Medicon Medical Sciences
Volume 2 Issue 5 May 2022
Review Article

Comparison of Dimensional Changes of Feet during Late Gestation between Nulliparous, Primiparous, and Multiparous Women

Avani Pal[1]* and Arati Mahishale[2]

[1]*(MPT), KLEU Institute of Physiotherapy, Belgaum, India*

[2]*Assistant Professor, KLEU Institute of Physiotherapy, Belgaum, India*

***Corresponding Author:** Avani Pal, (MPT), KLEU Institute of Physiotherapy, Belgaum, India.

Received: April 28, 2022; **Published:** May 03, 2022

Abstract

Introduction: Pregnancy is a time of many physical and physiological changes. Increased ligamentous laxity and hormonal changes leads to significant postural deviations and musculoskeletal changes. In addition, increased body weight of pregnancy, fluid retention lowers the arches of the foot, further adding to foot's length and width.

Objective: The purpose of the study was to find and compare the dimensional changes of feet during pregnancy in nulliparous (Group-A) primiparous (Group-B) and multiparous (Group-C) women.

Methods: A cross- sectional study involved a sample of 90 participants (30 in each group), in the age group of 18 – 35 years with gestational age of 32- 36weeks were measured for Foot arch index (FAI) and Navicular drop Test (NDT). Baseline characteristics were recorded, and BMI was calculated.

Results: Results showed a statistically significant difference in dimensions of foot markedly in group-B (P-value 0.00001) and group-C (P-value 0.0008) as compared to group-A. However, no significant difference was found between the trimester and total foot length in all the groups. There was significant change in Width of the foot (P- value 0.0018) markedly in group-B (P-value 0.0127) and group-C (P- value 0.0005). The Foot arch Index was positively correlated with Navicular Drop test, but negatively correlated with total length and width of foot.

Conclusion: The study concluded that there are dimensional changes of foot that occurs during pregnancy more in multipara than primipara irrespective of the trimester.

Keywords: Pregnancy; Flat foot; Foot dimensions; Foot arch index (FAI); Navicular drop Test (NDT)

Introduction

The foot arches are formed by the bones, ligaments and tendons and are essential for both movement and weight bearing. The foot has 3 distant arches, medial longitudinal arch, lateral longitudinal arch, transverse arch. The main function of these arches is to provide weight bearing and propulsion; thereby flexibility and stability are very essential components in order to support any weight [1].

Pregnancy is a time of many physical and physiological changes. These changes impact the musculoskeletal system, which can develop a variety of problems, such as back pain, separation of the pelvic bones, transient osteoporosis, and tendonitis, increase joint laxity and range of motion, increase in lordosis, change in COG, flat foot etc, which are hormonally mediated [2]. Oestrogens, progesterone, endogenous cortisols particularly relaxin are responsible for these musculoskeletal changes [3]. Significant weight gain and increased ligamentous laxity due to the hormonal changes may lead to Flatfeet in pregnancy. There is evidence that relaxin is a peptide hormone

produced by the corpus luteum in pregnant women and has important hormonal functions, including a direct effect on collagen [3, 4, 5].

A Neuromechanical adaptation to pregnancy refers to the change in gait, postural parameters, due to the numerous anatomical, physiological, and hormonal changes women experience during pregnancy. In addition, the increased body weight, fluid retention, and weight gain lowers the arches of the foot, further adding to the foot's length and width. The influences of increased hormones such as estrogen and relaxin initiate the remodeling of soft tissues, cartilage and ligaments [6].

Various management are available, for musculoskeletal problems; eg; low back pain, increase lordosis, foot pain etc. like foot wear modification, contract bath, also there is exercise prescription programme according to guidelines of American college of obstetrics and gynaecology, but studies of flat feet lacks evidence in pregnancy.

A Medline search from 1966 to the present day did not reveal any case reports of flat feet in pregnancy. The problem may often be so minor as to not cause concern and this may explain whythere have not been any cases reported in medical journals [3].

As study have evaluated flat feet objectively during pregnancy lacks evidence. Hence, the present study was undertaken to evaluate and compare the dimensional changes of feet during pregnancy.

