±17.493) mm, Waist girth (230.21±16.855)mm, Instep girth (227.48± 16.095) mm, Ankle girth (237.29 ±17.282) mm, Thumb height (41.69±4.374)mm, Toe width (20.43± 1.996) mm, Heel Center Width (89.26 ±6.287) mm, Lateral Malleolus Length (137.15 ±8.849) mm, Medial Malleolus Length (54.99 ±4.997) mm, Sphyrion Fibulare Height (56.33 ±6.447) mm, Sphyrion Height (65.78 ±6.660) mm and Foot arch height (12.38±4.911) mm. These anthropometric parameters were used to development of footwear-related products/ tools. The Mean±SD of foot anthropometric parameters are presented in Table 1.

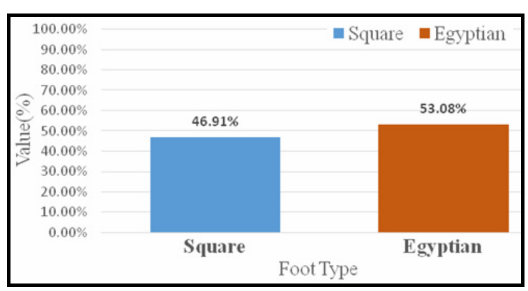
Table-1: Mean ± SD of foot anthropometric parameters of the studied population Total N=162

Parameters (mm)	Mean ± SD
Feet Length	248.01 ± 16.002
Feet Width	92.81 ± 6.190
Heel girth /Circumference	309.93 ± 20.917
Toe Circumference	208.98 ± 17.493
Waist girth /Circumference	230.21 ± 16.855
Instep girth /Circumference	227.48 ± 16.095
Ankle girth /Circumference	237.29 ± 17.282
Foot Arch Height	12.38 ± 4.911
Thumb Height	41.69 ± 4.374
Toe Width	20.43 ± 1.996
Heel Center Width	89.26 ± 6.287
Lateral Malleolus Length	137.15 ± 8.849
Medial Malleolus Length	54.99 ± 4.997
Sphyrion Fibulare Height	56.33 ± 6.447
Sphyrion Height	65.78 ± 6.660
Note: SD = Standard Deviation.	

Table-2: The comparative Percentage value of Egyptian, Square foot types in the Present study

Observation	Egyptian (n=86) (%)	Square (n=76) (%)
Present Study (N=162)	53.08	46.91
Sharma D et.al (N=197) [13]	39.08	23.85
Young CC et.al (N=708) [14]	76.09	-
Muzurova LV et.al (N=240) [15]	42.80	-
perezPico AM et.al (N=168) [16]	55.20	-

Fig-3: Percentage (%) value of Egyptian, Square foot type in the Present Study



The present study stated that most of the population belongs to the Egyptian feet type (n=86), followed by Square (n=76), In table 2, the Percentage (%) values of different foot types in the Present study are also compared with other findings (Fig-3).

The mean ± standard deviation value and percentile value (5th and 95th) for both Egyptian and square foot types are presented in Table 3. This study found that the square foot measurements are higher than those of the Egyptian feet. The square foot had higher values for feet length, feet width, heel girth, toe girth, waist girth, instep girth, ankle girth, thumb height, toe width, heel center width, lateral malleolus length, medial malleolus length, sphyrion fibulare height, and sphyrion height compared to the Egyptian foot, except for foot arch height. These percentile values (5th and 95th) are useful for designing footwear, orthotics, prostheses, and other foot-related tools/products. They also help ensure that a wide range of user needs are met, promoting comfort, safety, and effectiveness.

Table-3: The Mean ± SD and Percentile value (5thand 95th) of foot anthropometric parameters based on Egyptian and Square foot type

