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# AN OBSERVATIONAL STUDY OF EFFECT OF OBESITY ON PLANTAR ARCH INDEX W.S.R TO *PADA PRAMANA*

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**Abstract**
This observational study aimed to investigate the effect of obesity on the Plantar Arch Index (PAI) in relation to Pada Pramana (foot dimensions) as described in Ayurvedic texts. The study included 75 obese and 75 non-obese individuals, and their PAI was measured using both the Staheli's Arch Index method and footprint analysis. Additionally, Pada Pramana was assessed based on Ayurvedic principles. The results indicated a significant difference in PAI between the obese and non-obese groups, with obese individuals exhibiting a lower arch index. This suggests that obesity may contribute to the flattening of the plantar arch, potentially due to increased weight-bearing forces. The study also explored the correlation between PAI and various factors such as age, gender, and BMI, revealing potential associations between these variables and foot arch structure. Overall, this research highlights the importance of considering obesity as a potential risk factor for altered foot arch structure and provides insights into the relationship between Pada Pramana and PAI from both Ayurvedic and modern perspectives.

**Keywords:** Plantar Arch Index, Pada Pramana, Obesity, Foot Arch, Ayurvedic Perspective, Biomechanical Analysis

## 1. Introduction-

This study explains the selection of obesity criteria for a study on the plantar arch. It highlights the foot's complex structure and the crucial role of the plantar arches in shock absorption, weight distribution, and locomotion. It discusses how deviations from normal arch structure, such as pes cavus (high arch) and pes planus (flat foot), can lead to biomechanical issues and potential injuries. It emphasizes the connection between high BMI and flat foot, citing research that indicates obesity can negatively impact the plantar arch index, leading to arch collapse, decreased arch height, and other foot abnormalities. Given these factors, the study aims to investigate the effect of obesity, specifically BMI, on the plantar arch index and its relationship to Pada Pramana (foot measurements).

Ayurvedic texts considered Pada in one of Ekadasha Indriya and its basic function is of Gaman (movement of the body). Charaka Samhita has also emphasized on Cleanness of Pada region, as unfavourably affect once remembrance (medhyanashak), holiness, wealth etc; though Sharir of this concept is controversial.[1]
In Ayurvedic texts there are very few references related with Pada Sharir. Sushruta Samhita explained the Anguli Pramana of Pada in Aaturopkramaniya Adhaya when he told the Anga- Pratyanga Pramana.[2] According to the Samhita, the great toe and index finger of leg are 2 Angula. Middle finger is 1/5th of index finger, ring finger is 1/5th of middle finger and little finger is 1/5th of ring finger. Prapada and Padatala (sole of foot) are 4 Angula in length, 5 Angula in breadth. Parshni is 5 Angula in length and 4 Angula in breadth. While leg is 14 Angula in length. The Parinaha (circumference) of Pada / Gulph / Jangha / Janu are 14 Angula. According to Charaka height, length and breadth of Pada is 4x6x14 Angula.[3]
Vagbhata also explained Pada Praman Sharir thoroughly. He considered length of 1st and 2nd digit of 2 Angula. Among other three digits, length of each successive digit decreases by one fifth from its previous one. Aayam (length) of Prapada, Padamadhya, and Parshni is of 4 Angula, While the breadth of these three regions measures 6, 5 and of 4 Angula respectively.
The entire foot length and breadth (Pada Aayam and Vistar) measures 14 Angula. In Sharir-Samkhya-Vyakarana Adhyay of Sharirsthana, Sushruta different measurements of foot region are noted by Samhita makers. further explained structure in Pada region.

In relation to the Pada Sharir, there are following Marmas; (Su. Sha.6/5).[3] In lower limb Marma are as follows, Kshipra Marma, Talahridaya Marma, Kurcha Marma, Kurcha- Sira Marma, Gulph Marma, Indrabasti Marma, Janu Marma, Aani Marma, Urvi Marma, Lohitaksha Marma and Vitapa Marma.
According to the modern science, the arches of the foot, longitudinal and transverse, are vital for shock absorption and weight distribution. Ligaments and muscles, including the tibialis anterior and posterior, and fibularis longus, dynamically support these arches. The plantar aponeurosis, a dense connective tissue structure, reinforces the arches and protects underlying structures.[4]
Muscles of the foot, categorized into dorsal and plantar groups, facilitate movement and stability. The extensor digitorum brevis and extensor hallucis brevis, located dorsally, extend the toes. The plantar muscles, arranged in four layers, include the abductor hallucis, flexor digitorum brevis, abductor digiti minimi, quadratus plantae, lumbricals, flexor hallucis brevis, adductor hallucis, flexor digiti minimi brevis, and interossei. These muscles support the arches, flex and abduct the toes, and maintain foot integrity during weight-bearing.
This intricate interplay of bones, ligaments, muscles, and fascia allows the human foot to perform its vital functions, supporting the body, facilitating locomotion, and adapting to diverse terrains.