Methodology

A cross- sectional study involved a sample of 90 participants (30 in each group) with gestational age of 32- 36weeks who attended normal ANC checkup at K.L.E's Dr. Prabhakar Kore Hospital and medical research center, Belgaum, and who were referred for physiotherapy at, K.L.E's Dr. Prabhakar Kore Hospital and medical research center, Belgaum, for a period of two months spanning from October 2013- December 2013 were included in the study. The subjects were recruited by convenience sampling and were randomly allocated into three groups which were Group A (Nulliparous), Group B (Primiparous), Group C (Multiparous) women using the envelop method.

- ***Inclusion criteria***- were Age group 18- 35 years, pregnant women, Gestational age: 32-36 weeks, Nulliparous, Primiparous and multiparous women, Willingness to participate in study.
- ***Exclusion criteria***- were Neurological conditions (asymmetric Achilles tendon reflex, hyperesthesia in a radicular pattern), orthopedic deformities of spine & lower limb, Obstetric complications (Incompetent cervix, multiple gestations), multiple gestation at risk for premature labour, Persistent second or third trimester bleeding.
- ***Procedure***-Study was approved by the Institutional Ethical Review Committee. Women fulfilling eligibility criteria were recruited for the study and written informed consent was taken from study women prior to the commencement of the study. Details like name, age, height, weight, address, contact details, gestational age and trimester were recorded and data was assessed using clinical tests namely Foot arch index (FAI) and Navicular drop Test (NDT) for measuring the dimensions of the foot.

Outcome Measures

Navicular Drop Test (NDT)

The Navicular Drop Test (NDT) was intended to represent the sagittal plane displacement of the Navicular tuberosity assessing the height of the Navicular bone from a neutral position to a relaxed position in standing.

Performing the Test

First, mark Navicular tuberosity. Next, measure the height of the Navicular bone with the subtalar joint in neutral and the patient bearing most of the weight on the contra lateral limb. Finally, have the patient assume equal weight on both feet and remeasure the height of the Navicular. The difference between the first and second measurement is the Navicular drop. A difference of >10 mm is considered significant excessive foot pronation. Importance of the test: The medial longitudinal arch is the primary shock absorber

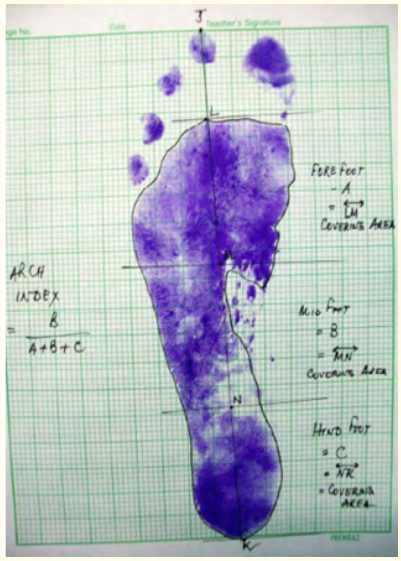
and load-bearing structure of the foot. Without this arched configuration, large forces at the foot would exceed the physiologic weight bearing capabilities of the tarsal bones.

Normal: 6-8mm; Flat foot/ Pes planus: ≥6-8mm; Excessive/ Pes cavus: ≥ 10-15mm.

Foot Arch Index (FAI)

A washable inkpad was rubbed on the plantar aspect of the subject's right foot and subject will be instructed to stand in standing position with both legs straight keeping aside bearing the body weight equally, on a cm calibrated graph-sheet provided; so that it totally covers her right foot. Thus the standard imprint of the weight bearing left/right foot will be taken, which was considered to be the foot-print of a 50% body-weight bearing foot (the other 50% of the body weight was borne by the left foot, whose print was not taken). Following the description in literature in the footprint, the linear distance of the centre of the heel (say the point K) and the tip of the second toe (axis of the foot) (say the point J) was measured. Next perpendicular line was drawn tangential to most anterior point of the main body of the foot print. Their point of intersection was marked (say the point L). Next the line LK was divided in equal three parts. Ultimately the main body of the footprint was divided in three areas from those points with the perpendiculars from the foot axis. The anterior, middle and posterior areas were marked as A, B, C respectively. Their areas were determined (in sq.cm).

Arch Index = B ÷ [A+B+C][16].



Normal values- 0.28 ±2. More than normal value is considered as pes planus and less than that is pes cavus.

