IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

EFFECTIVENESS OF ADOPTING ANCIENT INDIAN FOOTWEAR PRACTICE 'PADUKAS' ON NAVICULAR DROP HEIGHT AND DYNAMIC BALANCE IN YOUNG ADULTS WITH FLAT FEET.

A Pilot Study

[1]Dr Bhakti Washilkar, [2] Dr Shweta Pachpute

[1] BPTh, Late Shree Fakirbhai Pansare Education Foundation College of Physiotherapy, Nigdi, Pune, Maharashtra, India.

[2] Professor, HOD of Musculoskeletal Physiotherapy Department, Late Shree Fakirbhai Pansare Education Foundation College of Physiotherapy, Nigdi, Pune, Maharashtra, India.

Abstract: Strength of intrinsic muscles of the feet are necessary to maintain the medial longitudinal arch, and assists in intensifying sensory feedback to maintain balance. Poor balance is associated with weak intrinsic muscles and is a risk factor for injuries when participating in recreational activities. The 'Padukas' consists of a flat wooden sole and knob which is engaged between the great toe and second toe. Wearing 'Padukas' will stabilise the heel, ball of toes, and toes against the flat surface, therefore it can enable the intrinsic muscle to contract efficiently. This can make 'Padukas' a helpful tool for clinicians to improve foot strength and directly improve balance in a specific finely tuned and cost-effective way.

Method - Experimental pilot study is conducted on 12 subjects at college campus with flat feet. Subjects with recent lower limb injury and limb length discrepancy were excluded. Subjects with navicular drop ≥ 9 mm and age 18- to 25-year-old were included in study. Subjects performed a 4-week protocol (3 days/week, 5 sets of 2 mins and 1 min break between each set) in the 1st & 2nd week subjects performed alternate steps back & forth . In the 3rd & 4th weeks, the subject walked with padukas. After 4 weeks protocol navicular drop test and Y balance test are performed and the pre- and post-intervention results are compared.

Result - On comparison of Pre and Post intervention outcome of 10 subjects using paired t test, there is a significant reduction in navicular drop height ($p<0.05$) and significant improvement in Y balance ($p<0.05$).

Conclusion - There is effectiveness of adopting ancient Indian footwear practice 'Paduka' on navicular height and dynamic balance control in young adults with flat feet.

Index Terms - Paduka, Flat Feet, Navicular drop, Dynamic Balance, Intrinsic strength.

I. INTRODUCTION

The foot is an intricate structure that serves as the base of the kinetic chain. It has two primary functions during locomotion: stance and propulsion. In the early part of the stance phase, the foot must be flexible to help absorb the energy generated from the impact with the ground, as well as accommodate in different terrain. However, in the final part of stance phase during gait cycle, feet have to become a rigid lever to efficiently transmit propulsive forces into the ground during walking. [(1)]

The biomechanical interactions of the anatomical structures of the foot are complex. Integrity of medial longitudinal arch (MLA) is essential for optimum feet functioning, as it plays a vital role in transferring the forces of body through foot.[(2)]
The MLA also aids in shock absorption and the dispersal of forces transmitted from the foot through the rest of the body.[(3)] Overpronation of feet caused by reduced height of MLA can be assessed by the navicular drop test.

The MLA also has constant dynamic stabilisation from the surrounding active musculature. Extrinsic foot musculature is necessary for supporting the MLA [(4)]; however, recently it has been suggested that the intrinsic foot musculature (IFM) play an essential role in supporting the MLA, as well.[(5)] It is believed that the IFM provides firmness and stability for propulsion while allowing flexibility for shock absorption and attenuation of forces. This suggestion is plausible, as the IFM originates on the calcaneus and inserts distally into the tarsal joints, giving it an optimal angle of pull to provide a stabilising effect on the MLA.[(6)] Due to weakness of IFM it leads to loss of stability of feet leading to poor balance control. Dynamic balance is the ability to maintain balance in a moving state. Dynamic balance can be assessed by the Y balance test.

Common methods used by clinicians to strengthen the IFM are towel curls or marble pickups. However, while performing these exercises, the extrinsic foot musculature is recruited, such as the flexor digitorum longus, and there is less contribution from IFM in supporting the MLA.[(5)] Recently, the "short-foot" exercise is commonly implemented by clinicians because it specifically recruits the IFM independently of extrinsic foot musculature.[(5)] Essentially, the short-foot exercise involves pulling the ball of toes toward the heel without curling the toes. It is suggested that the SF exercise is a more useful strengthening exercise than the toe curl exercise for preventing MLA lowering.

