10.31674/mjmr.2022.v06i03.001

MJMR

Prevalence of Flat Foot in College Going Students: A Cross Sectional Study

Khadanga G B [1], Kumar P [2]

[1]Dept. of Physiotherapy, National Institute for Locomotor Disabilities, Kolkata, India

[2]Asst. Prof. Dept. of physiotherapy, National Institute of Locomotor Disabilities, Kolkata, India

****Corresponding Authors Email:** golakkhadanga@gmail.com*

ABSTRACT

Background: Proper posture and mobility depend on healthy feet. A medical ailment known as flatfoot, also known as pes planus, is characterised by a lack of or reduced medial longitudinal arch and an Osseo-ligamentous misalignment. The purpose of this study was to use medial longitudinal arch angle and navicular drop evaluation techniques to determine the prevalence of flat feet in college-going students between the ages of 18 and 25. **Methods:** In this cross-sectional research, 205 participants (116 men and 89 women) between the ages of 18 and 25 were evaluated for flat feet using Brody's navicular drop test and medial longitudinal arch angle measurement. Flat feet were defined as having a medial longitudinal arch angle of less than 130° and a navicular drop of more than 10mm. **Results:** The overall population's mean age (n=205) was 23.30 + 1.63 years. This study's findings indicated that flat feet were prevalent in 20% of the population when using the ND test (for males: 21.55%; for females: 17.97%), however they were prevalent in 5.36% of the population when using the MLAA measurement (for males: 5.17%; for females: 5.61%). **Conclusion:** The incidence of flat feet among young college-going students was assessed by the study's findings. Based on the study's findings, it can be said that using the navicular drop test, the prevalence of flat feet among college-going students was 20%, but using the medial longitudinal arch angle measurement, it was 5.61%.

Keywords: Flat foot, Navicular Drop, Medial Longitudinal Arch Angle

INTRODUCTION

The design and motion of the foot arches are essential to a person's health and the proper operation of the body. Adult flatfoot is characterised by partial or total loss (collapse) of the medial longitudinal arch (MLA) when in a weight-bearing situation and is described as a foot ailment that continues or develops after skeletal maturity (Lee *et al.*, 2005). The likelihood of having flatfeet varies with age, sex, body mass index, and ethnicity. Adults have reported having flat feet; the prevalence is at least 20%. Additionally, just 24% of children aged 6 years had flat feet, compared to 54% of children aged 3 years (Smyth *et al.*, 2017). It has been discovered that in preschoolers, the likelihood of having flat feet dropped by 36.8% year, with males much more likely than girls to have flat feet (Spahn *et al.*, 2004).

The most significant cause of flat feet is malfunctioning of the posterior tibial tendon (PTT). In the watershed region posterior to the medial malleolus, the tendon often degenerates and predisposes to tendinopathy (Van & Sangeorzan, 2003). In 1998, Mosier et al. established the histopathologic feature of acquired flatfoot and demonstrated that degenerative tendinosis is the mechanism for persistent failure of PTT (Pomeroy *et al.*, 1999). These medial soft-tissue longitudinal arch constraints weaken over time after PTT weakening, leading to the loss of the medial longitudinal arch. Following PTT failure, this is a typical mechanical route for the formation of adult flat feet (Harris & Beath, 1949). Adult flat foot problem can also result from isolated spring ligament damage, which is a different clinical condition (Abousayed *et al.*, 2017). In patients with established PTT insufficiency, Deland *et al.* observed an 87% frequency of superomedial and 74% of inferior spring ligament attrition or rips on MRI (Deland *et al.*, 2005). The principal static and dynamic support structure of the human foot's arch is the plantar aponeurosis, which also contributes to the stability of the forefoot and midfoot. According to Crary and colleagues' research, the plantar aponeurosis is the main component preventing malformation of the foot's arch (Sung *et al.*, 2017). The lowering of MLA height and subsequent rise in adult flatfoot incidence are both significantly influenced by the wear and tear on the intrinsic foot muscles. When individuals engaged in activities that fatigued the abductor hallucis of the foot, the navicular drop as evaluated by Brody's approach revealed an increase in pronation during the stance phase (Headlee *et al.*, 2008).