Statistical Analysis

Data was computed and analyzed using SPSS (Statistical package for social sciences) software version 16. For different quantitative parameters mean and SD were calculated. Test of significance namely one way ANOVA was used to compare the three groups (Group A, Group B, Group C) and mean age. Chi square test was used to compare the 3 groups to that of BMI and trimester status. Comparison of three groups with Foot arch Index (mm) Navicular Drop test (mm) scores; Total foot length(cm); Total width (cm) were done by Kruskal Wallis ANOVA and pair wise comparisons was done using Mann-Whitney U test. Correlation between Foot arch Index (mm),

Navicular Drop test (mm), Total length (cm) and Width of foot (cm) by spearman's rank correlation method. Correlation between age and BMI with Foot arch Index (mm), Navicular Drop test (mm), Total length (cm) and Width of foot (cm) by Karl Pearson's correlation method.

Results

Groups	***Mean***	***SD***
Group A	23.67	0.88
Group B	23.13	2.05
Group C	25.23	2.57
Total	24.01	2.14
F-value	9.2691	
P-value	0.0002*	
Pair wise comparisons by Tukeys multiple posthoc procedures		
Group A vs Group B	P=0.5465	
Group A vs Group C	P=0.0076*	
Group B vs Group C	P=0.0003*	

*p<0.05

Table 1: Comparison of three groups (Group A, Group B, Group C) with mean age by one way ANOVA.

Groups	***Mean***	***SD***
Group A	24.81	2.23
Group B	27.34	1.27
Group C	27.37	0.96
Total	26.51	1.98
F-value	25.8908	
P-value	0.00001*	
Pair wise comparisons by Tukeys multiple posthoc procedures		
Group A vs Group B	P=0.0001*	
Group A vs Group C	P=0.0001*	
Group B vs Group C	P=0.9964	

*p<0.05

Table 2: Comparison of three groups (Group A, Group B, Group C) with mean BMI by one way ANOVA.

BMI group	***Group A***	***%***	***Group B***	***%***	***Group C***	***%***	***Total***
Normal	13	43.33	0	0.00	0	0.00	13
Obese	17	56.67	30	100.00	30	100.00	77
Total	30	100.00	30	100.00	30	100.00	90
Chi-square=30.3902, p=0.00001*							

*p<0.05

Table 3: Comparison of three groups with BMI categories.

Trimester	*Group B*	*%*	*Group C*	*%*	*Total*
1st	2	6.67	0	0.00	2
2nd	11	36.67	12	40.00	23
3rd	17	56.67	18	60.00	35
Grand Total	30	100.00	30	100.00	60
Chi-square=2.0722 P = 0.3552					

Table 3: Comparison of three groups with trimester status.

Groups	*Mean*	*SD*	*Sum of ranks*
Group A	0.324	0.022	1093.00
Group B	0.298	0.017	1069.00
Group C	0.293	0.016	919.00
Total	0.302	0.021	
H-value	22.0863		
P-value	0.00001*		
Pair wise comparisons by Mann-Whitney U test			
Group A vs Group B	p=0.0003*		
Group A vs Group C	p=0.00001*		
Group B vs Group C	p=0.4119		

*p<0.0

Table 4: Comparison of three groups with Foot arch Index (mm) scores by Kruskal Wallis ANOVA.

Groups	*Mean*	*SD*	*Sum of ranks*
Group A	4.77	0.69	1023.50
Group B	3.60	1.01	991.00
Group C	3.69	1.12	1066.50
Total	3.90	1.09	
H-value	14.2892		
P-value	0.0008*		
Pair wise comparisons by Mann-Whitney U test			
Group A vs Group B	p=0.0003*		
Group A vs Group C	p=0.0027*		
Group B vs Group C	p=0.7394		

*p<0.05

Table 5: Comparison of three groups with Navicular Drop test (mm) scores by Kruskal Wallis ANOVA.

Groups	*Mean*	*SD*	*Sum of ranks*
Group A	21.31	1.01	674.50
Group B	21.32	1.49	1104.50
Group C	21.69	1.08	1302.00
Total	21.46	1.24	
H-value	1.4604		
P-value	0.4818		
Pair wise comparisons by Mann-Whitney U test			
Group A vs Group B	p=0.8815		
Group A vs Group C	p=0.3543		
Group B vs Group C	p=0.2772		

Table 6: Comparison of three groups with Total length (cm) scores by Kruskal Wallis ANOVA.

