IMMEDIATE CHANGES IN THE PLANTAR PRESSURE AFTER THE STRENGTHENING EXERCISES IN THE POPULATION HAVING FLAT FOOT: A RANDOMIZED CONTROLLED TRIAL

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Abstract

1.1.2 Background: Flatfoot, a common foot deformity, significantly impairs daily activities and quality of life by causing foot, ankle, and lower leg pain, especially with prolonged standing or walking. It leads to abnormal foot mechanics, altered gait, reduced mobility, and fatigue.

1.1.3 Objective: To investigate individuals with plantar pressure variations in their immediate response to the exercises through subgroup analysis, considering factors such as age, severity of flat feet, and other relevant participant characteristics.

1.1.4 Design: Single blinded randomized controlled trial.

1.1.5 Settings: Young adults with flatfeet, aged between 18-25 years.

1.1.6 Participants: A total of 40 participants were randomly assigned to either a strengthening exercises group (n = 20) or a control group with no intervention (n = 20), and all participants completed the study.

1.1.7 Main Outcome Measures: Average plantar reassure, maximum plantar pressure, centre of pressure, Clarke's angle, Staheli plantar arch index, Chippaux-Smirak index.

1.1.8 Results: The result of this study concluded a varied outcome regarding the acceptance and rejection of the null hypothesis across different variables. It suggests that strengthening exercises produce changeable effects compared to the control group. Specifically, there were significant differences observed in left average plantar pressure (LAP) $p < 0.002$ between the experimental group and control group. However, no notable distinctions were detected in left maximum plantar pressure (LMP), right maximum plantar pressure (RMP), and right average plantar pressure (RAP).

1.1.9 Conclusions: After performing 3 days strengthening exercise (SE) programme a variation in average plantar pressure observed. As a result, it can be inferred that integrating SE into regular routines is crucial for optimizing plantar pressure maintenance, reducing discomfort, minimizing injuries, aligning the feet, and ultimately enhancing the quality of life for young adults with flat feet.

1.1.10 Keywords: Foot posture, Flat foot, Plantar Pressure, Strengthening exercises, Win-track**.**

2.1 Background

Flatfoot (FF) a prevalent foot deformity globally, significantly contributes to common foot problems, impacting individuals' daily activities and quality of life. FF, also referred to as pes planus or plano-valgus foot, is a foot deformity characterized by a reduced medial arch height (1–3). The exact prevalence of FF remains uncertain due to inconsistent clinical examination practices; however, global studies estimate its prevalence to range between 5% and 57% across

different age groups. FF results from a combination of static and dynamic deformities (1) and is classified into three subtypes: rigid flat foot, flexible flat foot (FFF), and flexible flat foot with short tendo-Achilles (FFF-STA). FF can be congenital or develop over time (2).

Developmental FF is commonly observed in toddlers and may persist into adulthood without significant symptoms. Conversely, adult-acquired FF predominantly affects middle-aged individuals, presenting symptoms such as foot pain, reduced functionality, and foot malalignment (2). This condition can lead to disability, foot pain, and improper plantar pressure distribution (4). A primary aetiology of adult-acquired FF is the degeneration of the posterior tibial tendon (PTT) (5). Other contributing factors include pregnancy, obesity, foot injuries, PTT dysfunction, congenital anomalies, and arthritis (6). Individuals with FF often experience pain in the feet, ankles, and lower legs, which can be exacerbated by prolonged standing, walking, or physical activities (7). This pain can lead to altered gait patterns, decreased mobility, and fatigue, further affecting daily functioning and participation in routine tasks (8). Additionally, the improper distribution of plantar pressure (PP) associated with flatfoot can result in secondary complications such as knee, hip, and lower back pain, compounding the overall burden on individuals (5,9,10). Effective management of flatfoot and associated foot pain is crucial for maintaining an active and pain-free lifestyle, underscoring the importance of early diagnosis and appropriate therapeutic interventions.

Diagnosis of FF can be effectively conducted using various tools and methods, including the Foot Posture Index (FPI-6), footprint analysis, baropodometry (Win-track), and other physical examinations (10–12)

Recent studies have demonstrated that, strengthening exercises (SE) have emerged as a highly effective approach for managing flatfoot in contemporary clinical practice (13,14). These exercises target the intrinsic and extrinsic muscles of the foot, aiming to enhance arch stability and improve overall foot function. By focusing on muscle groups such as the posterior tibial, peroneal, and intrinsic foot muscles, strengthening exercises can help correct abnormal biomechanics and alleviate symptoms associated with flatfoot (4,14–16).