Parameters (mm)	Total (N=162)					
	Egyptian (n=86)			Square (n=76)		
	Mean ± SD	Percentile		Mean ± SD	Percentile	
		5th	95th		5th	95th
Feet Length	247.31 ± 15.08	220.57	270.97	248.81 ± 17.00	220.02	276.70
Feet Width	92.34 ± 5.97	82.82	102.37	93.34 ± 6.41	82.76	104.60
Heel girth/Circumference	308.14 ± 19.51	272.72	342.58	311.96 ± 22.29	273.75	346.49
Toe girth/Circumference	207.02 ± 17.93	180.21	239.20	211.21 ± 16.76	180.08	239.10
Waist girth/ Circumference	228.42 ± 16.51	202.22	256.39	232.24 ± 17.06	202.82	258.49
Instep girth/Circumference	226.11 ± 15.56	199.59	251.46	229.03 ± 16.60	201.68	255.91
Ankle girth/Circumference	235.94 ± 15.02	206.85	260.35	238.82 ± 19.46	211.03	265.00
Foot Arch Height	12.61 ± 4.82	4.70	21.17	12.13 ± 5.02	4.74	21.06
Thumb Height	41.64 ± 4.69	32.77	48.54	41.75 ± 4.00	35.15	49.30
Toe Width	20.40 ± 1.90	17.42	23.56	20.47 ± 2.10	17.48	23.82
Heel Center Width	88.61 ± 6.06	78.93	98.15	89.98 ± 6.48	79.20	100.46
Lateral Malleolus Length	136.76 ± 8.34	121.97	149.84	137.59 ± 9.40	121.67	153.02
Medial Malleolus Length	54.82 ± 5.02	45.93	62.79	55.19 ± 4.98	45.81	63.16
Sphyrion Fibulare Height	55.67 ± 6.36	45.30	65.89	57.08 ± 6.49	46.15	67.38
Sphyrion Height	65.13 ± 6.46	53.68	76.81	66.53 ± 6.83	55.65	76.22

Note: SD = Standard Deviation.

In the study, a Mann-Whitney U test was carried out to compare pooled data versus Egyptian foot types, pooled data versus square foot types, and Egyptian versus square foot types as shown in Table 4. The results revealed that there was no significant difference in all the parameters studied when comparing pooled data with Egyptian foot and square foot types at a p-value greater than 0.05. However, there was a significant difference observed between Egyptian and square foot types in Toe Circumference, Waist Circumference, and Heel Centre width at a p-value less than 0.05. No significant difference was observed in Foot Arch Height, Toe Width, Thumb Height, Medial Malleolus Length, Spherion Fibulare Height, Feet Width, Feet Length, Ankle Circumference, Lateral Malleolus Length, Instep Circumference, and Spherion Height between Egyptian and Square foot types.

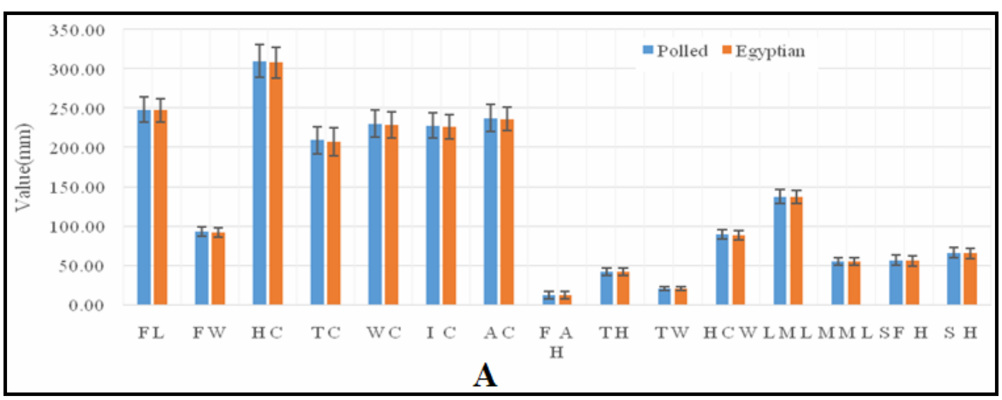
Table-4: Mann Whitney U test of foot anthropometric parameters of Pooled data v/s Egyptian foot type, Pooled data v/s square foot type, and Egyptian v/s square foot type

