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CORRELATION BETWEEN PLANTAR ARCH INDEX, WAIST HIP RATIO AND BODY MASS INDEX TO SITTING RISING TEST AMONG YOUNG SEDENTARY ADULTS

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Abstract: Sedentary Lifestyle has become a growing concern all around the world especially among the young adults. It has impacted on the health of the individuals causing obesity which has further lead to the prevalence of flat feet. Sitting on the floor crossed leg and rising is a functional activity that requires muscle strength, power, and flexibility of the lower limbs along with good balance and coordinated movements of the entire body. To measure all of the parameters, a simple test called "Sitting Rising Test" can be used.

The main purpose of this study is to co relate the plantar arch index , BMI,WHR to sitting rising test among young Sedentary Adults and also to assess the type of foot arch in an Individual(Normal or flat)and its effect on the SRT Scores.

Index Terms **- Sitting rising test, Medial arch of foot, Simple Ink print method, Staheli plantar arch index, PAI**

I. INTRODUCTION

Physical inactivity is a growing public health risk in industrialized societies, leading some to suggest that our bodies did not evolve to be sedentary [1].A widespread concern exists about the low level of vigorous physical activity and high rates of sedentary behavior in the current generation [2]. It has been termed a "Global Pandemic" [3]. Prevalence of Physical inactivity in India is estimated to be 13.4% (12.2%–14.8%) by the World Health Organization among adults aged 18 years and above,[4] and according to another study done by ICMR in 2014 it was 54.4% in the age group above 20yrs of age.[5] It has been estimated that physical inactivity may cause 6%–10% of the major non communicable diseases (NCDs) globally, including coronary heart disease (CHD), type 2 diabetes, and breast and colon cancers.[6].The major cause for this would be the urbanized world surrounded with chairs and couches.

Sedentary behavior can be defined as any waking behavior characterized by an energy expenditure <1.5MET while in sitting or reclining posture. Adults spend nearly 55-57% of their monitored time, or ≥7.7 hours/day in sedentary behaviors in activities such as TV viewing, computer use and electronic games, sitting in automobiles [7] amongst others.

Sitting is one of the starting position in which the lower limbs are fully supported .The hips and knees flexed to right angles. Individuals living in industrialized societies generally sit in chairs or reclined positions for prolonged period of time, greatly reducing muscle activity and energy costs needed to support the body .[8,2]

Increased sitting time has caused major deleterious effects on the health of individuals. According to a study sedentary behavior is not simply the absence of moderate-to-vigorous physical activity, but rather is a unique set of behaviors, with unique environmental determinants and a range of potentially-unique health consequences [9].

Sedentary lifestyle is well among the 10 leading causes of death and disability in the world [10], and has become one of the key Contributing factor for Obesity.

Obesity is characterized by excess lipid storage. Based on WHO criteria, underweight was identified as BMI < 18.5 kg/m² , overweight as BMI 25.0-29.9 kg/m² , and obese as BMI ≥ 30.0 kg/m².[11]

- According to WHO Asia Pacific guidelines Obesity can be divided into different types
- Generalized obesity (GO, BMI≥25kg/m2),
- Abdominal obesity (AO, waist circumference ≥90 cm for men and ≥80cm for women)
- Combined obesity (CO, GO plus AO).[12]

According to World Health Statistics Report 2012 globally one in six adults is obese and nearly 2.8 million individuals die each year due to overweight or obesity.[11]

The prevalence of obesity in India varies due to age, gender, geographical environment, socio-economic status, etc. According to ICMR-INDIAB study 2015, prevalence rate of obesity and central obesity varies from 11.8% to 31.3% and 16.9%–36.3% respectively [13].The body mass index (BMI) is commonly used as a surrogate marker for adiposity, calculated as weight in kilograms divided by height in meters squared [14]. Global and local prevalence estimates are based on the Body mass index (BMI) which provide a guide to obesity levels, as recognized by BMI values greater than or equal to 30. Apart from BMI,

there exist other parameters for the assessment of obesity among which is the waist circumference and waist: hip ratio (WHR).[15]