For assessing a flat foot, several tests have been suggested in various research. Visual examination technique, footprint analysis, arch height, navicular drop (ND), rearfoot angle, navicular drift, valgus index, medial longitudinal arch angle, radiographic evaluation, and calcaneal inclination angle are a few of the regularly utilised tests (Razeghi & Batt, 2002). The bulk of research in India has been done on children under the age of 10, but there are also a few pieces of literature on the frequency of flat feet in college-bound adolescents between the ages of 18 and 25. In the majority of the studies, the less reliable footprint method or visual evaluation approach was used to identify flat feet. Thus, the aim of this study was to determine the prevalence of flat feet in college-bound individuals between the ages of 18 and 25 by measuring the medial longitudinal arch angle and navicular drop.

METHODOLOGY

Design: A cross-sectional study was performed at the Department of Physiotherapy, National Institute for Locomotor Disabilities (Divyangjan), Kolkata.

Participants: Participants had to be 18 to 25 years old. Both male and female volunteers willing to participate were included. Exclusion criteria were subjects having congenital anomalies in the lower limb, history of surgery, fracture or dislocation in the lower limb, any neuromuscular disorder, presence of severe scoliosis, leg length discrepancy of more than 1.5 cm, acute ankle sprain, presence of corn or calluses in foot.

Outcome Measures: All participants were evaluated using the tests outlined below.

Navicular Drop Test

The height of navicular tuberosity was marked on the index card. Then the subject was asked to assume 50% weight bearing on the foot, which was in the talar head congruent position and another mark was made. The difference between the marks on the index card was measured with Vernier calliper. The ND was measured for both feet in each subject. A difference of 5-9 mm was considered normal and ≥10 mm was suggestive of presence of pronated or flat foot (Picciano, Rowlands & Worrell, 1993; Zuil-Escobar *et al.*, 2018, Kirmizi *et al.*, 2020). (Figure 1 & 2)

Figure1: Measurement of Navicular Drop in Sitting

Figure 2: Measurement of Navicular Drop in Standing

Medial Longitudinal Arch Angle

A line joining the medial malleolus to the navicular tuberosity and another line from navicular tuberosity to most medial aspect of the first metatarsal head was drawn. The angle between these two lines was measured and noted using a universal goniometer. If the angle was <130° then the oot was considered as pronated or flat foot and 130°-150° was considered as normal (Jonson & Gross, 1997). (Figure 3 & 4)

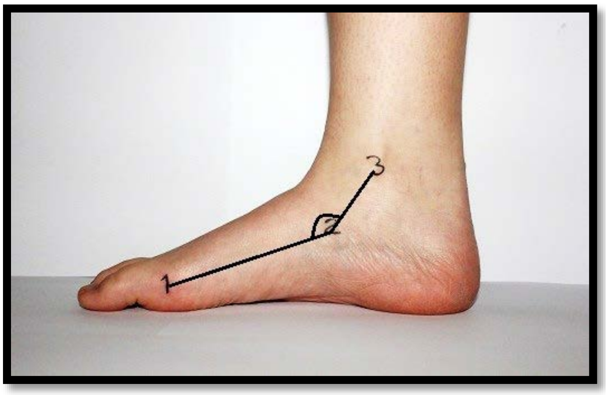

Figure 3: Anatomical landmark for Medial Longitudinal Arch Angle

Figure 4: Measurement of Medial Longitudinal Arch Angle

Data Analysis: Data was collected and analysed between October 2020 to September 2021. IBM SPSS version 25 software was used for analysis of the data. Descriptive statistics was used to find the prevalence of flat foot in college going students.

Results:

Prevalence of flat foot was checked in 205 college going students (116 male and 89 female). The mean age of the total population was 23.3 ± 1.63 years in which the mean age of male was 23.26 ± 1.78 years and female was 23.36 ± 1.4 years. The mean BMI of total population was 23.90 ± 4.01 kg/m^2. BMI for male was 24.36 ± 3.98 kg/m^2 and for female was 23.30 ± 3.99 kg/m^2.