Parameters (mm)	Polled vs Egyptian (N=248)		Polled vs square(N=238)		Egyptian vs Square(N=162)	
	Mann Whitney U test	Asymp. sig.	Mann Whitney U test	Asymp. sig.	Mann Whitney U test	Asymp. sig.
Feet Length	27124.00	0.62 (P>0.05)	25364.00s	0.59 (P>0.05)	13812.00	0.37 (P>0.05)
Feet Width	26692.50	0.44 (P>0.05)	25795.50	0.42 (P>0.05)	14243.50	0.16 (P>0.05)
Heel girth/ Circumference	26465.00	0.35 (P>0.05)	26023.00	0.31 (P>0.05)	14471.00	0.96 (P>0.05)
Toe girth/ Circumference	25893.00	0.19 (P>0.05)	26595.00	0.15 (P>0.05)	15043.00	0.01 (P<0.05)
Waist girth/ Circumference	26148.00	0.25 (P>0.05)	26339.00	0.22 (P>0.05)	14787.50	0.04 (P<0.05)
Instep girth/ Circumference	26514.00	0.37 (P>0.05)	25974.00	0.33 (P>0.05)	14422.00	0.10 (P>0.05)
Ankle girth/ Circumference	26517.00	0.37 (P>0.05)	25971.00	0.33 (P>0.05)	14419.00	0.10 (P>0.05)
Foot Arch Height	28767.00	0.55 (P>0.05)	23721.00	0.51 (P>0.05)	12169.00	0.28 (P>0.05)
Thumb Height	28087.00	0.88 (P>0.05)	24401.00	0.87 (P>0.05)	12849.00	0.79 (P>0.05)
Toe Width	27772.00	0.95 (P>0.05)	24716.00	0.94 (P>0.05)	13164.00	0.91 (P>0.05)
Heel Center Width	26260.00	0.29 (P>0.05)	26228.00	0.25 (P>0.05)	14676.00	0.05 (P<0.05)
Lateral Malleolus Length	27124.00	0.62 (P>0.05)	25364.00	0.59 (P>0.05)	13812.00	0.37 (P>0.05)
Medial Malleolus Length	27235.00	0.67 (P>0.05)	25253.00	0.65 (P>0.05)	13701.00	0.45 (P>0.05)
Sphyrion Fibulare Height	26490.00	0.36 (P>0.05)	25998.00	0.32 (P>0.05)	14446.00	0.10 (P>0.05)
Sphyrion Height	26314.00	0.30 (P>0.05)	26174.00	0.26 (P>0.05)	14622.00	0.66 (P>0.05)

Note: SD = Standard Deviation, *(P<0.05) = Significant.

The bar diagrams show the Mean and SD values of foot anthropometric parameters of different foot types (Fig-4).

Fig-4 (A and B): In between Pooled data v/s Egyptian foot type and Pooled data v/s square foot type shows no significant differences (p>0.05) in all studied foot anthropometric parameters.



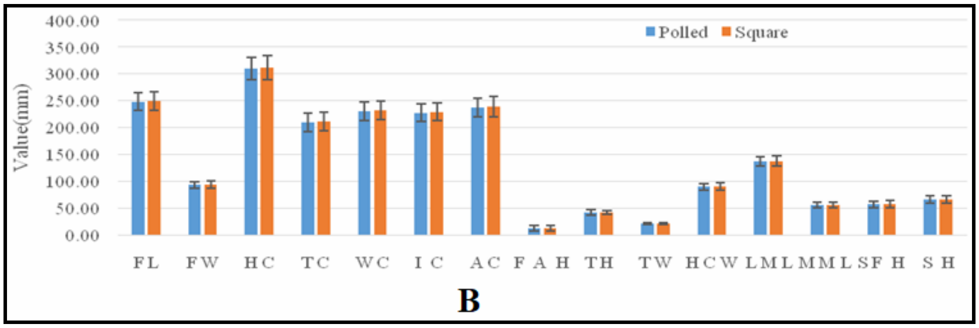
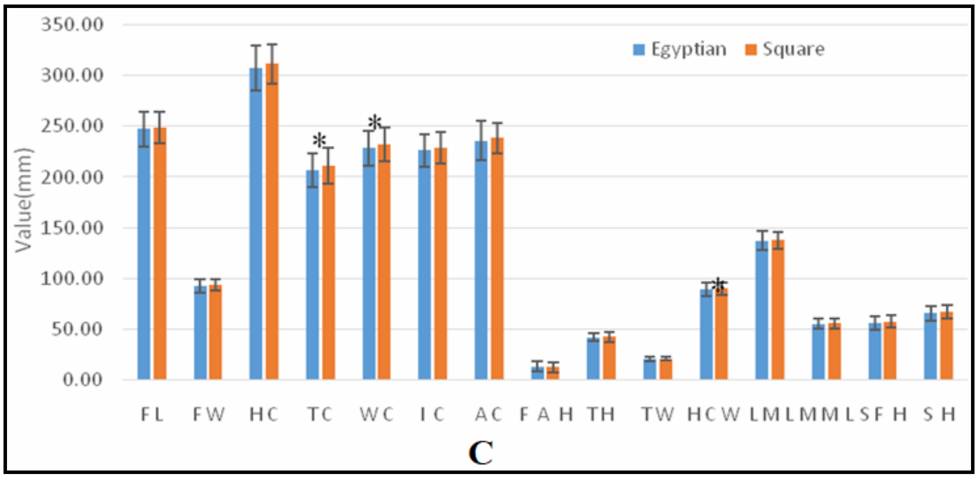