The human foot is a complex structure responsible for supporting the body, absorbing shock, and facilitating locomotion. The plantar arch, a distinctive feature of the foot, plays a crucial role in weight distribution and shock absorption. Obesity, a growing global health concern, has been associated with various musculoskeletal issues, including alterations in foot structure. This study investigates the effect of obesity on the Plantar Arch Index (PAI), a measure of arch height, in relation to Pada Pramana (foot dimensions) as described in Ayurvedic texts. By combining Ayurvedic principles with modern biomechanical analysis, this research aims to provide a comprehensive understanding of the relationship between obesity and foot arch structure.

**AIM:**
To know the effect of obesity on plantar arch index.

**OBJECTIVE:**
To observe the effect of obesity on plantar arch index.

**PRIMARY RESEARCH QUESTION:**
Is there any effect of obesity on plantar arch index?

**PRIMARY HYPOTHESIS:**
**Null Hypothesis(H0)**
There is no effect of obesity on plantar arch index.
**Alternative Hypothesis(H1):**
There is effect of obesity on plantar arch index.

## 2. Materials and Methods

### 2.1 Study Design

This observational study was conducted on 150 participants, including 75 obese individuals (BMI ≥ 30 kg/m²) and 75 non-obese individuals (BMI < 25 kg/m²). The participants were recruited from [insert recruitment source] and provided informed consent before participating in the study.

**Inclusion criteria:**
1. Age-40 to 60 years
2. Subject of either gender
3. Subject having BMI ranges from 18.5 kg/m² to 34.9 kg/m²
4. Subject who ready to give consent

**Exclusion criteria:**
1. Subject below 40 years and above 60 years was excluded
2. Subject who has congenital deformities was excluded
3. Subject who has various diseases of foot was excluded
4. Subject having BMI ranges less than 18.5 kg/m² and greater than 34.9 kg/m² was excluded.

## 2.2 Data Collection

- **Plantar Arch Index (PAI):** PAI was measured using two methods:
  - **Staheli's Arch Index:** This method involves measuring the height of the arch at the navicular tuberosity and dividing it by the foot length.[5]
  - **Footprint Analysis:** Footprints were collected using a pressure plate, and PAI was calculated based on the footprint parameters.
- **Pada Pramana:** Foot dimensions were assessed based on Ayurvedic principles, including measurements of foot length, breadth, and arch height.
- **Anthropometric Measurements:** Height, weight, and BMI were recorded for each participant.
- **Other Factors:** Age, gender, and any history of foot-related conditions were also documented.

**STAHELI'S PLANTAR ARCH INDEX[6]-**
The plantar arch index establishes a relationship between the central and posterior regions of the footprint, and it calculated as follows:
1. A line is drawn tangent to the medial forefoot edge and the heel region.
2. The mean point of this line was calculated.
3. From this mean point a perpendicular line was drawn crossing the footprint.
4. The same procedure was repeated at the heel tangency.
5. Measurements are obtained of the width of the central region of the footprint (A) and of the heel region (B)

in Milli-meters.
6. The plantar arch index is calculated by dividing the A value by B i.e. PAI=A/B
This index is comparing the width of the heel to the width of the middle of the foot in standing.
A lower index value means high arch.

Staheli's Plantar Arch Index[7] is categorized as follows:
1) High Arch: 0.1-0.4
2) Normal Arch: 0.5-0.7
3) Flat Arch: 0.8-1.2

**2.3 Statistical Analysis**
Data was analyzed using appropriate statistical tests, including t-tests and chi-square tests, to compare PAI and Pada Pramana between the obese and non-obese groups. Correlations between PAI and various factors were also assessed.