The mean ND for total population was 6.77 ± 2.31 mm on the right side whereas it was 6.87 ± 2.34 mm on the left side. For male subjects the mean ND was 10.20 ± 1.09 mm on the right side and 10.60 ± 1.81 mm on the left side. Similarly in female subjects it was 10.50 ± 0.70 mm and 9.50 ± 0.70 mm on the right and left side respectively. The mean MLAA for total population was 146.20 ± 7.30 degree on the right side and it was 142.02 ± 7.30 degree on the left side. For male subjects the mean MLAA was 133.40 ± 3.78 degree on the right side and 129.20 ± 3.27 degree. In female subjects it was found to be 134 ± 7.07 degree and 129 ± 1.41 degree on the right and left side respectively. [Table-1]

Table 1: Details of Demographic data

VARIABLES		TOTAL (n=205)	MALE (n=116)	FEMALE (n=89)
AGE (In years)		23.30 ± 1.63	23.26 ± 1.78	23.36 ± 1.44
BMI (kg/m^2)		23.90 ± 4.01	24.36 ± 3.98	23.30 ± 3.99
ND (mm)	RIGHT	6.77 ± 2.31	10.20 ± 1.09	10.50 ± 0.70
	LEFT	6.87 ± 2.34	10.60 ± 1.81	9.50 ± 0.70
MLAA (degree)	RIGHT	146.22 ± 7.30	133.40 ± 3.78	134 ± 7.07
	LEFT	142.02 ± 7.30	129.20 ± 3.27	129 ± 1.41

Prevalence of Flat foot using Navicular Drop Test:

In this study out of 205 subjects, total 41 (20%) were diagnosed with flat foot clinically having positive navicular drop test. Among them 25 (21.55%) were male and 16 (17.97%) were female subjects. Total 13 male (11.20%) and 08 female (8.98%) were having presence of unilateral flat foot. Bilateral flat foot was present in 12 males (10.34%) and 08 females (8.98%). [Table-2]

Table 2: Showing %age of Subjects having flat foot using Navicular Drop Test

	TOTAL (n=205)		UNILATERAL (n=205)		BILATERAL (n=205)	
	MALE (n=116)	FEMALE (n=89)	MALE (n=116)	FEMALE (n=89)	MALE (n=116)	FEMALE (n=89)
NUMBER OF INDIVIDUAL	25	16	13	08	12	08
% OF INDIVIDUALS	21.55	17.97	11.20	8.98	10.34	8.98
TOTAL NUMBER OF SUBJECTS	41		21		20	
% OF SUBJECTS	20		10.25		9.75	

Prevalence of Flat foot using Medial Longitudinal Arch Angle:

Prevalence of flat foot was also checked by measurement of medial longitudinal arch angle of foot. In this study out of 205 subjects, total 11 (5.36%) subjects were diagnosed with flat foot having positive medial longitudinal arch angle measurement. Among them 06 (5.17%) were male and 05 (5.61%) were female. Unilateral flat foot was found in 05 (4.31%) male and 04 (4.49%) female whereas bilateral flat foot was found in 01 male (0.86%) and 01 female (1.12%). [Table-3]

Table 3: Showing %age of Subjects having flat foot using Medial Longitudinal Arch angle

	TOTAL (n=205)		UNILATERAL (n=205)		BILATERAL (n=205)	
	MALE (n=116)	FEMALE (n=89)	MALE (n=116)	FEMALE (n=89)	MALE (n=116)	FEMALE (n=89)
NUMBER OF INDIVIDUAL	06	05	05	04	01	01
% OF INDIVIDUALS	5.17	5.61	4.31	4.49	0.86	1.12
TOTAL NUMBER OF SUBJECTS	11		09		02	
% OF SUBJECTS	5.36		4.39		0.97	