Fig-4 (C): In waist Circumference, Toe Circumference, and Heel Centre Width significant difference (p<0.05) visible between square foot type v/s Egyptian foot type.



FL= Feet Length, FW =Feet Width, HC = Heel Circumference, TC= Toe Circumference, WC =Waist Circumference, IC =Instep Circumference, AC= Ankle Circumference, FAH = Foot Arch Height, TH = Thumb Height, TW = Toe Width, HCW = Heel Center Width, LML= Lateral Malleolus Length, MML= Medial Malleolus Length, SFH= Sphyrion Fibulare Height, SH= Sphyrion Height.

Discussion

Footwear that incorporates precise anthropometric data can significantly enhance support for the foot's natural biomechanics, leading to improved performance, comfort, and safety, as well as decreased fatigue [17].

An in-depth comprehension of specific foot types and dimensions enables the design of footwear that offers superior fit, thereby fostering heightened comfort and reducing the likelihood of foot-related injuries. Additionally, the accurate measurement of feet proves advantageous in the development of orthotic devices and insoles tailored to alleviate discomfort and correct foot deformities, notably for the elderly demographic [18]. Customizing footwear to accommodate various foot types can effectively mitigate common place injuries such as plantar fasciitis, bunions, and stress fractures by furnishing essential support and cushioning, consequently promoting enhanced fit and injury prevention [19].

This study intended to assemble the foot anthropometric dimensions of the young Indian population according to their foot type and compare foot anthropometric parameters between different foot types (Egyptian foot and square foot). Table 1 shows the means and standard deviations of all foot anthropometric parameters. Some researchers have found that foot length, foot breadth, heel breadth, ball girth, toe girth, waist girth, instep girth, toe height, and instep height are the most frequently used foot dimensions for producing shoe lasts. Using these foot dimensions, one can group the foot into different foot types and develop a sizing system [20-21].

In Taiwan, some researchers collected 2486 adult participant samples and found that foot length and ball girth were the important dimensions influencing the shoe's last design. They also developed a foot sizing system. A good foot sizing system can be very beneficial for shoe and last manufacturing and can improve the fit of footwear [22]. This study provides measurements for the Egyptian foot and square foot type, including means, standard deviations, and the 5th and 95th percentile values. Previous studies in northwest Iran measured 21-foot dimensions from 580 volunteers and found that these values could be used by local footwear designers. The 5th to 95th percentile measurements encompass 90% of the population. Local manufacturers may use these dimensions to create products that are suitable for a significant portion of the population [23].

In this study, 53.08% of the subjects had Egyptian foot type. This suggests that Egyptian-type feet are present in the majority of the populations according to the findings of this study. Perez Pico AM et al. split the participants into control and institutional groups in their respective studies and found that 51.2% of participants in the institutional group and 55.2% of those in the control group, respectively, had Egyptian feet [16]. In another study conducted by Sharma D et al., 197 healthy adults were included in the study, and their foot type was determined by direct observation and classified into one of the three-foot types. They found that out of 197 adults, 77 had Egyptian feet, and 47 had square feet and it was stated that Egyptian foot was the most common and seen in 44.3% ($p = 0.1763$) of their selected population. Previous literature by Rieger ova J et al found in their study that a considerably higher frequency of Egyptian foot incidence was noted in both girls and boys (71.69% and 70.99% respectively) [24].