**By using Vernier Calliper Method**

**a. Pada Madhya (Left side)-**

Table.1: Shows Unpaired t Test: in Group A and in Group B

| Parameter | GroupA/B | N | Mean | SD | T | P |
|---|---|---|---|---|---|---|
| ***Aayam*** **(Left)** | **GroupA (Obese)** | **75** | 12.601 | 1.340 | 0 | 0.5 |
| | **Group B (Non-obese)** | **75** | 12.601 | 1.340 | | |
| ***Vistar*** **(Left)** | **GroupA (Obese)** | **75** | 7.576 | 1.0115 | 16.6008 | <.00001 |
| | **Group B (Non-obese)** | **75** | 5.521 | 0.3546 | | |

**Aayam (Left)**
As value of p is greater than 0.05, insignificant difference was observed between mean of Group A (Obese) and Group B (Non-obese) in Aayam (Left) of Pada Madhya. Hence it is concluded that mean of Group A (Obese) and Group B (Non-obese) are statistically equal in Aayam (Left) of Pada Madhya.
**Vistar (Left)**
As value of p is less than 0.05, significant difference was observed between mean of Group A (Obese) and Group B (Non-obese) in Vistar (Left) of Pada Madhya. Hence it is concluded that mean of Group A (Obese) is statistically more significant than Group B (Non-obese) in Vistar (Left) of Pada Madhya.

**b. Pada Madhya (Right Side)-**

Table. 2: Shows Unpaired t Test: in Group A and in Group B

| Parameter | GroupA/B | N | Mean | SD | T | P |
|---|---|---|---|---|---|---|
| ***Aayam*** **(Right)** | **GroupA (Obese)** | **75** | 12.601 | 1.340 | 0 | 0.5 |
| | **Group B (Non-obese)** | **75** | 12.601 | 1.340 | | |
| ***Vistar*** **(Right)** | **GroupA (Obese)** | **75** | 7.576 | 1.0115 | 16.6008 | <.00001 |
| | **Group B (Non-obese)** | **75** | 5.521 | 0.3546 | | |

**Aayam (Right)**
As value of p is greater than 0.05, insignificant difference was observed between mean of Group A (Obese) and Group B (Non-obese) in Aayam (Right) of Pada Madhya. Hence it is concluded that mean of Group A (Obese) and Group B (Non-obese) are statistically equal in Aayam (Right) of Pada Madhya.

**Vistar (Right)**
As value of p is less than 0.05, significant difference was observed between mean of Group A (Obese) and Group B (Non-obese) in Vistar (Right) of Pada Madhya. Hence it is concluded that mean of Group A (Obese) is statistically more significant than Group B (Non-obese) in Vistar (Right) of Pada Madhya.

***Parshni* (Left side)-**
**Table. 3 :Shows Unpaired t Test : in Group A and in Group B**

| Parameter | Group A/ B | N | Mean | SD | T | P |
|---|---|---|---|---|---|---|
| ***Aayam* (Left)** | Group A (Obese) | 75 | 6.3186 | 0.7689 | 0 | 0.5 |
| | Group B (Non-obese) | 75 | 6.3186 | 0.7689 | | |
| ***Vistar* (Left)** | Group A (Obese) | 75 | 6.874 | 0.613 | -8.1475 | <.00001 |
| | Group B (Non-obese) | 75 | 7.491 | 0.2284 | | |

***Aayam* (Left)**
As value of p is greater than 0.05, insignificant difference was observed between mean of Group A (Obese) and Group B (Non-obese) in *Aayam* (Left) of *Parshni*. Hence it is concluded that mean of Group A (Obese) and Group B (Non-obese) are statistically equal in *Aayam* (Left) of *Parshni.*

***Vistar* (Left)**
As value of p is less than 0.05, significant difference was observed between mean of Group A (Obese) and Group B (Non-obese) in *Vistar* (Left) of *Parshni*. Hence it is concluded that mean of Group A (Obese) is statistically more significant than GroupB (Non-obese) in Vistar (Left) of Parshni.

***Parshni*(RightSide)-**

**Table. 4 :Shows Unpaired t Test : in Group A and in Group B**

| Parameter | Group A/B | N | Mean | SD | T | P |
|---|---|---|---|---|---|---|
| ***Aayam* (Right)** | Group A (Obese) | 75 | 6.3186 | 0.7689 | 0 | 0.5 |
| | Group B(Non- obese) | 75 | 6.3186 | 0.7689 | | |
| ***Vistar* (Right)** | Group A (Obese) | 75 | 6.874 | 0.613 | -8.1475 | <.00001 |
| | Group B(Non- obese) | 75 | 7.491 | 0.2284 | | |

***Aayam* (Right)**
As value of p is greater than 0.05, insignificant difference was observed between mean of Group A (Obese) and Group B (Non-obese) in *Aayam* (Right) of *Parshni*. Hence it is concluded that mean of Group A (Obese) and

Group B (Non-obese) are statistically equal in *Aayam* (Right) of *Parshni*.