The main hypothesis of the present study was that there is a significant difference in the immediate changes in plantar pressure distribution between individuals with flat feet who

undergo targeted SE and those in the control group. Therefore, this study aims to analyze immediate changes in the PP after the SE in the population with FF.

3.1 Methods

3.1.1 Study design

The study was designed as a single blinded randomized control trial (RCT) registered on clinical trials (CTRI) with the trial number (CTRI/2024/03/xxxx66), was conducted between March-May 2024.The study followed the CONSORT guidelines (17).

3.1.2 Participants

The participants were recruited at the physiotherapy OPD. The patients were assessed in the researcher's room or in the laboratory, whichever was convenient for them.

3.1.3 Eligibility criteria

Inclusion criteria were population who was having flatfoot after the analysis with foot posture index (FPI). Both male and female population were included, age group 18-25-year-old and flexible and rigid both flat foot population were included, Informed consent was obtained from participants in writing. Exclusion criteria were Population below 18 years and above 25 years, people with lower limb fracture cases (last 3 months), population with Known case of diabetic neuropathy, any neurological problem, musculoskeletal problem like Osteoarthritis, Rheumatoid arthritis, Gout, etc.

3.1.4 Randomisation

Participants were randomized into two groups (Experimental group (EG) and control group (CG)). For randomization, the odd-even selection method was used. Randomization was performed after obtaining informed consent (Figure-2).

3.1.5 Ethical considerations

The research adhered to ethical principles outlined in the Declaration of Helsinki, and data handling complied with Organic Law 3/2018 on Personal Data Protection and Digital Rights.

Participants provided informed consent and the study was approved by the Institutional Ethics Committee (Registration no: EC/NEW/INST/2022/xxx0) on 15th October 2023.

3.1.6 Measurements

Demographic data were collected such as, age, gender, height, weight, body mass index (BMI), foot size. All the participants were assessed thoroughly and the plantar pressure (PP), Clarke's angle (CA), Staheli plantar arch index (SPI), Chippaux- Smirak index (CSI) measurements was recorded with the help of win-track (10) and foot print.

Average Plantar Pressure: Average plantar pressure refers to the average force applied to the sole of the foot during walking or other weight-loading activities. This is used to assess foot function, gait patterns, and to diagnose or monitor conditions affecting the feet.

Maximum plantar pressure: Maximum plantar pressure refers to the highest amount of force exerted on the sole of the foot during a specific activity, such as standing, walking or running. It provides valuable information about areas of high stress or potential injury risk on the foot.

Centre of pressure (COP): The COP is the point on the foot sole where the resultant force of all the pressure exerted by the body weight during standing or walking is concentrated. It represents the balance point of the applied forces and is used to analyze postural stability, gait patterns, and biomechanical characteristics of the foot during various activities.

CA: When the angle CA, which is formed by a line connecting the inner edge of the first metatarsal head to the heel and another line from the same metatarsal head to the highest point of the inner arch of the foot, measures below 41 degrees, it suggests the existence of FF (Figure-1) (18).

SPI: This ratio represents the relationship between the narrowest width of the middle of the foot and the widest width of the back of the foot. If there's FF, this ratio exceeds 0.8 (Figure-1) (19).

CSI: This ratio compares the narrowest width of the midfoot arch area to the widest width across the metatarsal bones. Based on CSI index, if someone is having flatfoot then the calculated number is <45 (Figure-1) (19).

After the baseline measurement (PP) exercise session were given and the same outcomes was recorded again after session, same was continued till three days for both the groups. CA, SPI and CSI were measured on the day-1 (pre-interventional) and on the last day (post-interventional).