Young CC et al. found in their study that 76.09% of subjects showed Egyptian foot type among the selected population [14-15, 24]. Additionally, 46.91% of subjects in the present research had square foot type, which findings contradict previously published literature [13] as they found in their study that only 23.85% of individuals possessed square feet. These findings indicate that the greater variation of foot type in the present study, compared to other findings, may be due to limited sample size, age, and gender differences. In this study, a Mann-Whitney U test was conducted between pooled data and different observed foot types (Egyptian, Square foot). Egyptian and Square types of feet have lower values in foot arch height and toe width in this study. Thumb Height, Medial Malleolus Length, Spherion Fibulare Height, Feet Width, Feet length, Toe Circumference, Waist Circumference, Ankle Circumference, Lateral Malleolus Length, Instep Circumference, Heel Centre Width and Spherion Height of foot dimension in compared to pooled data there was no significant difference were observed in all studied foot dimensions ($p>0.05$), But there was significant difference ($p<0.05$) observed in between Toe Circumference, Waist Circumference and Heel Centre Width of Egyptian v/s Square foot type.

This result also indicates that Individuals with different foot types require the same size but different design patterns per foot for better fitment and to prevent deformities such as hallux valgus, or hallux rigid and other conditions including flat foot, and hollow foot. The previous research finding shows a significant high heel width in boys and girls in the age cohort 18-24 years. However, the decline noted at 18 years of age also may be related to the same confounder that was affected at the same time group for foot length [25].

There is a study that suggests people with "Egyptian feet" are more likely to experience reduced joint loading and potential damage to the thumb and microfractures in the proximal phalanx due to high pressure on the second toe [26]. Currently, shoe sizes are not adjusted for foot morphology because of variations between different populations. Additionally, adult shoes are often designed as scaled-down versions of adult shoes, despite differences in foot shape between adults [27].

These findings could have various applications as they could help footwear manufacturers adopt the 3D design of a shoe based on factors that are influenced by the customer's foot shape, leading to improved shoe fit. There is a lack of reported foot dimension databases for the Indian population, mainly due to the lack of interest and database management for all adults, as well as limited funding for research and data collection on adult foot measurements. Designing footwear that takes into account the diverse foot shapes and sizes found in the Indian population can better cater to the needs of people engaged in different activities. By concentrating on the unique foot types and dimensions of Indian adults, footwear can be created to not only provide better fit but also promote overall foot health and well-being. This approach has advantages for consumers, manufacturers, and the scientific community.

Conclusion

The findings of the present study stated that most of the feet were Egyptian foot type (53.08%) followed by square foot type (46.91%). Square foot measurements were generally higher than Egyptian feet, except for foot arch height. Significant differences ($p<0.05$) were observed in waist circumference, toe circumference, and heel center width between the two-foot types. The Egyptian foot type showed lower values in all dimensions compared to the square foot type. However, all foot parameters for the square foot type were higher than the pooled data, except for foot arch height. These foot dimensions of this study will be utilized for the design and development of footwear-related products/tools to enhance user better fitment and comfort.

The present study also suggests that foot type is to be considered during the design of products/tools (footwear, orthosis, prosthesis, last) related to the foot; to ensure better fit and increased wearer comfort as well as reduce the risk of foot injuries. So, data from the present study is beneficial for designers and manufacturers to design foot-type-specific footwear and related other products. A detailed study is required to generate a database on foot dimensions and foot type on a large sample size considering age, sex, and ethnicity as the present study was restricted to a small sample size and a specific age range only.

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Conflicts of interest: There are no conflicts of interest.

References

1. Lillis C. Foot bones: Everything you need to know. *Medical News Today.* 2019. Available from: *medicalnewstoday.com/articles/324336.*
2. Bowman K. Every Woman's Guide to Foot Pain Relief: The New Science of Healthy Feet. *BenBella Books.* 2011.
3. Igbigbi PS, Ominde BS, Adibeli CF. Anthropometric dimensions of hand and foot as predictors of stature: A study of two ethnic groups in Nigeria. *Alexandria Journal of medicine.* 2018; 54(4):611-617.
4. Mauch M, Mickle KJ, Munro BJ, Dowling AM, Grau S, Steele JR. Do the feet of German and Australian children differ in structure?. Implications for children's shoe design. *Ergonomics.* 2008; 51(4):527-539.
5. Krishan K. Anthropometry in forensic medicine and forensic science - Forensic Anthropometry. *The Internet Journal of Forensic Science.* 2007; 2(1):95-97.
6. Ola AF. Personality Identification System based on Human Foot Anatomy. *International Journal of Science and Research (IJSR).* 2018; 9(2):490-497.
7. Tang UH, Siegenthaler J, Hagberg K, Karlsson J, Tranberg R. Foot anthropometrics in individuals with diabetes compared with the general Swedish population: Implications for shoe design. *Foot Ankle Online J.* 2017; 10(3):1.
8. Dickerson LC, Queen RM. The Design and Validation of a Low-Cost Foot Measurement System. *Journal of Biomechanical Engineering.* 2021; 143(8):084502.
9. Rogati G, Leardini A, Ortolani M, Caravaggi P. Validation of a novel Kinect-based device for 3D scanning of the foot plantar surface in weight-bearing. *Journal of Foot and Ankle Research.* 2019; 12:1-8.
10. Wolf S, Simon J, Patikas D, Schuster W, Armbrust P, Döderlein L. Foot motion in child’s shoes – a comparison of barefoot walking with shod walking in conventional and flexible shoes. *Gait & Posture.* 2008; 27(1):51-59.
11. Killian RB, Nishimoto GS, Page JC. Foot and ankle injuries related to rock climbing. The role of footwear. *Journal of the American Podiatric Medical Association.* 1998; 88(8):365-374.
12. Ayub A, Yale SH, Bibbo C. Common foot disorders. *Clinical Medicine & Research.* 2005; 3(2):116-119.