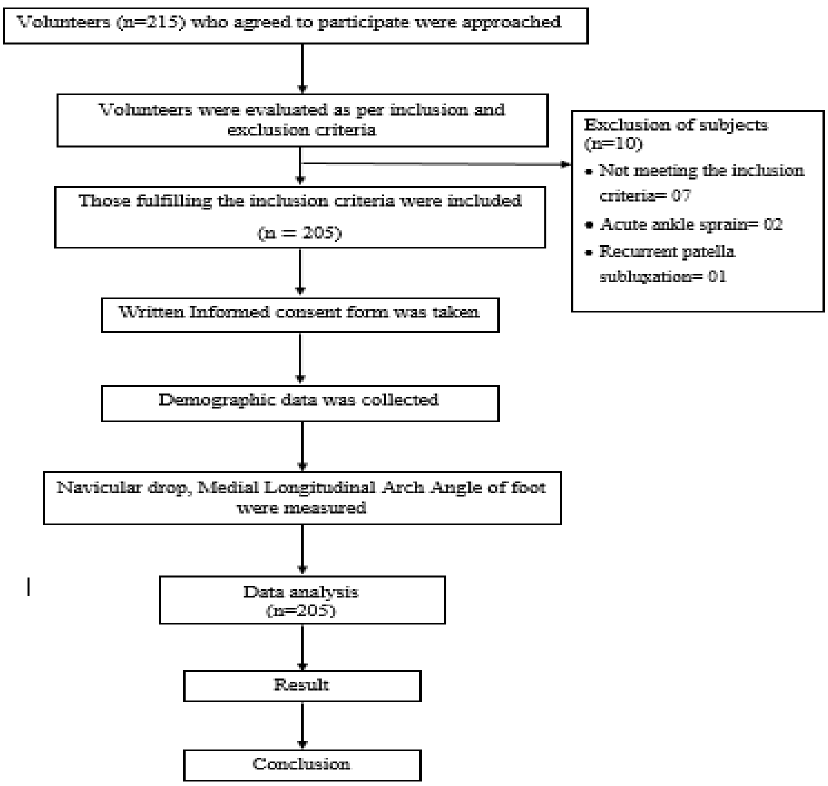

Figure 5: Consort flow diagram

DISCUSSION

When using the Navicular Drop test, the study's findings revealed that 20% of college going students had flat feet, however when using the Medial Longitudinal Arch Angle measurement, the prevalence was 5.36%.

In the adult population, flat feet are a prevalent problem. It often appears after skeletal maturity and is defined by a partial or total loss of the medial longitudinal arch (MLA) under load. Ferciot *et al.* explained the aetiology of developing flatfoot. They claim that infants with "turned up feet" and dorsiflexion contractures of the ankles who are born acquire a noticeable flatfoot condition as a result of aberrant muscle stresses placed on the growing foot throughout infancy (Ferciot, 2007). Contrarily, in adults, flat feet are typically acquired types, and their causes include PTT dysfunction, midfoot laxity, hindfoot external rotation, a tight heel cord, forefoot abduction, talar dislocation, damage to the ankle and foot, arthroses, Charcot's foot, and neuromuscular imbalance (Niki *et al.*, 2001).

It has been suggested that a number of variables contribute to the prevalence of flat feet in the adult population. Age is a key factor related with flatfoot deformity, according to Shibuya et al. Due to the development of structural normality during this time, it has been seen that the occurrence of flat feet in children aged 3 to 6 years has decreased. Additionally, it has been shown that the male gender plays a key role in flatfoot deformity. In contrast, it makes sense that the prevalence would rise in adults. However, a research by Sachithanandam and Joseph found no significant differences in the prevalence of flatfeet in skeletally mature participants by age group. Age was not shown to be a major risk factor for developing tibialis posterior dysfunction by Hohls-Gatzoulis et al (Shibuya et al., 2010). BMI is another crucial factor that has been linked statistically significantly to flat feet. According to the results of a research done on Turkish teenagers, height and weight have no bearing on the likelihood of developing flat feet. According to Arangio *et al.*, those with flat feet had considerably greater BMI than those without flat feet (Arangio, Wasser & Rogman, 2006).

When the navicular drop test was utilised in this study, males exhibited a substantially higher inclination toward flat feet than females: the prevalence of flat feet in males was 21.55% and in females, 17.97%.