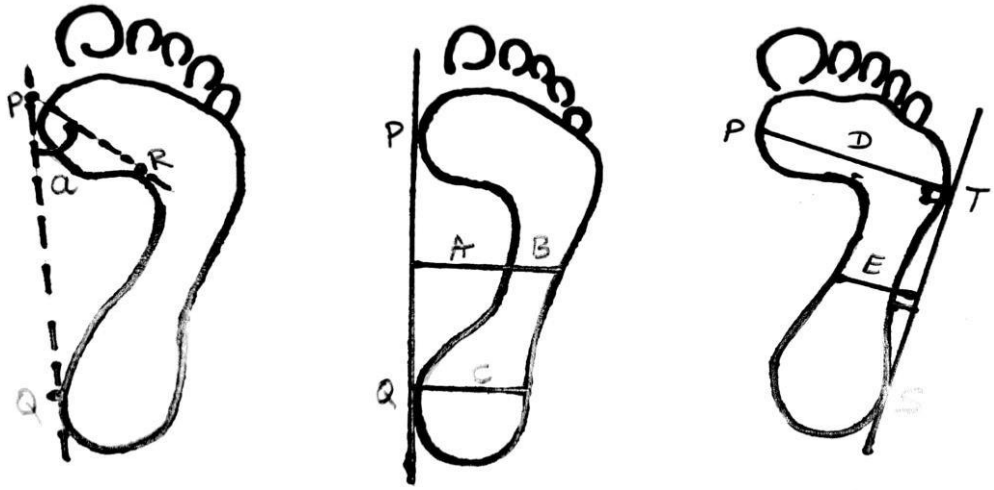

Figure 1: Foot print parameters a. Clarke's angle, b. Staheli Plantar arch Index, C. Chippaux smirak Index

3.1.7 Interventions

The intervention consisted of a 3-days SE programme performed for 60 minutes per session. The SE programme followed by the FITT principle including 10 exercises with 5 minutes of warm-up and cool-down period. The exercise session was conducted under the supervision of physiotherapist. The intervention for the EG consisted of 10 individual exercises (fanning of toes with inversion, heel strike with toe curl, heel raise and twist, ball hold and press, theraband pull, ball lifts, knee folds with ankle flexed, theraband pulling with inversion, toe dragging with inversion, fanning of toes with plantar flexion and toe curl). The CG didn't received any intervention and was advised to continue their routine daily activities. Same procedure was continued till three consecutive days for both the groups.

3.1.8 Data analysis

The statistical analysis was performed using IBM SPSS software, version 20. A descriptive analysis was conducted to assess demographic details such as age, height, weight, and BMI. Normality of the data was assessed using descriptive analysis, Z scores for skewness and kurtosis, and the Shapiro-Wilk test. For inferential statistical analysis, different approaches

were applied depending on the comparison. The Student T-test was used to compare means. Specifically, the Paired T-test was conducted for within-group comparisons to examine changes over time or conditions within the same group. Conversely, the Unpaired T-test was applied for between-group comparisons to analyze differences between distinct groups. Furthermore, for repeated measures analysis, ANOVA (Analysis of Variance) was utilized to check variations within and between groups across multiple time points.