However, because it is difficult to voluntarily contract the intrinsic foot muscles, the SF exercise is difficult to master. Although the subjects of previous studies[(7)] were given significant practice time to master the SF exercise ranging from 1 hour [(8)] to 2 weeks[(7,9)] ,the same is impractical in the clinical setting.

Therefore, 'Padukas' could be an alternate treatment for isolation of IFM which can be an effective method of reinforcing the MLA. 'Paduka' consists of consists of a flat wooden sole and knob which is engaged between the great toe and second toe (Fig 1). Wearing ancient Indian footwear 'Paduka' stabilizes the heel, ball of toes, and toes against the flat surface, therefore it might enable the intrinsic muscle to contract efficiently. This can make 'Padukas' a helpful tool for clinicians for strengthening of intrinsic muscles of feet.

Fig 2

II. METHODOLOGY

This experimental pilot study is conducted on 12 subjects with flat feet age 18-25 years old with mean of 22.58±1.37 years old at LSFPEFS COP Nigdi. Ethical committee clearance was obtained and permission was taken from the department. Written consent was taken from the subjects who fulfil the inclusion criteria and exclusion criteria. The subjects were informed about the test and intervention. Navicular drop test and Y balance test was performed. Wooden 'Padukas' was given and protocol was followed for 4 weeks. Post intervention outcome measure values were noted and statistical analysis and interpretation was done.

II.A INCLUSION CRITERIA

- Both genders will be included in study
- Age 18-26 years old
- UL or BL flexible flat feet
- Navicular drop of ≥ 9mm

II.B EXCLUSION CRITERIA

- Pain in ankle foot complex
- Congenital deformities of the foot and lower limb
- Contractures
- Sensory, vascular, and neurological problems
- Limb length discrepancy
- Diagnosed with Plantar fasciitis
- Recent or unhealed fractures of LL
- Subjects with hallux valgus

II.C OUTCOME MEASURES

NAVICULAR DROP TEST

Is used to measure height of medial longitudinal arch. The distance of navicular tuberosity is measured in non-weight bearing position i.e., sitting (Fig 2) and in weight bearing position i.e., standing (Fig 3). Flat feet is diagnosed when the difference of navicular bone height in sitting and standing is ≥ 9 mm.

Fig 2

Fig 3

Y BALANCE TEST

Is used to assess dynamic balance control in young adults. Subject has to stand at the center of Y on test leg and reach in three directions namely, anterior, posteromedial and posterolateral with non-test leg (Fig 4). Subject performed three trials on each leg and in each direction and values are noted. Same procedure is repeated on non-test leg. Composite score for both leg is calculated using follow formula: -

$$\text{Score of Y Balance Test} = \frac{\text{Anterior + Posteromedial +Posterolateral}}{3 \times \text{Limb Length}} \times 100$$

