Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Annals of Biological Research, 2014, 5 (7):40-48
(http://scholarsresearchlibrary.com/archive.html)

ISSN 0976-1233
CODEN (USA): ABRNBW

Normative values of Navicular drop test and the effect of demographic parameters - A cross sectional study

Umesh Adhikari[1], Watson Arulsingh[1], Ganesh Pai[2] and Joseph Oliver Raj[1]

[1]*Alva's college of Physiotherapy and Research Centre, Moodbidri*
[2]*Medical Director, Derma Care, Mangalore*

ABSTRACT

Though Brody's navicular drop test is a clinical, valid predictor of navicular height to characterize arch of human foot, normative values have not been yet provided and also the effect of demographic variables on navicular drop were not explored. The purpose of this study was to find out the normalative values of navicular drop of Brody's Navicular drop test. And to correlate the effect of age, gender, BMI and foot length on navicular drop. 112 healthy subjects, 51 males and 61 females of age 20 (19, 22) years, height 1.6 (1.5, 1.7) m, weight 55 (47.25, 62) kg. ND measurement of both feet were taken, all demographic data were measured to see any correlation exist with ND. Results revealed that normative median value for NDRT for male was found to be 6 (3, 8) and female was found to be 4 (3, 5). Normative median value for NDLT for male and female was found to be 4 (3, 6) and 3 (2, 5). Spearman's rho (ρ) for age versus NDRT(right foot) was found to be 0.15 (p=0.1), age versus NDLT (left foot) was found to be 0.17 (p=0.07). Spearman's rho (ρ) for height versus NDRT and NDLT were found to be 0.07 (p=0.45) and 0.15 (p=0.1) respectively. Spearman's rho for weight versus NDRT and NDLT were found to be 0.2 (p=0.04) and 0.32 (p=0.001) respectively. Spearman's rho for BMI versus NDRT and NDLT were found to be 0.2 (p=0.03) and 0.25 (p=0.01) respectively. Spearman's rho for mean foot length (MFL) versus NDRT and NDLT were found to be 0.08 (p=0.4) and 0.19 (p=0.048) respectively. The normative values of ND for male and female were given. All the demographic parameters did not show co-relation with ND except a low co-relation with BMI with ND and a borderline statistical significance with MFL and NDLT was demonstrated.

Key words; Medial longitudinal arch, Brannock device, Vernier caliper

INTRODUCTION

The structure and the movements of the foot arches are crucial for a person's wellbeing and for optimal function of the body [1]. Because the medial longitudinal arch (MLA) is the primary shock-absorbing structure of the foot, this area of the foot is particularly important for foot function [2].

The medial longitudinal arch (MLA) plays an important role in shock absorbance and energy transfer during walking [3,4]. Arch function depends on the shape of the foot [4], bony structure [5], ligamentous stability [6,7], and muscular fatigue [8] while factors like race [9,10] footwear [11,12], age, and gender [13] are found to influence the formation of MLA.

The feet are vulnerable to structural deficits such as excessive pronation and supination due to the inordinate forces applied to the medial longitudinal arch during daily activities [14, 15, 16]. An increased amount of pronation due to ligament laxity and repetitive stresses may cause the medial longitudinal arch to diminish. The potential for injury to the lower extremity is directly related to the height of the MLA [17]. These injuries occur gradually over time as a result of repetitive loading, causing creep and hysteresis within the ligamentous system of the foot [18, 19, 20].

High-arched and low-arched foot types seem to be a risk factor for overuse injuries in sport activities. The high arched cavus foot has been associated with low back facet syndrome and knee pain, while the low arched planus foot has been linked with pathologies including Morton's neuroma, plantar fascitis, hallux abducto valgus, chrondomalcia patella and shin splints [20, 21.22]. Dahle [23] found knee pain more common in football players with pronated or supinated foot types, compared with neutral foot type. Williams [24] found high-arched runners to have more ankle, bony, and lateral sided injuries, while low-arched runners had more knee, medial sided, and soft tissue injuries. Thus quantification of medial arch plays a vital role in categorizing homogenous group in research studies and also in analyzing the effect of biomechanics of gait variables changes observed during locomotion and to understand the efficacy of various orthotic prescriptions on the basis of foot arch types.