Waist circumference is a more accurate measure of the distribution of body fat, [16]. It has been shown to be more strongly associated with morbidity and mortality [16-18] .Waist Hip ratio is a simple index that measures the fat distribution. It is obtained by dividing waist circumference to hip circumference and provides an indication of predominance of fat storage in the abdominal region relative to that in the gluteal region [12] .A high WHR score is indicative of central fat distribution with excess abdominal fat. High values generally above 0.8 in women and above 1.0 in men are associated with an increased risk of impaired glucose tolerance, hyperinsulinaemia and hypertriglyceridemia, hypertension.

Increased BMI and waist circumference have both been associated with obesity related metabolic abnormalities.[19]

CROSSED LEGGED SITTING

Crossed legged Sitting posture is an old Indian tradition and an integral to activities of daily living in Eastern and Asian cultures.

Kapoor et al. conducted a study among Indian Individuals on the Range of Movements on the lower limb joints in crossed legged sitting posture. Through his study the following observations were seen:

- Flexion at the hip joint ranged from 82° to 100°, with a mean of 91°.
- Abduction at the hip joint ranged from 19° to 57°, with a mean of 39°.
- The external rotation ranged from 42° to 58°, with a mean of 49°.
- Flexion at the knee ranged from 126° to 142°, with a mean of 135°.
- Equines at the ankle ranged from 17° to 34°, with a mean of 29°.[20]

Sitting and rising from the floor is a basic functional task which requires appropriate levels of muscle strength, joint coordination, balance and flexibility.[21]

During the act of sitting on the floor ankles are crossed, hips are flexed and strongly abducted and laterally rotated, knees are flexed so that the lateral aspect of knees and ankles are pressed to the floor.[22]

When sitting down with crossed leg, the soles of the feet are the fixed point from which movement is initiated and the movement of lowering is controlled by eccentric contraction of leg extensors and concentric contraction of leg flexors.

When standing up, ankle plantar flexors work concentrically while dorsiflexors contract eccentrically. Excellent ankle strength is required to stand from sitting on the floor without using the hands and without swaying or losing balance.[21]

SITTING RISING TEST

Claudio Gil Araujo, a Brazilian scientist of Gama Filho University in Rio de Janeiro, Brazil, proposed a simple method to assess the ability to sit and rise from floor termed "sitting-rising test (SRT)." It objectively quantifies the number of supports needed and the presence or absence of balance stability for these actions.[23]

The test has excellent reliability (ICC=0.970-0.999). The inter-rater reliability was excellent (ICC=0.872–0.967) test-retest reliability was good (ICC=0.679–0.863). The inter-rater and test-retest reliabilities were both high, indicating that the test is reliable for assessing the quality of movement in sitting and rising from the floor. Sitting score: sensitivity 90.0%, specificity 66.7%. Rising score: both sensitivity and specificity 80.0%.[21]

Proper levels of muscle strength, power, coordination, body composition, balance, and flexibility are required for various daily activities and, more specifically, for a successful transition from standing to a sitting position as well as rising from the floor[23,24] .

The ability of sitting and rising from the floor is measured according to the number of supports needed to perform each of the movements and the presence or absence of instability when sitting and rising.

The score for each of the actions ranges from a minimum of 0 to a maximum of 5, with half-point intervals. Starting from 5, one point is subtracted for each support utilized, that is, for each hand, forearm, knee, or side of the leg used, and an additional 0.5 point is subtracted if the evaluator notices an unsteady execution (partial loss of balance) during the actions. Independently of the number of attempts performed, the best score for each one of the two actions is considered the resulting SRT score for sitting and rising from the floor. Moreover, a composite SRT score – sum of sitting and rising scores – is also calculated and ranges from 0 to 10. A score of 10 indicates the ability to sit and to rise from the floor without using any support – hand or knee – or presenting instability [25].

The main merits of these procedures are:

a) Simplicity in the collection of relationship predictions

b) Do not depend on high-tech equipment and

c) Do not need experienced evaluators.