It has been shown that males had a larger rearfoot valgus across all age groups. Furthermore, within the analysed sample of some earlier research, a significant variation in the development of the rearfoot valgus between boys and girls was found. The male exhibited a one-year delay in the development of the rearfoot valgus compared to the female, according to an analysis of the mean valgus in the various age groups. These finding complements research by Pfeiffer *et al.* that discovered that male individuals were more likely than female ones to have flat feet (Pfeiffer *et al.*, 2006).

Particularly those in the heel, arch, and metatarsal head areas, the specialised fat pads on the plantar surface of the foot are made to cushion the underlying foot bones from the ground reaction stresses produced by walking and other everyday activities. It is believed that the plantar fat pads dissipate part of the mechanical energy involved with each foot contact, effectively absorbing stress for the entire body. Age and gender may have an impact on the fat pad's thickness. Males have been found to have a much bigger mid-foot fat pad than females, which has been linked to their higher occurrence of flat feet (Adhikari *et al.*, 2014). Additionally, males have considerably higher arch index values than females, indicating that the plantar surface of the midfoot is in contact with the ground to a greater extent in men. This supports the findings of Pfeiffer *et al.*, Stavlas *et al.*, (2005), and Chang *et al.* (2010), who found that men were more likely than women of the same age to have flat feet.

When medial longitudinal arch angle measurement was employed in the current study to diagnose flat feet, it was discovered that women are more likely than men to have flat feet.

It had been suggested that the laxity of the ankle ligaments in men and women differed. Typically, female ankles are more supple than male ankles (Senadheera, Ekanayake & Wanigatunge 2016). Senadheera *et al.* (2016) and Wilkerson & Mason (2000) had a similar opinion, citing female hyperlaxity of joints as a potential cause of the gender difference seen in the population of people with flat feet.

In the current study, students studying allied health care had a greater frequency of flat feet. Graduates in allied health programmes must spend a lot of time standing while performing clinical tasks in a hospital setting due to professional obligations. In these conditions, the existence of flatfoot may have a detrimental effect on their output in terms of productivity and efficiency (Jayabandara *et al.*, 2021).

The height of the medial arch was measured in this study using the navicular drop test. Male and female volunteers made up the entire population, and the mean RND was 6.77±2.31 mm and the mean LND was 6.87±2.34 mm. The medial longitudinal arch may weaken as a result of increasing pronation brought on by ligament elasticity and repeated stressors. The height of the medial arch has a direct bearing on the possibility of lower extremity injury. Repetitive stress leads to these injuries over time, which creep and hysteresis within the ligamentous system of the foot. In order to analyse the impact of the biomechanics of gait variable changes noticed during locomotion, the medial arch must be quantified (Adhikari *et al.*, 2014)

The stance phase of typical walking appears to include substantial medial and vertical displacement of the navicular bone. The navicular height had been hypothesised to be a sign of dynamic navicular bone mobility. Additionally, it would seem that both static and dynamic measurements of the navicular bone serve as a global indication of the midfoot and rearfoot components of foot pronation or supination because it is one of the four bones that make up the three articulations of the restricted tarsal mechanism (Cornwall & McPoil, 1999). The outcomes of this investigation are consistent with Nielsen *et al.* (2009) and Bandholm *et al.* (2008), who assessed a dynamic ND and discovered comparable outcomes. Additionally, 10.34% of males and 8.98% of females in this research had bilateral flat feet, whereas 11.20% of males and 8.98% of females had unilateral flat feet. Similar findings were reached before in a research by Aenumalapalli A *et al.* that evaluated the occurrence of bilateral and unilateral flat feet (Tang, Ng & Lai, 2020).