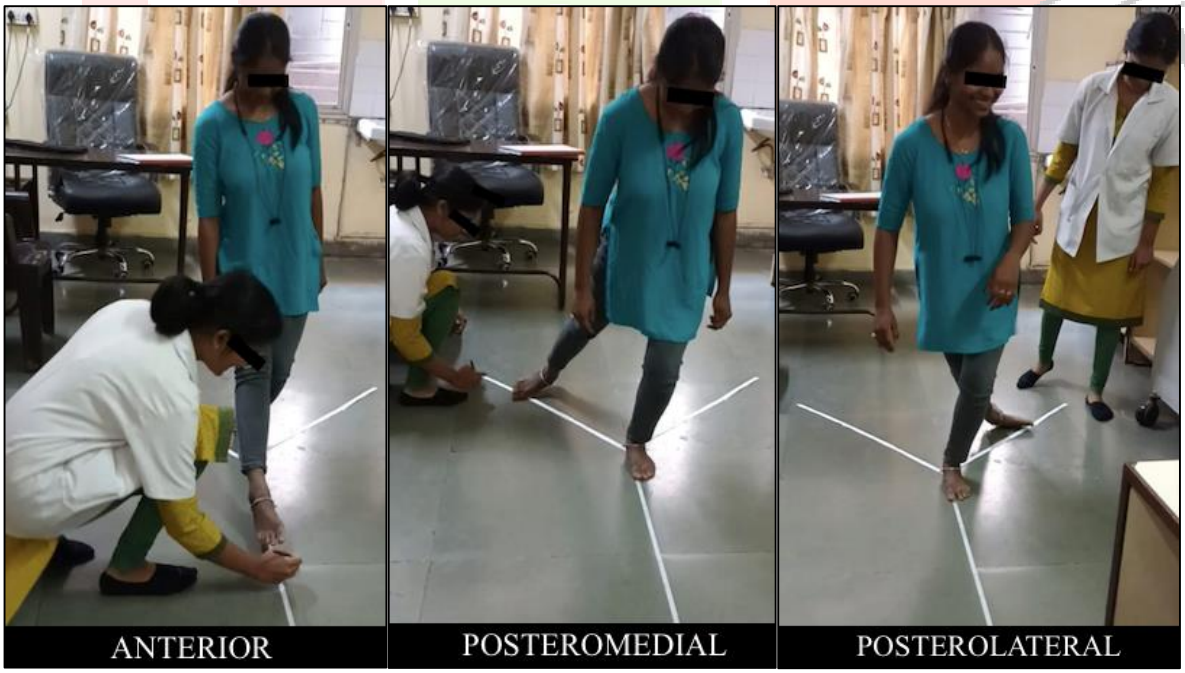

Fig 4

II.D INTERVENTION PROTOCOL

- Subjects performed a 4-week protocol (3 days/week, 5 sets of 2 mins and 1 min break between each set)
- In the 1st & 2nd week subjects performed alternate steps back & forth (Fig 5)
- In the 3rd & 4th weeks, the subject walked with 'Padukas' (Fig 6)
- After 4 weeks protocol navicular drop test and Y balance test are performed and the pre- and post-intervention results are compared.

Fig 5

Fig 6

III. STATISTICAL ANALYSIS

Data was collected and analysed by appropriate statistical test

Within group, Paired t test was used for pre and post readings of Navicular drop test and Y balance test.

IV. RESULTS

Outcome Measure	Navicular drop		Y balance test		P Value
FOOT	RIGHT	LEFT	RIGHT	LEFT	
PRE	11.3±3.62	10.9±3.38	69.07±6.23	68.11±6.09	<0.05
POST	7.8±1.22	7.7±1.15	75.26±5.84	75.20±6.15	<0.05

Table 1

NAVICULAR DROP HEIGHT

On comparison of Pre right foot (11.3 ±3.62) left foot (10.9 ±3.38) and post right foot (7.8 ±1.22) left foot (7.7 ±1.15) result of navicular drop test shows that there was significant reduction in navicular drop height (P<0.05).

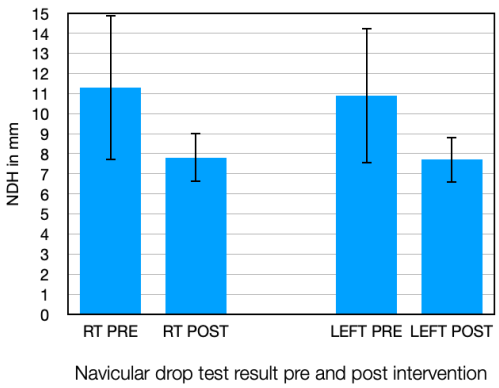

Chart 1

Y BALANCE TEST

On comparison of Pre right foot (69.07 ±6.23) left foot (68.11 ±6.09) and Post right foot (75.26 ±5.84) left foot (75.20 ±6.15) result of Y Balance test shows that there was significant improvement in dynamic balance (P<0.05).

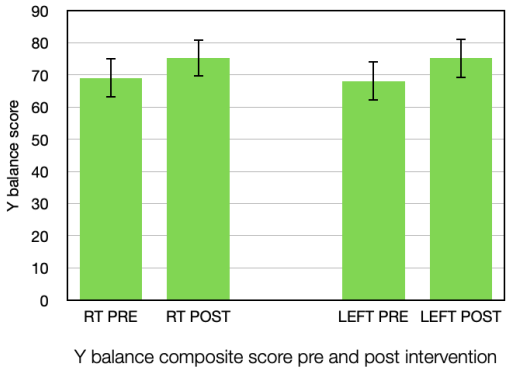

Chart 2

V. DISCUSSION

In the present study, effect of 'Padukas' on flat feet was aimed at reducing navicular drop height and improving dynamic balance by specifically targeting foot intrinsic muscles.

Findings of the present study showed that there was significant improvement in reduction of navicular drop height and improving dynamic balance in subjects with flat feet.