Height of navicular bone is important in maintaining the integrity of medial longitudinal arch as it is situated at the medial side of the tarsus, between the talus behind and the cuneiform bones in front.

Navicular height measurement is commonly used to measure medial arch height. Different methods have been purposed by researchers for characterizing MLA. Visual assessment of MLA has been proposed [25]. But found not to be reliable and valid [26, 27]. Though many foot print methods are getting advocated for efficacy, navicular drop test and arch index, truncated navicular height have been proven to be valid and reliable [20,28-31,40]. Navicular drop is defined as the change in height of the navicular bone when the foot moves from subtalar neutral non weight bearing to a relaxed weight bearing stance [31] despite their proven validity, the effect of foot sizes on the relative drop was not taken into account or correlated [32]. Brody's Navicular drop test is a valid predictor of navicular height in non weight bearing and weight bearing position to characterize the arches of the foot, however normative values has not been provided. Brody [33], Beckett [34], and Mueller [35] have merely reported 15, 13, and 10 mm, respectively, as upper limit range for normal navicular drop. Brody reported values of ND fewer than 10mm as normal and values over 15mm as abnormal. Fukano [1] recommended that normal values have not yet been confirmed as foot length, age, gender, and Body Mass Index (BMI) may influence the navicular drop.

Thus this study was aimed to find normalative values of navicular drop and also to see the effect of demographic measures such as body weight, height, BMI, foot length, age on navicular drop.

MATERIALS AND METHODS

Fig.1 Materials required for the study

METHODOLOGY

It is a cross sectional study, convenient sampling method adapted, samples based on the pilot study conducted on 12 subjects the sample size estimation was 112 with 5% acceptable margin of error in estimating true population mean. Materials needed for the study given in [Figure 1] were Index card, Vernier caliper, Custom made Bronnack device, Marker, Weighing machine, Stadiometer.

The study was approved by the institutional ethical committee. Informed consent from the participants was taken. Subjects selected for this study were healthy individuals, both male and female and age group between 18-30 yrs. Exclusion criteria were subjects with recent fracture of foot (within 6 months), foot deformities, recent injury to foot, any neuromuscular disease of lower extremity and low back pain within 1 year of duration. Subjects who met inclusion and exclusion criteria were selected for the study. Demographic data was obtained from all the participants. Navicular drop was measured using Brody method. The purpose and procedure of the study was explained to all the subjects.

PROCEDURE:

Individual subject was placed in a sitting position with their feet flat on a firm surface with the hip and knees flexed to 90 degree and ankle joints in neutral position [Figure 2]. Subtalar neutral position is achieved when talar depressions are equal on medial and lateral side of the ankle [36][Figure 3].The examiner takes measurement by Kneeling in front of the subject. While the subject was still on a sitting position, a dot was marked on the navicular tuberosity [Figure4]. An index card was placed and was marked at the level of navicular tuberosity [Figure5]. Then the subject was asked to bear an equal weight on both the foot and was asked to stand. The new position of navicular tuberosity was marked in index card [Figure6]. The difference between the marks in index card was measured with vernier caliper in millimeter [Figure7]. Both right and left feet was assessed.

Fig. 2 Subject in a sitting position with hip and knee 90 degree and ankle in neutral position.

MEASURING FOOT LENGTH

Custom made Bronnack device was used for measuring the foot length in this study [38].

The subject was asked to bear equal weight on both the feet. One end of brannock device is held at the calcaneum and the other end to the tip of the great toe which measures the foot length. [Figure 8]

Fig. 3 Foot in subtalar neutral position achieved by equal talar depression on both the side.

Fig.4 Mark is placed over the navicular tuberosity.

Fig.5 Navicular height on an index card in sitting.

Fig.6 A new position of navicular tuberosity in standing position marked on a Index card.