A score of 10 is the most frequently seen in men aged 16 to 25 years old and in women aged 16 to 40 years old. However, less than 8% of men and women aged > 55 years old achieved a composite score of 10. [25]

In one of the recent studies conducted by Jagatheesan Alagesan PT et al, young Indian adults were recruited having a mean age of 21.01 ± 2.1 .The mean value of SRT obtained was 7.9 ± 1.6 (7.6 to 8.2). The value of SRT in Males was 8.3 ± 1.5 and female was 7.2 ± 1.5 with significance difference between them (p=0.001) [26].

The SRT can be considered a simple screening procedure in which a low score largely reflects the degree of impairment in the components of musculoskeletal fitness – mainly those indicating a reduction in muscle strength and/or joint flexibility.

According to a study conducted by de Brito LB et al, SRT predicts the mortality rate in individuals aged 51-80 yrs. The score in the range of 8-10 indicates a low risk of death, whereas low score is associated with >6 fold higher all-cause mortality in men and women. Even more relevant is the fact that a 1-point increment in the SRT score was related to a 21% reduction in mortality. [23]

But there is further scope in this area of interest which requires intervention that would facilitate an Individual with low score to improve his/her SRT Scores.

PLANTAR ARCH INDEX

The human foot has been structurally and functionally evolved and developed to be one of the most striking modifications in human evolution. [27] This advanced modification of foot is attained by its anatomy which is comprised of foot bones, strengthened by ligaments and tendons allowing the foot to support the weight of the body in the erect balanced posture with least weight. These composite anatomical components form a rigid structure called the arches of the foot.

There are three arches in the foot, which are referred to as:

- The longitudinal medial arch,
- The longitudinal lateral arch,
- The transverse arch.

The foot arches are used to determine the shape or morphology of the foot, whether it is normal arch (normally aligned foot), high arch (supinated foot) or flat arch (pronated foot). [28]

These arches mainly the medial longitudinal arch, plays essential functions in the biomechanics of the foot. It acts as a shock absorbing structure. Apart from that the arch provides an elastic, springy connection between the forefoot and the hind foot supporting, and weight bearing. This association safeguards so that a majority of the forces incurred during weight bearing of the foot can be dissipated before the force reaches the long bones of the leg and thigh.[29]

There is also a growing concern on the increasing graph of the prevalence of flat feet among individuals ranging from adolescent to old age. In a study conducted by Yashika Kalra, et al the total prevalence of flat feet among the South Indian population aged 18-24yrs was 39.7% including 21.8% in males and 17.9% in females.[30]

In the bivariate analysis done in one of the studies, the presence of flat foot was significantly associated with age, comorbidity, BMI and foot size. Among patients diagnosed with flat foot a higher BMI (31.45 kg/m² vs. 28.4045 kg/m²) was observed.[31]

Flat feet or pes planus is a postural deformity in which the arches of the foot collapses, with the entire sole of the foot coming into complete or near-complete contact with the ground. In pes planus, the head of the talus bone is displaced medially and distal from the navicular. As a result, the spring ligament and the tendon of the tibialis posterior muscle are stretched, so much so that the individual with pes planus loses the function of the medial longitudinal arch (MLA).[32]

The deformation experienced by the medial longitudinal ligament makes feet to be the region suffering the highest variations in a human body. These functional features make clinical examination of this region important.

Previous studies have reported that a strong correlation was observed between BMI categories and foot arches [30]. An increase in the body weight and Body Mass Index (BMI) literally influence our foot arch, especially those with flat foot.[33] Even though obesity has repeatedly been associated with the presence of flat foot.[34]

In overweight and obese individuals, changes in their foot shape were observed due to excessive biomechanical loading and pressure.[35]

Footprint parameters act as an essential tool in assessing the foot arch or foot shape [36] .The assessment of plantar arch development, by the relationship between arch region width and heel region width obtained on a footprint, is proposed by Engel [37] and Staheli [38] called “The Plantar Arch Index”

Staheli’s Plantar Arch Index method is used to determine the incidence of pes planus among Individuals. According to Cavanagh PR et.al the test has a reliability of 0.96 and 0.94.[5]

It is defined as the ratio of the width of the central region of the foot to the width of the heel region of the foot. Plantar arch index (PAI) = A/B. If the PAI is >1.15, then it is considered as a flat foot. [39]

Plantar arch index is easy to obtain from footprints and that there are no differences in terms of gender or age [40].