This study focuses on using 'Padukas' as effective treatment tool for strengthening of feet in a new interesting way. As this challenging footwear doesn't come with strap to stabilize the foot therefore the intrinsic and extrinsic muscles have to work together constantly to keep the footwear intact during walking. Ineffective gripping of 'Paduka' will cause 'Paduka' to slip off from feet, therefore giving instant feedback to the subject that contraction was not efficient.

As 'Padukas' are made up of hard wooden sole and it may improve the transmission of tactile sensory input to the mechanoreceptors of foot sole enabling the central nervous system to respond accordingly to control balance. Franklin S et al. (2015) also suggested that minimal footwear can strongly intensify sensory feedback simulating barefoot walking giving faster results as compared to any other footwear.[22]

In a similar clinical trial study conducted by Sarvaiya V et al. (2020) on elderly (60-80 years old) who received four-week intervention of walking in multiple direction with wooden 'Padukas' for 25 mins per session showed improved balance and reduced risk of fall. [21]

Lynn et al. (2012) reported that the intrinsic foot muscles require great effort for maintenance of medial longitudinal arch of foot. They investigated the effect of two types of SFE and TCE exercises on static balance, dynamics and MLA height index in healthy volunteer students [23]. It was stated that SFE exercises had far greater effects on static and dynamic balance as compared to the TCE exercise ratio. This result is explained by Newsham et al.(2010) that SFE isolates intrinsic foot muscle much better than TCE which involves contribution from extrinsic muscles such as flexor digitorum longus [5]

SFE is believed to stimulate proprioceptors on the sole of foot, thereby increasing afferent input to the spinal cord, which enhances voluntary action and improves stability.

The result of this study also revealed that there is significant increase in dynamic balance control as the navicular drop height reduces, these findings are consistent with previous study conducted by Bhave SM et al. (2021) that have reported corelation between flat feet and poor dynamic balance.[12]

Therefore, using this challenging footwear to build strength of feet muscles and balance opens up new perspective in rehabilitation.

VI. CONCLUSION

This study concluded that there is effectiveness of adopting ancient Indian footwear practice 'Paduka' on navicular height and dynamic balance control in young adults with flat feet.

VII. CLINICAL IMPLICATION

Clinically it can be used for intrinsic feet muscle strengthening in conditions like flat feet, plantar fasciitis or even in normal feet to challenge the balance and dynamic stability.

'Padukas' for feet strengthening can be used as it incorporates feet intrinsic muscles efforts throughout the gait cycle. The foot has to keep constant grip on 'Padukas' during stance phase and swing phase also, otherwise it will slip off. This makes

it a functional form of strengthening with simultaneous contribution from intrinsic and extrinsic muscles of ankle foot complex.

VIII. LIMITATION OF STUDY

Footwear used by subjects in rest of the day were not controlled.

IX. RECOMENDATION AND FUTURE SCOPE OF STUDY

- Control group can be used to compare the effectiveness of intervention
- 'Padukas' effectiveness can be compared with traditional methods of intrinsic strengthening
- Study can be conducted in patients diagnosed with plantar fasciitis and ankle sprain rehab.
- It can be given to general population for further betterment of balance and stability.