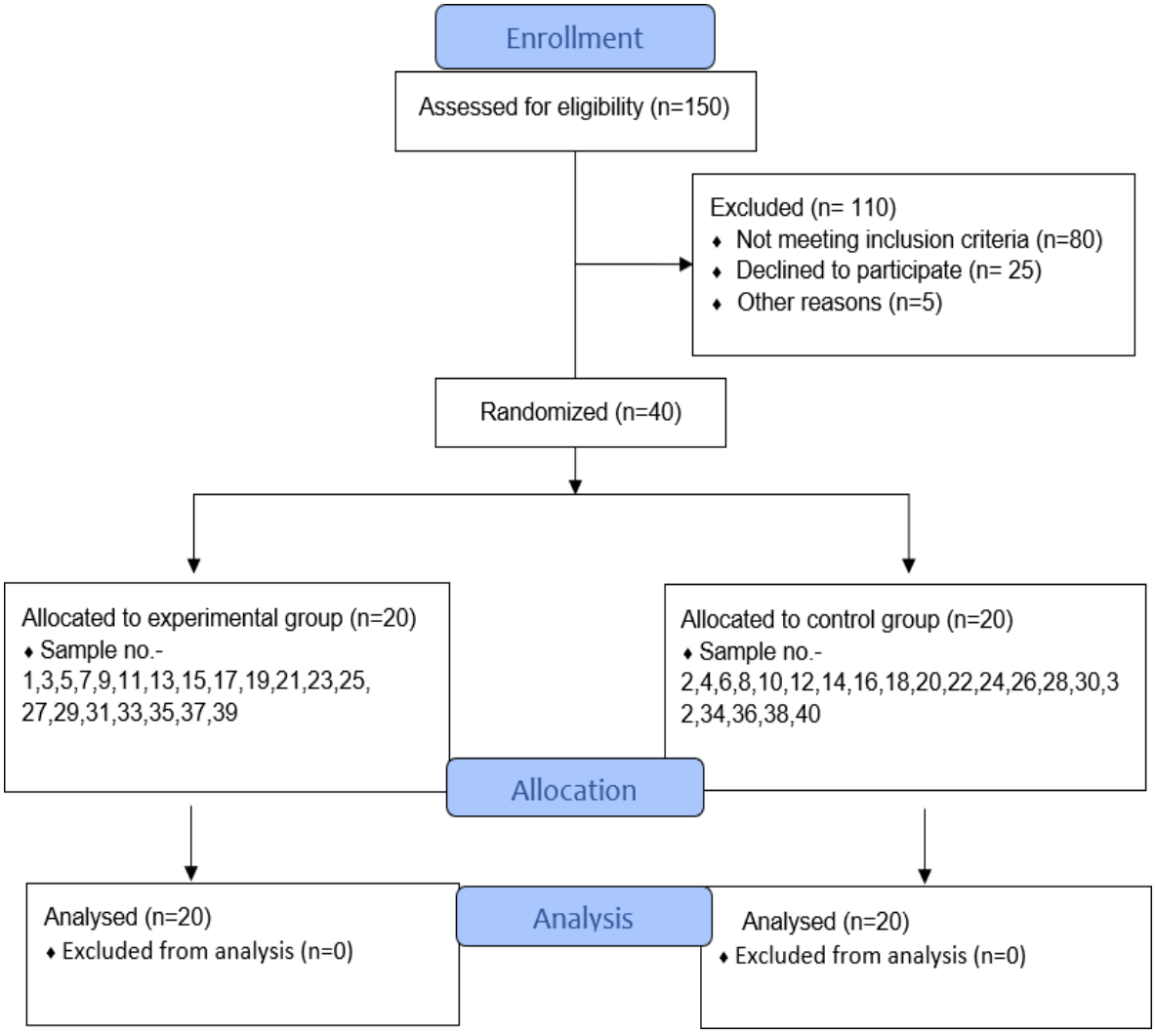

Figure 2: Flow chart of participant's allocation

4.1 Results

Selection of the sample of participants and sample size

According to G Power, an effect size of 0.30, a power of 0.80 and a significance rate of 0.05, the estimated required sample size was 352 participants, with 176 in each group. To account for a 10% dropout rate, an additional 35.2 participants were considered, bringing the adjusted sample size to 40 for the pilot study, with 20 participants in the EG and 20 in the CG.

4.1.1 Characteristics of the participants

Of the 40 participants included in this study in EG the mean and standard deviation (SD) for age, height, weight, BMI and foot size is 21.55 ± 1.84, 164.60 ± 7.41, 70.55 ± 11.25, 26.04 ± 3.78, 24.29 ± 1.77 and in CG 20.85 ± 2.34, 163.80 ± 9.53, 69.40 ± 14.42, 25.89 ± 4.87, 24.73 ± 1.74 (Table-1).

Table 1: Demographic characteristics of participants at baseline (n = 40)

S.NO	VARIABLES	EG (n=20) MEAN ± SD	CG (n=20) MEAN ± SD
1	Age	21.55 ± 1.84	20.85 ± 2.34
2	Height	164.60 ± 7.41	163.80 ± 9.53
3	Weight	70.55 ± 11.25	69.40 ± 14.42
4	BMI	26.04 ± 3.78	25.89 ± 4.87
5	Foot size	24.29 ± 1.77	24.73 ± 1.74

4.1.2 Outcome measures

Plantar Pressure:

In the study for EG and CG (within group) pre-and post-intervention assessments were taken for both left and right foot's PP variables, including area, maximum PP, average PP, thrust, and weight distribution. The mean and SD for area, maximum PP, average PP, thrust, weight distribution of both feet studied (table-2 & 3).