Figure 1: Foot print with normal medial arch

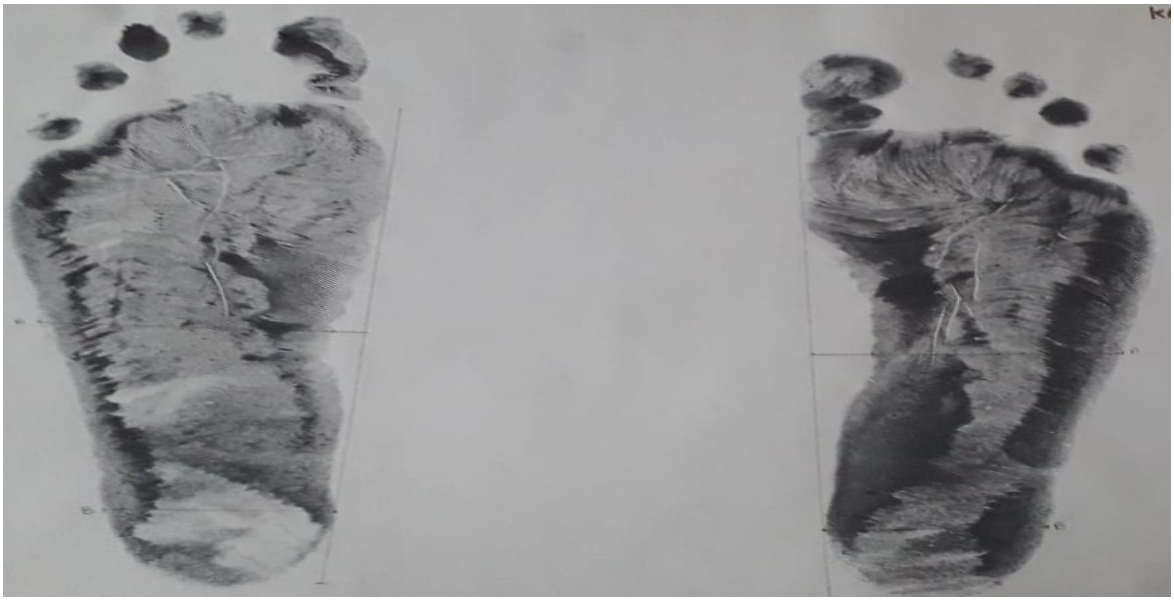


Figure 2: Footprint of collapsed medial arch(bilateral)

II.RESEARCH METHODOLOGY

The primary source of data was collected from R.V. College of Physiotherapy®

SOURCE OF DATA:

METHOD OF COLLECTION OF DATA:

The data for the study will be collected based on the following categories:

- **Study setting:** R.V. College of Physiotherapy®
- **Study duration:** 1 month
- **Study design:** Co-relational study
- **Sampling technique:** Convenience Sampling
- **Study recruitment:** Participants aged between 18 to 25 years

Sample size calculation:

$$n=(Z\alpha/2 + Z\beta)^2 p.q \div d^2$$

$$n=90$$

INCLUSION CRITERIA

- Age 18-25years
- Inclusion of both the genders
- Subjects who can Follow Command

EXCLUSION CRITERIA

- Any recent fractures
- Neurological Impairments
- Subjects not willing to participate.
- Lower extremity trauma like a fracture, any ankle conditions, with any pain.