Groups	*Mean*	*SD*	*Sum of ranks*
Group A	7.68	0.39	430.00
Group B	8.15	0.66	1221.50
Group C	8.35	0.62	1429.50
Total	8.12	0.64	
H-value	12.6494		
P-value	0.0018*		
Pair wise comparisons by Mann-Whitney U test			
Group A vs Group B	p=0.0127*		
Group A vs Group C	p=0.0005*		
Group B vs Group C	p=0.2340		

*p<0.05

Table 7: Comparison of three groups with Width of foot (cm) scores by Kruskal Wallis ANOVA.

Variables	*Foot arch Index (mm)*	*Navicular Drop test (mm)*	*Total length (cm)*	*Width of foot (cm)*
Foot arch Index (mm)	-			
Navicular Drop test (mm)	0.7024*	-		
Total length (cm)	-0.1825	-0.2040*	-	
Width of foot (cm)	-0.5264*	-0.5288*	0.4471*	-

*p<0.05

Table 8: Correlation between Foot arch Index (mm), Navicular Drop test (mm), Total length (cm) and Width of foot (cm) by spearman's rank correlation method (n=90).

Variables	*Foot arch Index (mm)*	*Navicular Drop test (mm)*	*Total length (cm)*	*Width of foot (cm)*
Foot arch Index (mm)	-			
Navicular Drop test (mm)	0.9055*	-		
Total length (cm)	0.1529	0.2145	-	
Width of foot (cm)	-0.0352	0.0213	0.2508	-

*p<0.05

Table: Correlation between Foot arch Index (mm), Navicular Drop test (mm), Total length (cm) and Width of foot (cm) by spearman's rank correlation method (Group A).

Variables	*Foot arch Index (mm)*	*Navicular Drop test (mm)*	*Total length (cm)*	*Width of foot (cm)*
Foot arch Index (mm)	-			
Navicular Drop test (mm)	0.5186*	-		
Total length (cm)	-0.1195	-0.3900*	-	
Width of foot (cm)	-0.4696*	-0.6211*	0.6212*	-

*p<0.05

Table: Correlation between Foot arch Index (mm), Navicular Drop test (mm), Total legth (cm) and Width of foot (cm) by spearman's rank correlation method (Group B).

Variables	*Foot arch Index (mm)*	*Navicular Drop test (mm)*	*Total legth (cm)*	*Width of foot (cm)*
Foot arch Index (mm)	-			
Navicular Drop test (mm)	0.6397*	-		
Total length (cm)	-0.3619*	-0.1509		
Width of foot (cm)	-0.5493*	-0.5344*	0.2935	-

*p<0.05

Table: Correlation between Foot arch Index (mm), Navicular Drop test (mm), Total length (cm) and Width of foot (cm) by spearman's rank correlation method (Group C).

Variables	*Total samples*		*Group A*		*Group B*		*Group C*	
	Age	*BMI*	*Age*	*BMI*	*Age*	*BMI*	*Age*	*BMI*
Foot arch Index (mm)	-0.1011	-0.4644*	0.3058	-0.1197	-0.1597	-0.3609	0.0608	0.1324
Navicular Drop test (mm)	-0.0515	-0.3173*	0.3444	-0.0740	-0.1234	-0.0573	0.0008	0.1239
Total length (cm)	0.0207	-0.0995	-0.0205	0.1409	0.2203	-0.0170	-0.2405	-0.2797
Width of foot (cm)	0.1957	0.4179*	0.4178*	0.4529*	0.0151	0.1676	0.1423	0.0911

*p<0.05

Table: Correlation between age and BMI with Foot arch Index (mm), Navicular Drop test (mm), Total length (cm) and Width of foot (cm) by Karl Pearson's correlation method.

Table 1 shows The average age of the participants using ANOVA in Group A was 23.67±0.88 years, in Group B was a 23.13±2.05 years and in Group C was a 25.23±2.57 years with p value = 0.002 showed statistical difference. When intra pair comparison was done by Tukeys multiple posthoc procedures, Group A vs. Group B With no statistical difference with p value of P=0.5465, Group A vs. Group C with Stastical difference with p value P=0.0076 and Group B vs. Group C with statistical difference of p value of P=0.0003.

Table 2 shows The average BMI of the participants was 24.81 ± 2.23; 27.34± 1.27 and 27.37 ± 0.96 in Group A, Group B and Group C respectively with p value = 0.00001 which showed statistical difference. When intra pair comparison was done by Tukeys multiple posthoc procedures, Group A vs. Group B statistical difference with p value of P=0.0001, Group A vs. Group C with Stastical difference with p value P=0.0001 and Group B vs. Group C with no statistical difference of p value of P=0.9964.