Table 2:Plantar pressure variables of experimental group

Experimental group (n=20) left plantar pressure variables						
variables	Day1 (mean±SD)		Day2(mean±SD)		Day3(mean±SD)	
	Pre	Post	Pre	Post	Pre	Post
Area	56.15±17.33	56.20±16.67	57.05±18.74	56.50±15.86	58.00±16.73	56.95±19.32
Max pressure	2052.90±438.56	1992.80±416.43	2087.85±492.75	1975.80±500.41	2012.80±472.90	2017.25±493.17
Average Pressure	780.55±155.91	764.15±144.84	794.15±173.22	843.10±158.58	770.70±151.69	795.70±197.66
Thrust	56.00±8.25	55.90±7.06	56.60±5.69	56.25±6.18	57.20±7.68	56.45±6.41
Weight Distribution	39.60±8.10	39.40±8.09	39.95±6.71	39.40±6.36	40.10±7.62	39.50±6.67
Experimental group (n=20) Right plantar pressure variables						
variables	pre	post	pre	post	pre	post
Area	47.65±14.41	47.95±14.80	49.45±18.31	49.85±17.66	49.65±14.98	49.45±13.43
Max pressure	1741.00±476.17	1729.70±488.38	1748.80±375.38	1640.40±298.44	1607.25±237.52	1719.30±340.88
Average Pressure	715.65±154.08	709.10±153.62	704.40±147.19	691.80±136.41	669.50±102.06	681.90±92.96
Thrust	44.00±8.25	44.25±7.06	43.40±5.69	44.15±6.57	42.80±7.68	43.85±6.99
Weight Distribution	31.95±6.99	37.95±4.74	39.05±8.78	31.55±8.08	30.20±7.09	30.80±7.12

Table 3: Plantar pressure variables of control group

Control group (n=20) left plantar pressure variables						
variables	Day1 (mean±SD)		Day2(mean±SD)		Day3(mean±SD)	
	pre	post	pre	post	pre	post
Area	48.9±18.19	52.85±16.27	51.40±18.81	55.40±18.10	51.65±14.28	49.20±14.25
Max pressure	2522.65±435.97	2464±623.40	2324.85±636.86	2251.45±523.43	2359.25±559.32	2253.00±519.21
Average Pressure	1007.95±162.40	962.60±232.09	946.40±216.16	868.60±189.45	982.70±207.74	942.55±196.60
Thrust	63.30±9.33	61.35±10.85	60.95±8.78	60.85±6.86	59.85±7.74	58.25±6.34
Weight Distribution	45.35±14.49	43.80±13.85	43.20±11.49	42.75±9.02	42.55±9.94	41.00±8.10
Control group (n=20) Right plantar pressure variables						
variables	pre	post	pre	post	pre	post
Area	37.35±16.22	40.00±16.83	41.55±18.04	45.95±18.13	43.55±20.49	44.25±15.43
Max pressure	1783.15±588.36	1802.35±471.33	1699.95±375.50	1620.40±341.49	1779.90±474.72	1780±448.21
Average Pressure	777.90±248.52	793.95±198.28	758.75±149.93	687.35±159.76	801.75±200.73	756.05±146.99
Thrust	36.70±9.33	38.65±10.85	39.05±8.78	39.15±6.86	40.15±7.74	41.75±6.34
Weight Distribution	25.90±8.91	27.45±10.16	28.10±9.67	28.55±10.20	28.60±9.43	30.30±10.26