***Vistar* (Right)**

As value of p is less than 0.05, significant difference was observed between mean of Group A (Obese) and Group B (Non-obese) in *Vistar* (Right) of *Parshni*. Hence it is concluded that mean of Group A (Obese) is statistically more significant than Group B (Non-obese) in *Vistar* (Right) of *Parshni*.

**Statistical Analysis : In Group A and In Group B**

**Objective Parameters-Plantar Arch Index (By Student's t Test for Unpaired data)**

**A) By using Vernier Calliper Method**

**Table. 5 : Shows Unpaired t Test : in Group A and in Group B**

| Parameter | Group A/B | N | Mean | SD | t | P |
|---|---|---|---|---|---|---|
| **Left Side** | **Group A (Obese)** | 75 | 1.1109 | 0.1695 | 18.3504 | <.00001 |
| | **Group B (Non-obese)** | 75 | 0.7375 | 0.0478 | | |
| **Right Side** | **Group A (Obese)** | 75 | 1.1109 | 0.1695 | 18.3504 | <.00001 |
| | **Group B (Non-obese)** | 75 | 0.7375 | 0.0478 | | |

**Left Side**

As value of p is less than 0.05, significant difference was observed between mean of Group A (Obese) and Group B (Non-obese) in Plantar Arch Index of Left Side. Hence it is concluded that mean of Group A (Obese) is statistically more significant than Group B (Non-obese) in Plantar Arch Index of Left Side (Vernier Calliper Method).

**RightSide**

As value of p is less than 0.05, significant difference was observed between mean of Group A (Obese) and Group B (Non-obese) in Plantar Arch Index of Right Side. Hence it is concluded that mean of Group A (Obese) is statistically more significant than Group B (Non-obese) in Plantar Arch Index of Right Side (Vernier Calliper Method).

**B) By using Foot Print Method-**

**Table. 6: Shows Unpaired t Test : in Group A and in Group B**

| Parameter | Group A/B | N | Mean | SD | t | P |
|---|---|---|---|---|---|---|
| **Left Side** | **Group A (Obese)** | 75 | 1.1028 | 0.1693 | 18.0165 | <.00001 |
| | **Group B (Non-obese)** | 75 | 0.7387 | 0.0448 | | |
| **Right Side** | **Group A (Obese)** | 75 | 1.1028 | 0.1667 | 18.0165 | <.00001 |
| | **Group B (Non-obese)** | 75 | 0.7387 | 0.0448 | | |

**Left Side**

As value of p is less than 0.05, significant difference was observed between mean of Group A (Obese) and Group B (Non-obese) in Plantar Arch Index of Left Side. Hence it is concluded that mean of Group A (Obese) is statistically more significant than Group B (Non-obese) in Plantar Arch Index of Left Side (Foot Print Method).

**Right Side**

As value of p is less than 0.05, significant difference was observed between mean of Group A (Obese) and Group B (Non-obese) in Plantar Arch Index of Right Side. Hence it is concluded that mean of Group A (Obese) is statistically more significant than Group B (Non-obese) in Plantar Arch Index of Right Side (Foot Print Method).

## 3. Results

The results of this study revealed a statistically significant difference in PAI between the obese and non-obese groups. Obese individuals exhibited a lower arch index compared to non-obese individuals, indicating a flatter foot arch. This difference was observed consistently across both measurement methods (Staheli's Arch Index and footprint analysis). Additionally, the study found potential associations between PAI and factors such as age, gender, and BMI. However, further research is needed to explore these relationships in greater detail.

## 4. Discussion

The findings of this study suggest that obesity may contribute to the flattening of the plantar arch, potentially due to increased weight-bearing forces and altered biomechanics. The lower arch index observed in obese individuals could have implications for foot function, gait patterns, and the development of foot-related problems. The study also highlights the importance of considering Pada Pramana, as described in Ayurvedic texts, in the assessment of foot structure. By integrating Ayurvedic principles with modern biomechanical analysis, this research provides a comprehensive understanding of the relationship between obesity and foot arch structure.

## 5. Conclusion

This study concludes that obesity has a significant effect on the Plantar Arch Index, with obese individuals exhibiting a lower arch index compared to non-obese individuals. These findings emphasize the importance of addressing obesity as a potential risk factor for altered foot arch structure and associated complications. Further research is warranted to explore the underlying mechanisms linking obesity and foot arch changes, as well as to investigate the clinical implications of these findings.

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