13. Sharma D, Agarwal P. Determination of Types of Foot in the Indian Population and Its Association with Ingrowing Toenail. *Journal of Foot and Ankle Surgery (Asia Pacific).* 2017; 1;5(1):13-15.
14. Young CC, Niedfeldt MW, Morris GA, Eerkes KJ. Clinical examination of the foot and ankle. *Primary care: Clinics in office practice.* 2005; 32(1):105-132.
15. Muzurova LV, Kochelaevskaya IE. Individual variability of morphometric parameters feet of girls 18-19 years from Saratov region of the Russian Federation. *Russian Open Medical Journal.* 2017; 6(1):104.
16. Pérez Pico AM, Marcos Tejedor F, Martínez Quintana R, Iglesias Sánchez MJ, Mayordomo R. Digital formula is conditioned by deformities and footwear characteristics in older people. A comparison between general population and population with psychiatric disorders. *Eur. J Anat.* 2018:51-58.
17. Price, Carina, and Richard Jones. Investigating footwear biomechanics concepts in ‘health and well-being’ footwear. *University of Salford (United Kingdom),* 2014.
18. Li Pui Ling. Development of balance-enhancing geriatric indoor footwear. *The Hong Kong Polytechnic University.* 2019; 1(1):1-165.
19. Tajerian, Maral and Jaqueline Garcia. Garments and Footwear for Chronic Pain. *Frontiers in Pain Research* 2021; 2: 757240.
20. Kalebota N, Szirovicza L, Tucaković-Mujagić L, Drenovac M. The structure of body measurements for the determination of shoe sizing for young Croatian men. *Collegium Antropologicum.* 2003; 27(2):635-643.
21. Lee YC, Wang MJ. Taiwanese adult foot shape classification using 3D scanning data. *Ergonomics.* 2015; 58(3):513-523.
22. Cheng FT, Perng DB. A systematic approach for developing a foot size information system for shoe last design. *International Journal of Industrial Ergonomics.* 2000; 25(2):171-185.
23. Manna I, Pradhan D, Ghosh S, Kar SK, Dhara P. A comparative study of foot dimension between adult male and female and evaluation of foot hazards due to using of footwear. *Journal of Physiological Anthropology and Applied Human Science.* 2001; 20(4):241-246.
24. Riegerová J, Zeravova M, Pestukova M. Analysis of morphology of foot in Moravian male and female students in the age infans 2 and juvenils. *Acta Univ Palacki Olomuc Gymn.* 2005;1;35:69-72.
25. Xu M, Li JX, Hong Y, Wang L. Foot morphology in Chinese adolescents aged between 13 to 18 years varies by gender and age. Medical Science Monitor. *International Medical Journal of Experimental and Clinical Research.* 2019; 25:937.
26. Oztekin HH, Boya H, Nalcakan M, Ozcan O. Second-toe length and forefoot disorders in ballet and folk dancers. *Journal of the American Podiatric Medical Association.* 2007; 1; 97(5):385-388.
27. Mauch M, Mickle KJ, Munro BJ, Dowling AM, Grau S, Steele JR. Do the feet of German and Australian children differ in structure? Implications for children's shoe design. *Ergonomics.* 2008; 1; 51(4):527-539.

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