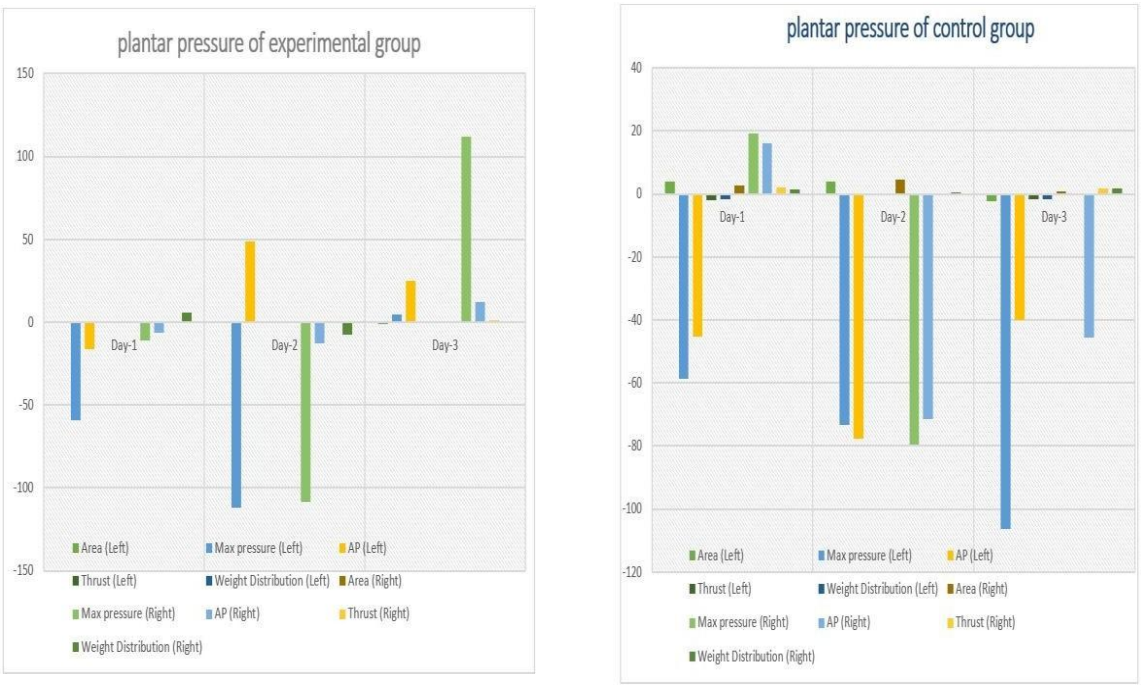

Figure 3: Graphical presentation of plantar pressure of experimental and control group

The PP details of all 20 subjects in the EG are presented with different colour coding, clearly indicating a notable enhancement in the mean PP of each participant. This suggests that strengthening exercises are effective in eliciting immediate alterations in certain PP variables. Conversely, the PP details of all 20 subjects in the CG show no noteworthy improvement in the PP of any participant included in the study (Figure-3).

In the study, we assessed various biomechanical variables including CA, SPI & CSI pre- and post-treatment in both the experimental and control groups (Table-4)

Table 4: Descriptive analysis of outcome measures of both groups

Variable	Exp				Control			
	Left		Right		Left		Right	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
clarke's angle	11.87 ± 6.18	14.55±6.34	13.35±5.63	15.86±7.14	14.87±7.90	14.25±7.49	16.22±7.917	15.65±7.970
staheli plantar arch index	1.05 ± 0.21	0.94±0.19	1.00±0.16	0.912±0.131	0.914±0.175	0.960±0.199	0.904±0.268	0.970±0.245
chippaux-smirak index	0.610 ± 0.114	0.556±0.094	0.616±0.109	0.570±0.103	0.596±0.199	0.612±0.137	0.569±0.197	0.577±0.149

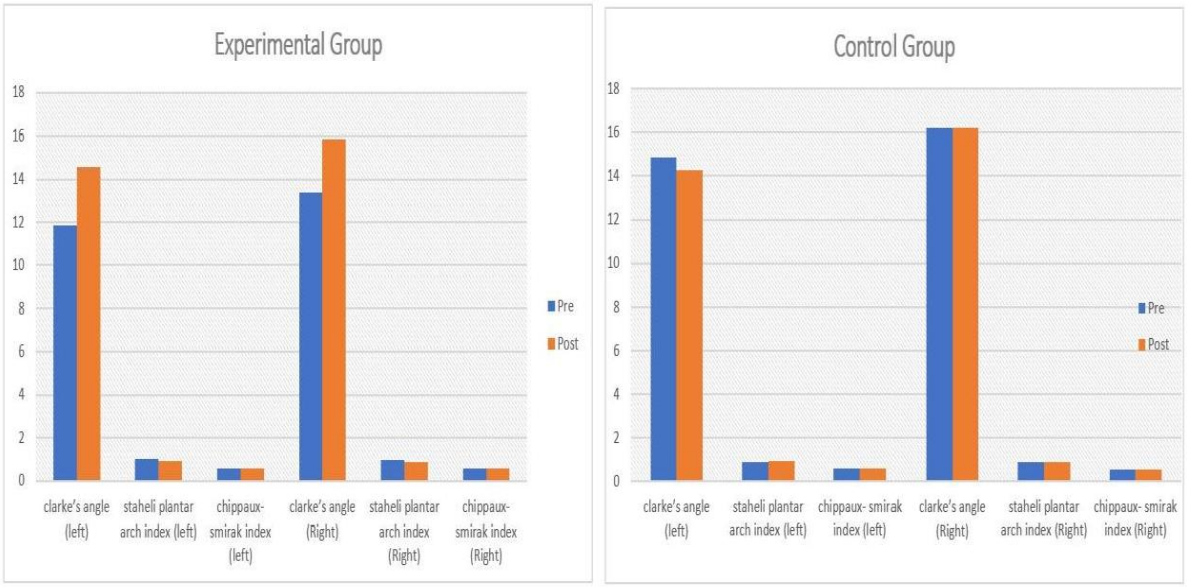

Figure 4: Graphical presentation of descriptive analysis of outcome measures of both groups from day-1 to day-3

The biomechanical change details for all 20 subjects in the EG are illustrated using different colour coding. The graph indicates significant improvements in the biomechanical variables (CA, SPI, and CSI) for each subject. Specifically, the CA value increased, while the SPI and CSI values decreased on Day-3 post-intervention compared to Day-1 pre-intervention readings. Conversely, in CG there is no changes observed in these variables (Figure-4).