Table 3 shows Comparison of three groups with trimester status with p value of 0.3552, showed statistically no difference suggesting that dimensional changes of foot can occur during pregnancy as whole irrespective of the trimester.

Table 4 shows the average FAI scores in Group A was 0.324 ± 0.022 (mm), in Group B was 0.298 ± 0.017 (mm), and in Group C was 0.293 ± 0.016 (mm) with statistical difference of p- value of 0.00001. When intra pair comparison was done by Mann-Whitney U test , Group A vs. Group B statistical difference with p value of P=0.0003, Group A vs. Group C with Stastical difference with p value P=0.00001 and Group B vs. Group C with no statistical difference of p value of P=0.4119. Suggesting that dropping of the arches and changes in the dimensions of foot markedly in primipara and multipara group when compared to nullipara.

Table 5 shows the average NDT scores in Group A was 4.77 ± 0.069 (mm), in Group B was 3.60 ± 1.01 (mm), and in Group C was 3.69 ± 1.12 (mm) with statistical difference of p value of 0.0008. When intra pair comparison was done by Mann-Whitney U test, Group A vs Group B statistical difference with p value of P=0.0003, Group A vs. Group C with Stastical difference with p value P=0.0027 and Group B vs. Group C with no statistical difference of p value of P=0.7394. Suggesting in reduction of Navicular bone height resulting in the alteration of the dimensions of foot markedly in primipara and multipara group when compared to nullipara.

Table 6 shows The average total length of foot (cm) scores by Kruskal Wallis ANOVA in Group A was 21.31± 1.01 (cm), in Group B was 21.32 ± 1.49 (cm), and in Group C was 21.69 ± 1.08 cm) with no statistical difference of p value of 0.4818. When intra pair comparison was done by Mann-Whitney U test , Group A vs. Group B with no statistical difference with p value of P=0.8815, Group A vs. Group C with no Stastical difference with p value P=0.3543 and Group B vs. Group C with no statistical difference of p value of P=0.2772. Suggesting there is no change in the Total length dimension of foot during pregnancy.

Table 7 shows The average width of foot (cm) scores by Kruskal Wallis ANOVA in Group A was 7.68 ± 0.39 (cm), in Group B was 8.15 ± 066 (cm), and in Group C was 8.35 ± 0.62 cm) with statistical difference of p value of 0.0018. When intra pair comparison was done by Mann-Whitney U test, Group A vs. Group B with statistical difference with p value of P=0.0127, Group A vs. Group C with Statical difference with p value P=0.0005 and Group B vs. Group C with no statistical difference of p value of P=0.2340. Suggesting that, there are dimensional changes of width of foot markedly in multipara and primipara when compared to nullipara group.

Table 8 shows Correlation was done using spearman's rank correlation method between FAI and NDT were positively related with p value of 0.7024 suggesting if there is drop of arches of foot the height of Navicular bone also reduces.FAI and NDT were negatively correlated with total length of foot (cm) with p value of – 0.1825 and – 0.2040 respectively and with width of foot (cm) with p value of – 0.5264 and – 0.5288 respectively. Suggesting no dimensional changes resulted in total length and width of foot. Total length of foot was positively correlated with width of foot (cm) with p value of 0.4471suggesting if there is increase in total length of foot, results in changes in width dimensional of foot.

Discussion

A study done by Gijon-Nogueron et al in 2013, on women's feet change during pregnancy owing to hormonal and anatomical changes, thus having a strong influence on the decrease in their quality of life during pregnancy. This preliminary study aimed to value the

anthropometric and positional changes that affect their feet. The study concluded that foot of the pregnant woman tends to flatten during gestational weeks 12 to 34, taking a more pronated posture, and the anthropometric changes in late pregnancy result in increases in foot length and forefoot width, changes that seem to be moderate. However, the present study has evaluated the foot changes in late gestation (12-34) weeks which also showed statistic significance changes in the FAI and NDT.

The study concluded that Shape characteristics (2005) of footprints in pregnant women and in the period after childbirth were calculated based on the defined criterion. The results of the group of four women tested in three periods suggest that there is no clear tendency towards the foot arch falling/increasing of the foot arch "fall" during the pregnancy period. The reason for not finding the changes could be that only 4 pregnant females were screened, and which cannot be generalized with a small sample size. However, our study screened a total of 90 subjects to measure the FAI and NDT which showed significant changes in all three groups.