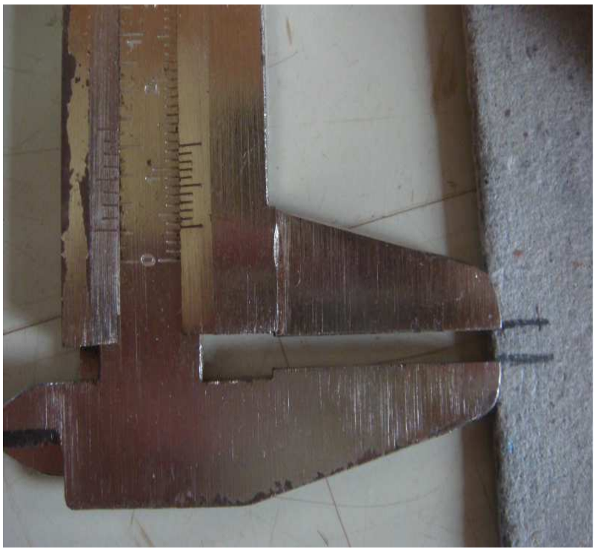

Fig.7 Measurement of ND by using vernier caliper in mm.

Fig.8 Measurement of foot length using custom made Brannock Device.

STATISTICAL ANALYSIS

The subjects included for the study were 112 including both male and female who were healthy, taken from Alvas Education Foundation. Statistical Package for Social Sciences, Version-16 (SPSS-16) has been used for analyzing the collected data. Normality of the collected data was established by Kolmogorov–Smirnov. The data didn't follow the normal distribution; hence we expressed descriptive statistics median (IQR) and 95% confidence interval. Left and right Navicular drop was compared using wilcoxon signed-rank test. Difference between male and female was established by Mann-Whitney U test.

The co-relation between the demographic parameters and Navicular drop and the demographic parameters was established by Spearman rank co-relation.

RESULTS

112 healthy subjects of age 20 (19, 22) years, height 1.6 (1.5, 1.7) m, weight 55 (47.25, 62) kg BMI 20.2 (18.6,23.5), Mean foot length (FL) 24.1 (22.5,25.4) given in Table 1. Out of which 51 were male and 61 were female of age 19 (18, 22) years and 20 (19, 21) years respectively, of height 1.7 (1.7, 1.8) m and 1.57 (1.5,1.6) m respectively, of weight 60 (54, 68) kg and 50 (44.5, 57) kg, BMI 25.1 (18.2,23.6) for male and 19.8 (18.4,23.1) for female. FL for male 25.5 (24.5,26) and 22.7 (22,23.9) for female who were participated in this study illustrated in Table 2. As the data doesn't follow the normal distribution the central tendencies was expressed in median (IQR) and 95% CI. Subject participated in this study was tested for ND in right and left foot between male and female and the normative values are shown in Figure 9. The subjects were also tested for the foot length.

As there was no significant difference in right and left foot length, median foot length was taken given in Table 3. MFL for male was 25.5 (24.5, 26) cm and for female was 22.7 (22, 23.9) cm. Overall Static ND ranged from 2-11mm. 93.8% of the population had an NDRT less than 9mm and greater than 2mm. 96.4% of the population had an NDLT less than 9mm and greater than 2mm.

Table 1 narrates median values of demographic data

PARAMETERS	MEDIAN (IQR)	95%CI
N	112	
Age	20 (19,22)	19.9-20.7
Weight	55 (47.25,62)	53.8-57.9
Height	1.6 (1.5,1.7)	1.61-1.64
Bmi	20.2 (18.6,23.5)	20.4-21.7
Mean FL	24.1 (22.5,25.4)	23.8-24.5

Table 2 narrates demographic characteristics between male and female.

PARAMETERS	MALE n=51	FEMALE n=61	p-value
Age	19 (18,22) (19.8-21.1)	20 (19,21) (19.7-20.6)	0.7
Height	1.7 (1.7,1.8) (1.6-1.7)	1.57 (1.5,1.6) (1.5-1.6)	<0.001
Weight	60 (54,68) (58.7-64.7)	50 (445,57) (48.8-53.3)	<0.001
BMI	21.5 (18.7,23.6) (20.4-22.3)	19.8 (18.4,23.1) (19.9-21.8)	<0.35
Mean FL	25.5 (24.5,26) (25.1-25.9)	22.7 (22,23.9) 22.7-23.3)	<0.001