A repeated measures analysis was conducted to compare the mean and SD of maximum and average PP of both the feet from dat-1 to day3 between EG and CG (Table-5).

Table 5: Repeated measure analysis between control group and experimental group

Variables	Group	Mean ± SD	Variables	Group	Mean ± SD
	Control	-58.1 ± 592.2		Control	-45.35 ± 233.1
	Experimental	-60.1 ± 380.2		Experimental	-16.4 ± 127.1
LMP1	Total	-59.1 ± 491.2	LAP1	Total	-30.875 ± 185.9
	Control	-73.4 ± 512.4		Control	-77.8 ± 173.2
	Experimental	-112.05 ± 468.8		Experimental	48.95 ± 170.01
LMP2	Total	-92.725 ± 485.2	LAP2	Total	-14.425 ± 181.1
	Control	-106.25 ± 503.7		Control	-40.15 ± 188.9
	Experimental	4.45 ± 441.7		Experimental	25 ± 155.4
LMP3	Total	-50.9 ± 471.00	LAP3	Total	-7.575 ± 173.9
	Control	19.2 ± 415.2		Control	16.05 ± 154.3
	Experimental	-11.3 ± 604.1		Experimental	-6.55 ± 167.3
RMP1	Total	3.95 ± 511.8	RAP1	Total	4.75 ± 159.3
	Control	-79.55 ± 333.03		Control	-71.4 ± 121.9
	Experimental	-108.4 ± 323.2		Experimental	-12.6 ± 102.9
RMP2	Total	-93.975 ± 324.2	RAP2	Total	-42 ± 115.3
	Control	0.8 ± 357.1		Control	-45.7 ± 137.3
	Experimental	112.05 ± 360.1		Experimental	12.4 ± 117.5
RMP3	Total	56.425 ± 358.5	RAP3	Total	-16.65 ± 129.5
Variables	Group	Mean ± SD	Variables	Group	Mean ± SD
	Control	-58.1 ± 592.2		Control	-45.35 ± 233.1
	Experimental	-60.1 ± 380.2		Experimental	-16.4 ± 127.1
LMP1	Total	-59.1 ± 491.2	LAP1	Total	-30.875 ± 185.9
	Control	-73.4 ± 512.4		Control	-77.8 ± 173.2
	Experimental	-112.05 ± 468.8		Experimental	48.95 ± 170.01
LMP2	Total	-92.725 ± 485.2	LAP2	Total	-14.425 ± 181.1
	Control	-106.25 ± 503.7		Control	-40.15 ± 188.9
	Experimental	4.45 ± 441.7		Experimental	25 ± 155.4
LMP3	Total	-50.9 ± 471.00	LAP3	Total	-7.575 ± 173.9
	Control	19.2 ± 415.2		Control	16.05 ± 154.3
	Experimental	-11.3 ± 604.1		Experimental	-6.55 ± 167.3
RMP1	Total	3.95 ± 511.8	RAP1	Total	4.75 ± 159.3
	Control	-79.55 ± 333.03		Control	-71.4 ± 121.9
	Experimental	-108.4 ± 323.2		Experimental	-12.6 ± 102.9
RMP2	Total	-93.975 ± 324.2	RAP2	Total	-42 ± 115.3
	Control	0.8 ± 357.1		Control	-45.7 ± 137.3
	Experimental	112.05 ± 360.1		Experimental	12.4 ± 117.5
RMP3	Total	56.425 ± 358.5	RAP3	Total	-16.65 ± 129.5

Note: LMP- Left maximum pressure, RMP- Right maximum pressure, LAP- Left average pressure, RAP- Right average pressure

In both groups we compare several biomechanical variables including CA, SPI, CSI between pre- and post-treatment in both the left & right foot. In comparison of CG and EG the mean and SD, mean difference, t-value and significant of LtMDCA is -0.62 ± 1.29, 2.68 ± 3.93, -3.31000, -3.571, 0.04 respectively. For RtMDCA the reading is -0.57 ± 1.11, 2.50 ± 5.55, -3.07500, -2.428, 0.02 respectively. For LtMDSPI the value is -0.04 ± 0.073, 0.10 ± 0.10, -0.15450, -5.404, 0.23 respectively. For RtMDSPI the reding is -0.03 ± 278, 0.09 ± 0.09, -0.12300, -1.867, 0.16 respectively. For LtMDCSI the value is -0.01 ± 0.10, 0.05 ± 0.06, -0.07000, -2.494, 0.39 respectively. For RtMDCSI the reading is -0.06 ± 0.13, 0.046 ± 0.067, -0.05200, -1.571, 0.36 respectively (Table-6).