MATERIALS REQUIRED

1) Stadiometer
2) Weighing machine(Dolpnin)
3) Calculator(Casio HL-820LV Electronic Calculator)
4) A3 Sheet
5) Ink
6) Inch tape
7) Tray
8) Protractor
9) Scale
10) Water
11) Consent form

PROCEDURE:

Measurements:

Subjects who fulfill the inclusion criteria will be recruited for the study from R V College of Physiotherapy® by convenient sampling based on inclusion and exclusion criteria. The purpose of study is explained to the participants and the written consent form is obtained from the participants.

- Anthropometric measurements taken:

I. Height: Height is measured with a wall-mounted stadiometer.
II. Weight: Weight is measured with a beam balance scale.
III. BMI: Body Mass Index is calculated using the formula: Weight/Height²
IV. Waist circumference: Waist circumference is measured at the level of umbilicus using a measuring tape.[44]
V. Hip Circumference: Hip circumference is measured at the at the level of the maximum extension of the buttocks posteriorly in a horizontal plane using a measuring tape.[45]
VI. Waist Hip Ratio: It is calculated by using the formula: waist/hip.

- **Medial Arch of foot**: Foot print of the subjects are taken using the simple Ink print Method.[32]
  Procedure: Subjects with barefoot are instructed to place their feet in a tray containing water soluble ink.
  The subjects are required to place their foot firmly on an A3 size sheet of paper to get good print on the sheet.
  Finally the subjects are instructed to lift their foot away from the tray one after other and not allowing dragging of the feet to happen.

FINDINGS:

The foot prints are collected and the STAHELI PLANTAR ARCH INDEX is used as a measuring scale to determine the presence of medial arch.

STAHELI PLANTAR ARCH INDEX:

A line is drawn tangent to the medial forefoot edge and the heel region. The Mean point of this line is calculated. From this point a perpendicular line is drawn crossing the foot print and same procedure repeated for heel tangency point. The width of the central region of the footprint is considered as "A," and the width of the heel region is considered as "B." Plantar Arch Index is obtained by dividing the A value by B value.

Plantar arch index (PAI) = A/B.

If the PAI is >1.15, then it is considered as a flat foot.[39]

Figure 3:Plantar Arch Index

SITTING RISING TEST PROCEDURE:

- The Test must be performed on a flat, non-slip surface with the appraised barefoot, without socks and devoid of clothes that limit their movement.
- The Evaluator should position oneself close, forward and diagonally to the subject.
- In the first run the evaluator should instruct the subject in a simple and direct way.
  "Try to sit and get up, using the least number of possible support and without becoming imbalanced"
- Normally up to 2 attempts are performed.
- The subject starts the test with a maximum score of 5 points for each of the sitting and standing actions, being subtracted from it one point for each extra support used and half a point for each Imbalance Noticeable bodily Resistance.
- Point Deduction :Placing hand ,forearm knee or the side of the leg on the floor for support, hand on knee to facilitate Rising or sitting.[42]

Table 1: SRT Scoring

TOTAL SCORE	REASONING
5	Without support
4.5	1 Imbalance
4	1 support
3.5	1 support 1 imbalance
3	2 support
2.5	2 support 1 imbalance
2	3 support
1.5	3 support 1 imbalance
1	4 supports
0.5	4 support 1 Imbalance
0	>4 supports or with appraiser's help

Table 2: SRT Categories

Category	Scores
CATEGORY I (poor)	0-3(5-6times at higher risk)
CATEGORY II(Fair)	3.5-5.5
CATEGORY III	6-7.5
CATEGORY IV(Good)	8-10(2-5times at higher risk)

III.STATISTICAL ANALYSIS

The data collected for this were analyzed statistically which are as follows:

DESCRIPTIVE STATISTICS:

All categorical variables were presented graphically in form of histogram and graphs .The Quantitative variables were summed by computing Mean and Standard Deviation. The correlations were plotted using scattered plot diagram and Pearson's correlation coefficient was used.