A crucial criterion for determining how the ankle and foot move in the sagittal plane and for observing the biomechanical changes brought on by flat feet is the measurement of the medial longitudinal arch angle. The MLAA is a crucial indication for assessing the performance of the windlass system. According to studies, a shift in the moment of the medial longitudinal arch causes the forefoot and the hindfoot to "flatten out" during the terminal stance phase of the gait cycle. Normal feet modify their hindfoot eversion and inversion during the loading response to release the midtarsal joint and absorb shock, whereas flat feet experience much more hindfoot eversion, forefoot abduction, and internal rotation in relation to the tibia. These impair the capacity of the flat-footed gait to absorb stress and make it harder for the foot to resupinate and invert for propulsion. The increased medial longitudinal arch flexibility during plantigrade walking on the stiff surface was also shown by the flatfoot group's bigger medial longitudinal arch deformation angle.

Measurement of MLAA was advised as a trustworthy method for determining if a person has a flat foot by Dahle *et al* and Donatelli. In this study, 5.36% of participants had a flat foot diagnosis based on clinically positive MLAA results. Additionally, the prevalence of both unilateral and bilateral flat feet in both males and females was measured. Positive medial longitudinal arch angles unilaterally, bilaterally, and for the entire population had never been separately measured in a study before. The mean left MLAA was determined to be 142.02 ±7.30 degree, while the mean right MLAA for the entire population was 146.22±7.30 degree. It was 133.40 ± 3.78 degrees and 129.20 ± 3.27 degrees for the male population. It was 134 ±7.07 degrees and 129 ± 1.41 degrees, respectively, for the female population. The values of this study were consistent with the results of Dahle *et al's* and Jonson *et al.*

LIMITATIONS AND FUTURE RECOMMENDATIONS:

First off, the study's age range was restricted to solely allied health care students, whose ages ranged from 18 to 25. So, a greater age range may be used in future studies. The second drawback is the fluctuation in prevalence rate when two different evaluation methods were used, thus further research may be done to determine the most effective technique for determining flat foot prevalence. Additionally, the gold standard for diagnosing flat feet continues to be weight-bearing radiography examinations of the ankle and foot. Therefore, this approach may be used for future research.

Conflict of Interest

The authors declare that they have no competing interests in writing this article.

CONCLUSION

It can be concluded from the results of the study that:

i. The prevalence of flat foot in college going students was 20% using navicular drop test, however unilaterally it was prevalent in 10.25% subjects and bilaterally in 9.75% subjects.

ii. The prevalence of flat foot in college going students was 5.36% using medial longitudinal arch angle. Unilaterally the prevalence was 4.39% and bilaterally it was 0.97%.

iii. It was also seen that prevalence of flat foot was more in male as compared to female.

ACKNOWLEDGEMENT

The authors are thankful to the institutional authority for completion of the work.

REFERENCES

Abousayed, M. M., Alley, M. C., Shakked, R., & Rosenbaum, A. J. (2017). Adult-Acquired Flatfoot Deformity: Etiology, Diagnosis, and Management. *JBJS reviews*, *5*(8), e7. https://doi.org/10.2106/JBJS.RVW.16.00116

Adhikari U, Arulsingh W, Pai G, Raj JO. (2014) Normative values of navicular drop test and the effect of demographic parameters-A cross sectional study. *Annals of Biological Research;* 5(7):40-8.

Arangio, G. A., Wasser, T., & Rogman, A. (2006). Radiographic comparison of standing medial cuneiform arch height in adults with and without acquired flatfoot deformity. *Foot & ankle international*, *27*(8), 636–638. https://doi.org/10.1177/107110070602700813

Bandholm, T., Boysen, L., Haugaard, S., Zebis, M. K., & Bencke, J. (2008). Foot medial longitudinal-arch deformation during quiet standing and gait in subjects with medial tibial stress syndrome. *The Journal of foot and ankle surgery : official publication of the American College of Foot and Ankle Surgeons*, *47*(2), 89–95. https://doi.org/10.1053/j.jfas.2007.10.015

Cornwall, M. W., & McPoil, T. G. (1999). Relative movement of the navicular bone during normal walking. *Foot & ankle international*, *20*(8), 507–512. https://doi.org/10.1177/107110079902000808

Dahle, L. K., Mueller, M. J., Delitto, A., & Diamond, J. E. (1991). Visual assessment of foot type and relationship of foot type to lower extremity injury. *The Journal of orthopaedic and sports physical therapy*, *14*(2), 70–74. https://doi.org/10.2519/jospt.1991.14.2.70

Deland, J. T., de Asla, R. J., Sung, I. H., Ernberg, L. A., & Potter, H. G. (2005). Posterior tibial tendon insufficiency: which ligaments are involved?. *Foot & ankle international*, *26*(6), 427–435. https://doi.org/10.1177/107110070502600601

Donatelli R. (1995) The biomechanics of the foot and ankle. FA Davis Company.