A study done by Mueller MJ et al (1993) on use of navicular drop as an indicator of pronation at the foot. The purpose was to test the reliability of a method to measure navicular drop and to assess the relationships among measures of forefoot to rear foot position, subtalar joint neutral position, and navicular drop. The results support traditional biomechanical theory but indicate that other factors contribute significantly to navicular drop. The present study has also included the test along with FDI to manually measure the Navicular drop and other parameters.

The reason for foot change as explained by Ponnapula P et al put forth that the anatomic and physiologic changes occurring with pregnancy result in a variety of symptoms affecting the lower extremity. The purpose of this investigation is to provide a comprehensive look at the lower extremity changes experienced during pregnancy and correlate symptoms with underlying aetiology in a literature review.

The reason to include gestational age (12-34) was that Midfoot plantar pressure significantly increases during late gestation. A study done by Gaymer C et al (2009) concluded that the physiological changes in late pregnancy result in an increase in midfoot plantar pressure.

Plantar pressure and foot pain in the last trimester of pregnancy was studied by Karadag-Saygi E et al (2010). However, the subjects in the present study did not experienced any pain although foot changes were evident. This could be due to long term adaptation to pronated foot which started in early gestation.

A study done by Harrison et al, on primigravida foot anthropometric effects on foot, posterior-pelvic and low back pain. The study concluded that although no overall differences were found in lower extremity alignment, it is possible that individual biomechanical response to pregnancy is variable. Future research should investigate whether back, hip, and foot pain during pregnancy are more common in women who do experience changes in lower extremity alignment vs. those who demonstrate no changes.

Conclusion

The present study has included subjects with different parity to know the cyclic changes in the foot occurring from nulliparous to primiparous and multiparous which suggest the need for therapeutic and exercises intervention to prevent the same right from conception and to strengthen the arches of foot antenatally and postnatally which could significantly reduce the further pain and dysfunction occurring due to acquired flat foot during pregnancy.

Acknowledgement

We thank all the Participants in this study without whom this study would have been impossible. We also acknowledge KLE Department of Physiotherapy, KLE Department of OBG and KLE's Dr. Prabhakar Kore Hospital and MRC for allowing us to conduct the study.

Conflicts of Interest

None Declared.

References

1. Foot arches, Elizabeth Quinn; About.com Guide; Sports health medicine (2013).
2. Bonnie L Bermas MD. Musculoskeletal changes and pain during pregnancy and postpartum.
3. EK Bohemen, NST GENDI. Department of Rheumatology, Nuffield Orthopaedic Centre, Oxford and Rheumatology Department, Basildon Hospital, Nether Mayne, Basildon, Essex Accepted 27 October 199.
4. Weiss G. The physiology of human relaxin. ContribGynaecolObstet 18 (1991): 130-46.
5. Bryant-Greenwood GD, Schwabe C. Human rclaxins: chemistry and biology. Endocr Rev 15 (1994): 5-26.
6. Maternal physiological change in pregnancy; Wikipedia, the free encyclopedia.htm
7. Anthropometric Foot Changes During Pregnancy; A Pilot Study; JAPMA 103.4 (2013): 314-321.
8. Jeanna M Fascione., et al. "Dynamic footprint measurement collection technique and intrarater reliability: ink mat, paper pedography, and electronic pedography". J Am Podiatr Med Assoc 102.2 (2012): 130-8.
9. Mueller MJ., et al "Navicular drop as a composite measure of excessive pronation". J Am Podiatr Med Assoc 83.4 (1993): 198-202.
10. Plantar Pressure and Foot Pain in the Last Trimester of Pregnancy, Evrim Karadag-Saygi, MD, Marmara University Hospital, Physical Medicine, official journal of AOFAS.
11. Theresa Foti., et al. "A Biomechanical Analysis of Gait during Pregnancy". J Bone Joint Surg Am 82.5 (2000): 625-625.
12. Navicular Drop Test.
13. Navicular Drop Test 2011-15.
14. Navicular Drop Test 2008-16.
15. Navicular Drop Test 2010-14.
16. Hironmoy Roy., et al. "Arch Index: An Easier Approach for Arch Height (A Regression Analysis)". JNM Hospital, WBUHS, West Bengal, India;Al Ameen J Med Sci 5.2 (2012): 137-146.

Volume 2 Issue 5 May 2022