Spearman's rho (ρ) for age versus NDRT was found to be 0.15 (p=0.1), age versus NDLT was found to be 0.17 (p=0.07). Spearman's rho (ρ) for height versus NDRT and NDLT were found to be 0.07 (p=0.45) and 0.15 (p=0.1) respectively. Spearman's rho for weight versus NDRT and NDLT were found to be 0.2 (p=0.04) and 0.32 (p=0.001) respectively. Spearman's rho for BMI versus NDRT and NDLT were found to be 0.2 (p=0.03) and 0.25 (p=0.01) respectively. Spearman's rho for MFL versus NDRT and NDLT were found to be 0.08 (p=0.4) and 0.19 (p=0.048) respectively. (Table no 4)

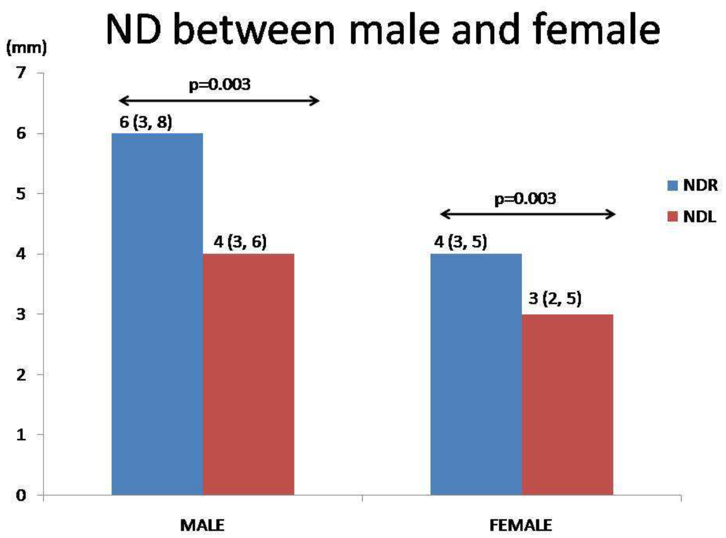

Figure 9 produces normalative values of ND on right and left foot.

NORMATIVE DATA OF NAVICULAR DROP

Table 3 narrates values of median foot length.

NAVICULAR DROP	MEDAIN(IQR)	95%CI
Right	5 (3,6)	0.46-0.54
Left	4 (3,5)	0.39-0.47

CORRELATION OF DEMOGRAPHIC PAREMETERS WITH ND

Table no.4 shows that the co-relation between demographic parameters with navicular drop on both right and left foot.

DEMOGRAPHIC PARAMETERS	NDRT SPEARMAN'S RHO(ρ)	NDLT SPEARMAN'S RHO(ρ)
Age	0.15 (p=0.1)	0.17 (p=0.07)
Height	0.07 (p=0.45)	0.15 (p=0.1)
Weight	0.2 (p=0.04)*	0.32 (p=0.001)**
BMI	0.2 (p=0.03)*	0.25 (p=0.01)*
Mean FL	0.08 (p=0.4)	0.19 (p=0.048)*

**- Significant at (p < 0.05); **-Significant at (p < 0.01)*

According to Porteny and Watkin's criteria low degree of positive association was found between weight versus NDRT and NDLT with spearman's rho (ρ) 0.2 (p=0.04) and 0.32 (p=0.001) respectively. Low degree of positive association between BMI versus NDRT and NDLT with spearman's rho (ρ) 0.2 (p=0.03) and 0.25 (p=0.01) respectively. No association was found between age versus ND and height versus ND. However, while interpreting results caution should be taken for MFL versus NDLT. According to Porteny and Watkin's criteria it shows a low co-relation with borderline statistically significant p=0.048[Table no.4].

DISCUSSION

This study investigated the normative value of ND and influence of age, gender, height, weight, BMI and Foot length on ND. Normative median value for NDRT for male was found to be 6 (3, 8) and female was found to be 4 (3, 5). Normative median value for NDLT for male and female was found to be 4 (3, 6) and 3 (2, 5). This study found that the overall normative median value for male and female showed a minimal difference of 1mm whereas the difference between male and female, right and left foot showed 2mm and 1mm respectively.