Ferciot C. F. (1972). The etiology of developmental flatfoot. *Clinical orthopaedics and related research*, *85*, 7–10. https://doi.org/10.1097/00003086-197206000-00003

Footprint Parameters. *Journal of manipulative and physiological therapeutics*, *41*(8), 672–679. https://doi.org/10.1016/j.jmpt.2018.04.001

Harris R I, Beath T. (1949) Army Foot Survey. An Investigation of Foot Ailments in Canadian Soldiers. *British Journal of Surgery*. 37(146):255. https://doi.org/10.1002/bjs.18003714645

Headlee, D. L., Leonard, J. L., Hart, J. M., Ingersoll, C. D., & Hertel, J. (2008). Fatigue of the plantar intrinsic foot muscles increases navicular drop. *Journal of electromyography and kinesiology : official journal of the International Society of Electrophysiological Kinesiology*, *18*(3), 420–425. https://doi.org/10.1016/j.jelekin.2006.11.004

Jayabandara A, Rodrigo D, Nadeeshan S, Wanniarachchi C, Rajathewa P, Makuloluwa T, Perera D. (2021) Prevalence of Flatfoot and Its Correlation with Age, Gender and BMI among Undergraduates at the Faculty of Allied Health Sciences, General Sir John Kotelawela Defence University. *Journal of Pharmacy and Pharmacology.;* 9:287-91.

Jonson, S. R., & Gross, M. T. (1997). Intraexaminer reliability, interexaminer reliability, and mean values for nine lower extremity skeletal measures in healthy naval midshipmen. *The Journal of orthopaedic and sports physical therapy*, *25*(4), 253–263. https://doi.org/10.2519/jospt.1997.25.4.253

Kirmizi, M., Cakiroglu, M. A., Elvan, A., Simsek, I. E., & Angin, S. (2020). Reliability of Different Clinical Techniques for Assessing Foot Posture. *Journal of manipulative and physiological therapeutics*, *43*(9), 901–908. https://doi.org/10.1016/j.jmpt.2020.02.002

Lee MS, Vanore JV, Thomas JL, Catanzariti AR, Kogler G, Kravitz SR, Miller SJ, Gassen SC. Diagnosis and treatment of adult flatfoot. The Journal of Foot and Ankle Surgery. 2005 Mar 1;44(2):78-113. https://doi.org/10.1053/j.jfas.2004.12.001

Nielsen, R. G., Rathleff, M. S., Simonsen, O. H., & Langberg, H. (2009). Determination of normal values for navicular drop during walking: a new model correcting for foot length and gender. *Journal of foot and ankle research*, *2*, 12. https://doi.org/10.1186/1757-1146-2-12

Niki, H., Ching, R. P., Kiser, P., & Sangeorzan, B. J. (2001). The effect of posterior tibial tendon dysfunction on hindfoot kinematics. *Foot & ankle international*, *22*(4), 292–300. https://doi.org/10.1177/107110070102200404

Razeghi, M., & Batt, M. E. (2002). Foot type classification: a critical review of current methods. *Gait & posture*, *15*(3), 282–291. https://doi.org/10.1016/s0966-6362(01)00151-5.

Shibuya, N., Jupiter, D. C., Ciliberti, L. J., VanBuren, V., & La Fontaine, J. (2010). Characteristics of adult flatfoot in the United States. *The Journal of foot and ankle surgery : official publication of the American College of Foot and Ankle Surgeons*, *49*(4), 363–368. https://doi.org/10.1053/j.jfas.2010.04.001

Smyth, N. A., Aiyer, A. A., Kaplan, J. R., Carmody, C. A., & Kadakia, A. R. (2017). Adult-acquired flatfoot deformity. *European journal of orthopaedic surgery & traumatology : orthopedie traumatologie*, *27*(4), 433–439. https://doi.org/10.1007/s00590-017-1945-5.