ANALYTICAL STATISTICS:

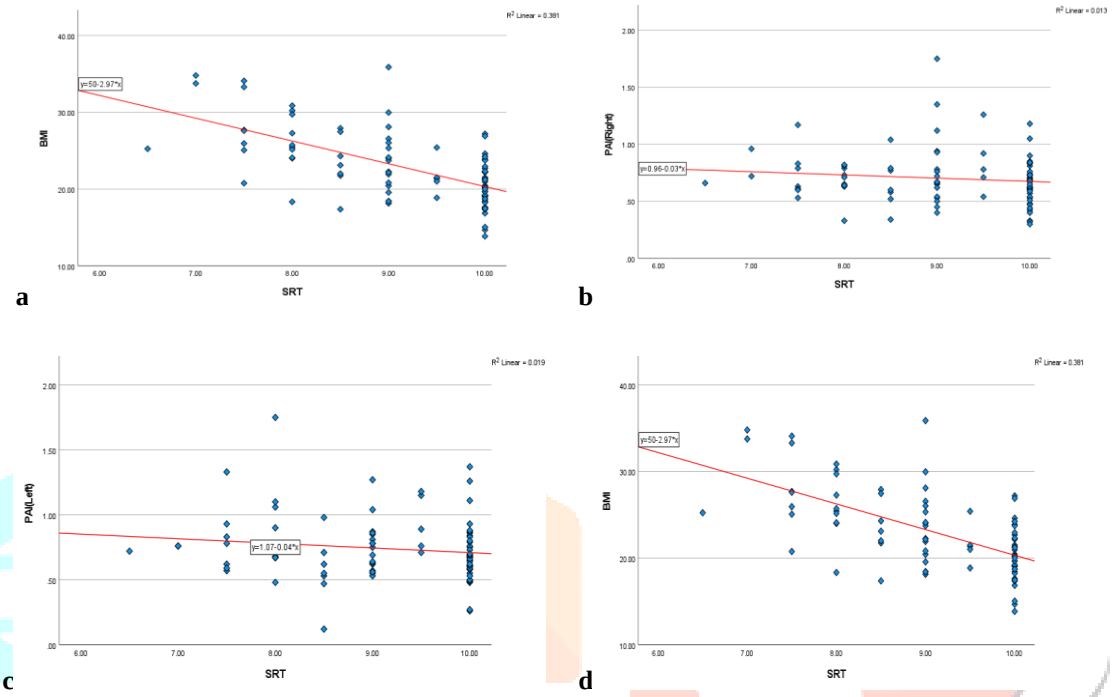
The data were entered using Microsoft Excel 2010 and the Analysis was done using the software SPSS® 26.0 IBM®.

IV. RESULTS AND DISCUSSION

Table 3: Table representing The Frequency, Mean ±Standard deviation of demographic characteristics of participants.

DEMOGRAPHIC CHARACTERSTICS	N	MEAN±STD. DEVIATION
Weight	90	59.4722±12.92597
Height(mt²)	90	2.5986±.24917
Hip Circumference	90	96.0667±10.24509
Waist Circumference	90	77.4500±11.13680
BMI	90	22.9002±4.59880
WHR	90	.8056±.07183
SRT	90	9.1333±.95635
PAI(Left)	90	1.0667±.25084
PAI(Right)	90	1.0556±.23034
PAI<1.15(L)	84	.6957±.18062
PAI<1.15(R)	85	.6616±.17025
SRT(Normal)(L)	84	9.1429±.95555

SRT(Normal)(R)	85	9.1412±.96242
Flatfeet(Left)	6	1.3600±.20179
Flatfeet(Right)	5	1.3420±.23931
SRT(Flatfeet Left)	6	9.0000±1.04881
SRT(Flatfeet Right)	5	9.0000±.93541



a b c d

Figure:4:Graph representing Correlation between a)SRT&BMI b)SRT&PAI(L)c)SRT&PAI(R)d)SRT&WHR