X. REFERENCES

1. Levangie PK, Norkin CC. Joint structure and function: a comprehensive analysis. FA Davis; 2019; 403-443pp.
2. Robbins SE, Hanna AM. Running-related injury preven- tion through barefoot adaptations. *Med Sci Sports Exerc*. 1987;19:148–156.
3. Nack JD, Phillips RD. Shock absorption. *Clin Podiatr Med Surg*. 1990;7:391–397.
4. Thordarson DB, Schmotzer H, Chon J, Peters J. Dynamic support of the human longitudinal arch—a biomechanical evaluation. *Clin Orthop Relat Res*. 1995;316:165–172.
5. Newsham KR. Strengthening the intrinsic foot muscles. International Journal of Athletic Therapy and Training. 2010 Jan 1;15(1):32-5.
6. Kura H, Luo Z, Kitaoka K. Quantitative analysis of the intrinsic muscles of the foot. *Anat Rec*. 1997;249:143–151.
7. Jung DY, Kim MH, Koh EK, Kwon OY, Cynn HS, Lee WH. A comparison in the muscle activity of the abductor hallucis and the medial longitudinal arch angle during toe curl and short foot exercises. Phys Ther Sport. 2011; 12(1): 30–5.
8. Mulligan EP, Cook PG. Effect of plantar intrinsic muscle training on medial longitudinal arch morphology and dynamic function. Man Therapy. 2013; 18(5): 425–30.
9. Kim MH, Kwon OY, Kim SH, Jung DY. Comparison of muscle activities of abductor hallucis and adductor hallucis between the short foot and toe-spread-out exercises in subjects with mild hallux valgus. J Back Musculoskel Rehab. 2013; 432 26(2): 163–8.
10. Bhoir MT. Prevalence of flat foot among 18-25 years old physiotherapy students: cross sectional study. Indian Journal of Basic and Applied Medical Research; September 2014: Vol.-3, Issue- 4, P. 272-278.
11. Viseux FJ. The sensory role of the sole of the foot: Review and update on clinical perspectives. Neurophysiologie Clinique. 2020 Feb 1;50(1):55-68.
12. Bhave SM, Damke US, Chitale NV, Naqvi WM. Correlation of BMI with Dynamic balance using Y-Balance Test in Young Adults with Flexible Flat Foot: A Pilot study. Indian Journal of Forensic Medicine & Toxicology. 2021 Mar 24;15(2):871-4.
13. Pisal SN, Chotai K, Patil S. Effectiveness of short foot exercises versus towel curl exercises to improve balance and foot posture in individuals with flexible flat foot. Indian Journal of Forensic Medicine & Toxicology. 2020 Jul 30;14(3):653-8.
14. Wan FK, Yick KL, Winnie WM. Effects of heel height and high-heel experience on foot stability during quiet standing. Gait & Posture. 2019 Feb 1;68:252-7.
15. Azhagiri R, Malar A, Hemapriya J, Sumathi G. The cause and frequency of PES Planus (Flat Foot) problems among young adults. Asian Journal of Medical Sciences. 2021 Jul 1;12(7):107-11.
16. Kahle MG, Deshmukh NA, Muley P, Suryawanshi M. The Association between Flat Feet and Body Mass Index in Various Age Groups. Indian Journal of Forensic Medicine & Toxicology. 2020 Oct 1;14(4).
17. Zuil-Escobar JC, Martínez-Cepa CB, Martín-Urrialde JA, Gómez-Conesa A. Medial Longitudinal Arch: Accuracy, Reliability, and Correlation Between Navicular Drop Test and Footprint Parameters. J Manipulative Physiol Ther. 2018 Oct;41(8):672-679.
18. Ramos A, Fernandes S, Pooja PJ, Krishnan P. Assessment of the flat foot using plantar arch index in young adults. Biomedicine. 2021;41(3):535-8.
19. Azhagiri R, Malar A, Hemapriya J, Sumathi G. The cause and frequency of PES Planus (Flat Foot) problems among young adults. Asian Journal of Medical Sciences. 2021 Jul 1;12(7):107-11.
20. Shree S, Revathi S, Thiyagarajan A, Kumar D. Does Obesity Cause Flat Foot?. J Obes Ther 2: 1. of. 2018;4:2.
21. Sarvaiya V, Shimpi A, Mitra S. Revival of 'Paduka', an ancient form of Indian footwear to increase foot muscle strength and balance: A randomized controlled trial–A Hypothesis.
22. Franklin S, Grey MJ, Heneghan N, Bowen L, Li FX. Barefoot vs common footwear: a systematic review of the kinematic, kinetic and muscle activity differences during walking. Gait & posture. 2015 Sep 1;42(3):230-9.
23. Lynn SK, Padilla RA, Tsang KK. Differences in static-and dynamic-balance task performance after 4 weeks of intrinsic-foot-muscle training: the short-foot exercise versus the towel-curl exercise. Journal of sport rehabilitation. 2012 Nov 1;21(4):327-33.
24. Janda V, Vavrova' M. *Sensory Motor Stimulation*: A video. Presented by JE Bullock-Saxton. Brisbance, Australia, Body Control Systems; 1990.
25. Robbins S, Waked E, Allard P, McClaran J, Krouglicof N. Foot position awareness in younger and older men: the influence of footwear sole properties. Journal of the American Geriatrics Society. 1997 Jan;45(1):61-6.
26. Puszczałowska-Lizis E, Dąbrowiecki D, Jandziś S, Żak M. Foot deformities in women are associated with wearing high-heeled shoes. Medical science monitor: international medical journal of experimental and clinical research. 2019;25:7746.