Spahn, G., Schiele, R., Hell, A. K., Klinger, H. M., Jung, R., & Langlotz, A. (2004). Die Prävalenz von Beschwerden und Deformierungen des Fusses bei Adoleszenten -- Ergebnisse einer Querschnittuntersuchung [The prevalence of pain and deformities in the feet of adolescents. Results of a cross-sectional study]. *Zeitschrift fur Orthopadie und ihre Grenzgebiete*, *142*(4), 389–396. https://doi.org/10.1055/s-2004-822844

Senadheera, S. P., Ekanayake, S., & Wanigatunge, C. (2016). Dietary Habits of Type 2 Diabetes Patients: Variety and Frequency of Food Intake. *Journal of nutrition and metabolism*, *2016*, 7987395. https://doi.org/10.1155/2016/7987395

Sung, P. S., Zipple, J. T., Andraka, J. M., & Danial, P. (2017). The kinetic and kinematic stability measures in healthy adult subjects with and without flat foot. *Foot (Edinburgh, Scotland)*, *30*, 21–26. https://doi.org/10.1016/j.foot.2017.01.010

Stavlas, P., Grivas, T. B., Michas, C., Vasiliadis, E., & Polyzois, V. (2005). The evolution of foot morphology in children between 6 and 17 years of age: a cross-sectional study based on footprints in a Mediterranean population. *The Journal of foot and ankle surgery: official publication of the American College of Foot and Ankle Surgeons*, *44*(6), 424–428. https://doi.org/10.1053/j.jfas.2005.07.023

Van Boerum, D. H., & Sangeorzan, B. J. (2003). Biomechanics and pathophysiology of flat foot. *Foot and ankle clinics*, *8*(3), 419–430. https://doi.org/10.1016/s1083-7515(03)00084-6

Pfeiffer, M., Kotz, R., Ledl, T., Hauser, G., & Sluga, M. (2006). Prevalence of flat foot in preschool-aged children. *Pediatrics*, *118*(2), 634–639. https://doi.org/10.1542/peds.2005-2126

Picciano, A. M., Rowlands, M. S., & Worrell, T. (1993). Reliability of open and closed kinetic chain subtalar joint neutral positions and navicular drop test. *The Journal of orthopaedic and sports physical therapy*, *18*(4), 553–558. https://doi.org/10.2519/jospt.1993.18.4.553

Prachgosin, T., Chong, D. Y., Leelasamran, W., Smithmaitrie, P., & Chatpun, S. (2015). Medial longitudinal arch biomechanics evaluation during gait in subjects with flexible flatfoot. *Acta of bioengineering and biomechanics*, *17*(4), 121–130.

Pomeroy, G. C., Pike, R. H., Beals, T. C., & Manoli, A., 2nd (1999). Acquired flatfoot in adults due to dysfunction of the posterior tibial tendon. *The Journal of bone and joint surgery. American volume*, *81*(8), 1173–1182. https://doi.org/10.2106/00004623-199908000-00014

Tang, C., Ng, K. H., & Lai, J. (2020). Adult flatfoot. *BMJ (Clinical research ed.)*, *368*, m295. https://doi.org/10.1136/bmj.m295

Wilkerson, R. D., & Mason, M. A. (2000). Differences in men's and women's mean ankle ligamentous laxity. *The Iowa orthopaedic journal*, *20*, 46–48.

Zuil-Escobar, J. C., Martínez-Cepa, C. B., Martín-Urrialde, J. A., & Gómez-Conesa, A. (2018). Medial Longitudinal Arch: Accuracy, Reliability, and Correlation Between Navicular Drop Test and Footprint Parameters. *Journal of manipulative and physiological therapeutics*, *41*(8), 672–679. https://doi.org/10.1016/j.jmpt.2018.04.001