Table 4: Table representing the correlation and Interpretation

Correlation	**Pearson's coefficient**	**Interpretation**
PAI (Right)-SRT	-.116	Very weak Correlation
PAI (Left)-SRT	-.139	Very weak Correlation
BMI-SRT	-.617**	Very strong Correlation.
WHR-SRT	-.156	Very weak Correlation.
PAI<1.15 (L) -SRT(Normal)(L)	-0.129	Very weak correlation
PAI<1.15 (R) -SRT (Normal)(R)	-0.138	Very weak correlation
PAI>1.15 (L) -SRT (Flatfeet)(L)	-0.496	Moderate correlation
PAI>1.15 (R) -SRT (Flatfeet)(R)	-0.61	Very weak correlation

V.DISCUSSION

The present study was intended to find out the correlation between plantar arch index, BMI, WHR, with SRT among young sedentary adults aged 18-25 years and an assessment was done on the performance of SRT scored by subjects with normal medial arch and the subjects with decreased medial arch using PAI.

In the current study negative correlation was observed between BMI and SRT and Pearson's coefficient(r -0.617) was obtained that indicated very strong Correlation.

Our approach was similar to that reported by Gotmare et al where BMI and SRT had strong negative correlation(r= -0.5515).[43]

But when a correlation was conducted in a study by Roorda LD et al [48] no correlation was observed between the waist hip ratio and SRT. A different observation was observed in the present study where there was negative correlation between WHR and SRT with Pearson's coefficient r -0.156 which indicates very weak correlation.

In our study foot prints of the subjects were obtained. The classification of the foot was done using staheli plantar arch index. The values were categorized as PAI taken from Left and Right foot respectively. The Mean ±Standard deviation of PAI (Left) was 1.07±0.251 and PAI(Right) was 1.06±0.23.

The Foot prints were categorized into PAI<1.15 as Normal Feet, PAI>1.15 as Flat feet.

The Subjects foot prints were Categorized as Flat Feet and Normal feet of both sides, and the SRT was correlated to Individual type of feet(Normal, Flat)on both the sides(Left, Right)

Among 90 subjects only 6 subjects had Left side Flat feet with Mean ±Standard deviation of 13600±.20179 and only 5 subjects had Right Side Flat feet with Mean ±Standard deviation of 1.3420±.23931.The SRT scores scored amongst these subjects were collected.

Mean ±Standard deviation of 9.0000±1.04881 was seen in the SRT scores scored by subjects with Left Flat feet. And Mean ±Standard deviation of 9.0000±.93541 was seen in SRT score scored by the subjects with Right flat feet.

When Both sided Flat feet was correlated to the respective SRT scores, PAI>1.15 (L) was observed to be negatively correlated with SRT (Flatfeet)(L) with SRT Pearson's coefficient r-0.496 which indicates moderate correlation

And PAI>1.15 (R) was observed to be positively correlated with SRT (Flatfeet)(R) with SRT Pearson's coefficient r-0.61 which indicate very weak correlation.

Similar Procedure was followed for the foot prints that had Normal Arch (PAI<1.15).

Among 90 subjects, 84 subjects had PAI<1.15 on left side with Mean ±Standard deviation of .6957±.18062;and on right side A total of 85 out of 90 had Normal arch feet with Mean ±Standard deviation of 9.1429±.95555.

Mean ±Standard deviation of Normal Arched foot of left and right was observed to be .6616±.17025 and 9.1412±.96242 respectively.

When Both sided Flat feet was correlated to the respective SRT scores, PAI<1.15 (L) was negatively correlated with SRT (Normal) (L) with SRT Pearson's coefficient r-0.129 which indicate very weak correlation

And PAI<1.15 (R) is negatively correlated with SRT (Normal)(R) with SRT Pearson's coefficient r-0.138 which indicate very weak correlation.

VI.CONCLUSION

•The current study was intended to find the correlation of Plantar arch index ,BMI ,and WHR with SRT,and to assess the type of medial arch of foot and its significance in SRT.

•The result of this study showed that there exist a very weak correlation of PAI and WHR with SRT. And a strong correlation of BMI with SRT. Individual assessment of the foot arch through plantar arch index and its correlation to respective SRT scores revealed a range of very weak to moderate correlation with SRT.

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