Brody [33] has suggested the uppermost value of 15 mm, considered as abnormal as and lower than 10mm considered as a normal value. Brody Navicular drop test is a static measurement of ND. Though Brody has not given a separate value for right and left feet, the study supports the Brodys borderline value. This study has given a separate value for right and left feet for both male and female. Mueller [35] has suggested a borderline of 10mm for the static ND. The result of this study matches the Mueller recommendation; however they have suggested that there might be change in dynamic ND as foot length may affect the ND.

The median ND for male right foot was 6 (3, 8) mm, for left foot was 4 (3, 6) mm whereas female right foot was 4 (3, 5) and for left foot was 3 (2, 5). But Nielsen [32] measured a dynamic ND using a VSA and found a mean ND of 5.3 (± 1.8) mm for male and 5.2 (± 1.6) mm for female.

Mark. W.conwell [30] has suggested the height of the NB between foot flat and heel-off was 7.9 mm. The study reported that the NB seems to undergo significant vertical as well as medial displacement during the stance phase of normal walking. Menz Hb [20] has suggested that the static ND test is the best measure of the foot pronation which can be a useful tool for measuring foot pronation.

Male participants had a mean drop of 6mm in right feet and 4mm in left feet where as 4mm for right feet and 3mm of left for female respectively. Bandholm [37] reported a significant difference in static ND of 2.8 mm between injured and healthy participants and the static ND was not adjusted for foot length which he purposed hypothetically to be the cause of injury. Reduction of ND value in female compared to males might be attributed to smaller foot length. In this study female mean foot length was 22.7cm and male mean foot length was 25.5cm.

The study of demographic parameters such as age, height, weight, BMI and foot length which were compared with ND have resulted in either no co-relation or a very low co-relation. A very low co-relation was found between weight and BMI to navicular drop. BMI versus NDRT and NDLT with spearman's rho (ρ) 0.2 ($p=0.03$) and 0.25 ($p=0.01$). Similarly, low degree of positive association was found between weight versus NDRT and NDLT with spearman's rho (ρ) 0.2 ($p=0.04$) and 0.32 ($p=0.001$) respectively. Nielsen [32] suggested that age and BMI has no significant co-relation in ND. However, this study did not include participants with BMI larger than 29.6 and participants older than 30 years. Therefore it is still unknown that whether BMI larger than 29.6 might have an influence on ND. In this study a very low co-relation was found between ND and BMI.

Arzu Erden [39] found the level of navicular drop (ND), was greater in individuals with a higher than normal weight in males and in total subjects (p male ND= 0.007, p total ND= 0.001). This study showed no co-relation between MFL and NDRT. However, MFL and NDLT showed a low co-relation with borderline statistical significant. This study was static ND test but Nielsen [32] suggested that the dynamic navicular drop is influenced by foot length and gender. Hence, further studies can be done to investigate the dynamic ND relating with foot length.

CONCLUSION

The normative values of ND for male and female were calculated where male ND values were higher compared to female. All the demographic parameters taken did not show co-relation with ND except a low co-relation between weight and BMI with ND and a borderline statistical significant co-relation between MFL and NDLT was demonstrated. The study supports the null hypothesis and rejects the alternate hypothesis.

Acknowledgement
Author expresses sincere thanks to Professor Radakrishnan M.Phil, (PhD) Alva's physical Education Director for rendering his full-fledged help in getting samples in due course of time for this study. Self funded project work as well as a part of Major PhD research.

REFERENCES

[1] M Fukano, T Fukubayashi: *Eur J Appl Physiol* **2009**, 105:387-392.
[2] CA Oatis, PF Beattie: Kinesiology II editions. Philidelphia **2009**: Lippincott Williams & Wilkins;.
[3] RF Ker, MB Bennett, SR Bibby, RC Kester, RM Alexander. *Nature* **1987**, 325:147-9.
[4] M Ogon, AR Aleksiev, MH Pope, C Wimmer, and CL Saltzman: *Foot Ankle Int* **1999**, 20:263-6
[5] JD Nack, RD Phillips: *Clin Podiatr Med Surg* **1990**, 7:391-7.

[6] AH Franco. *Phys Ther* **1987,** 67:688-94
[7] HB Kitaoka, ZP Luo, KN An:**.** *Foot Ankle Int* **1998**, 19:447-51
[8] DH Richie Jr:. *Clin Podiatr Med Surg* **2007**, 24:617-44.
[9] DL Headlee ,JL Leonard ,JM Hart , CD Ingersoll ,J Hertel**:** *J Electromyogr Kinesiol* **2008**, 18:420-5
[10] SF Stewart. I**.** *Clin Orthop Relat Res* **1970**, 70:111-23
[11] Cl Saltzman, DA Nawoczenski, KD Talbot. *Archieves of Physical Medicine and rehabilitation* **1995**;1;45-9.
[12] UB Rao, B Joseph: *J Bone Joint Surg Br* **1992**, 74:525-7.
[13] V Sachithanandam, B Joseph:. *J Bone Joint Surg Br* **1995**, 77:254-7
[14] D. Robert, Nicole M. Bennet, Alicia D. eldridge., Logan College of chiropractic, **2003** chesterfield MO 63006-1065.
[15] ML Gross. PM Daclin.. *Am J Sports Medicine* **1991;**19:409-12
[16] C Huang, , H Kitaoka, An Kn, Chao Eys.. *Foot and Ankle* **1993**;14:353-7.
[17] AM Picciano, MS T Rowlands. *JOSPT* **1993**;18:553-8
[18] B Vicenzino, LA Griffiths, A Hadley..*JOSOPT* ***2*****000**;30:333-9
[19] TC Michaud..baltomre*:* williams and wilkins;**1993**
[20] HB Menz. *JAPMA* **1998**;119-29.
[21] LD Lutter.. *Clinics in sports medicine* **1985**;4:685-98
[22] RA Mann, DE Baxter, LD Lutter. Running symposium.*foot and ankle* **1981**;1:190-224
[23] LK Dahle, MJ Mueller, A Delitto, JE Diamond:**.** *J Orthop Sports Phys Ther* **1991**, 14:70-4.
[24] DS Williams, IS McClay, J Hamill**.** *Clin Biomech (*Bristol, Avon*)* **2001**, 16:341-7.
[25] DN Cowan, JR Robinson, BH Jones, DW Polly,Jr, BH Berrey.. *Foot Ankle Int*. **1994;**15(4):213-217.
[26] SR Jonson, MT Gross. *J Orthop Sports Phys Ther*. **1997**;25(4):253-263.
[27] HB Menz, SE Munteanu.. *J Orthop Sports Phys Ther*. **2005;**35(8):479-486.
[28] A Vinicombe , A Raspovic, HB Menz.. *J Am Podiatr Med Assoc*. **2001**;91(5):262-268
[29] S Weiner-Ogilvie, K Rome.. *J Am Podiatr Med Assoc*. **1998;**88(8):381-386.
[30] MW Cornwall, TG McPoil. *Foot Ankle Int*. **1999;**20(8):507-512.
[31] M Razeghi, ME Batt.. *Gait Posture*. **2002**; 15(3):282-291.
[32] RG Nielsen, MS Rathleff, OH Simonsen, H Langberg. *J Foot Ankle Res*. **2009**; 2:12.
[33] Brody DM: *Orthop Clin North Am* **1982**, 13:541-58
[34] ME Beckett, DL Massie, KD Bowers, DA Stoll. *J Athl Train* **1992**, 27:58-62.
[35] Mueller MJ, Host JV, Norton BJ**.** *J Am Podiatr Med Assoc* **1993**, 83:198-202.
[36] KE Sell, TW Verity, Worrell, B J Pease,J. *J Orthop Sports phys Ther*.**1994**;19:162-167
[37] 37. T Bandholm, L Boysen, S Haugaard, MK Zebis, J Bencke**.** *J Foot Ankle Surg* **2008**, 47(2)**:**89-95.
[38] 38. J Christian Barton, Daniel Bonanno and Hylton B Menz *Journal of Foot and Ankle Research* **2009**, 2:10 doi:10.1186/1757-1146-2-10
[39] 39. Arzu Erden, Filiz Altug, Uğur Cavlak .,*sports medicine journal* **2013** no 34.
[40] 40. S George Murley, B Hylton., Menz and B Karl Landorf ., *Journal of Foot and Ankle Research*, **2009**.2:22 doi:10.1186/1757-1146-2-22