Table 6: Comparison of outcome measures of both groups

Group	LtMDCA		RtMDCA		LtMDSPI		RtMDSPI		LtMDCSI		RtMDCSI	
	Control GRP	Exp Grp	Control GRP	Exp Grp	Control GRP	Exp Grp	Control GRP	Exp Grp	Control GRP	Exp Grp	Control GRP	Exp Grp
Mean ± SD	-0.62 ± 1.29	2.68 ± 3.93	-0.57 ± 1.11	2.50 ± 5.55	-0.04 ± 0.07	0.10 ± 0.10	-0.03 ± 0.28	0.09 ± 0.09	-0.01 ± 0.10	0.05 ± 0.06	-0.06 ± 0.13	0.05 ± 0.07
Mean Difference	-3.31000		-3.07500		-0.15450		-0.12300		-0.07000		-0.05200	
t	-3.571	-3.571	-2.428	-2.428	-5.404	-5.404	-1.867	-1.867	-2.494	-2.494	-1.571	-1.571
Sig	0.04		0.02		0.23		0.16		0.39		0.36	

Note- LtMDCA- Left mean difference Clarke's angle, RtMDCA- Right mean difference Clarke's angle, LtMDSPI- Left mean difference Staheli plantar arch index, RtMDSPI- Right mean difference Staheli plantar arch index, LtMDCSI- Left mean difference Chippaux-Smirak index, RtMDCSI- Right mean difference Chippaux-Smirak index

Pairwise comparisons between the two groups were conducted for the variables LMP, RMP, LAP, and RAP. For the experimental group, the mean differences, standard errors, and significance values were as follows 8.2, 113.503, 1, -17.3, 89.379, 0.848, -73.617, 30.22, 0.02, -31.433, 25.558, 0.226 respectively. For control group the values were 41.825, 98.828, 1, -17.3, 89.379, 0.848, 73.617, 30.22, 0.02, 31.433, 25.558, 0.226 (Table-7).

Table 7: Pairwise comparison between both groups

Variables	Group	Mean Difference	Std. Error	Sig.
LMP	Experimental	8.2	113.503	1
LMP	Control	41.825	98.828	1
RMP	Experimental	-17.3	89.379	0.848
RMP	Control	-17.3	89.379	0.848
LAP	Experimental	-73.617*	30.22	0.02
LAP	Control	73.617*	30.22	0.02
RAP	Experimental	-31.433	25.558	0.226
RAP	Control	31.433	25.558	0.226

Note- LMP-Left maximum pressure, RMP-Right maximum Pressure, LAP-Left average pressure, RAP-Right average pressure

5.1 Discussion

The findings of this study indicated that individuals with FF who underwent strengthening exercises as part of the intervention experienced an immediate change in the average PP. These results align partially with previous research highlighting the impact of strengthening exercises on PP among individuals with FF (20).

FF refers to a persistent foot condition marked by the decreasing of the MLA, united with hindfoot valgus and midfoot abduction in weight bearing position (4,14). In general, between 20- 30 % of people in the 18-to-25-year age range have the FF (21,22). To asses effectiveness of Shortfoot exercises in FF most of the study used Clarke's angle, Staheli plantar arch index, Chippaux-Smirak index and PP as an outcome measure (22,23).

In one of the study, systematic review, it is suggested that performing a greater than 5 weeks of continuous SE helps to improve in MLA in FF (14). Intrinsic and extrinsic muscle dysfunction are identified as contributing factors to the development of FF. So, primary goal in the rehabilitation of individuals with FF is to enhance the strengthening of the muscles that supports the medial arch (24). In an experimental study, it suggests that when it comes to enhancing the

intrinsic muscle activation of the MLA, the short foot exercise succeeds over the conventional group. people with flat feet showed enhanced foot intrinsic muscle activity after completing the 4-week short foot exercise program (21).

Pain, hypofunction, impaired PP distribution, disability and misalignment of static foot posture is very common in FF. In case of FF there is more chance of foot injury as compare to normal foot (4,25). Studies have recorded that static foot alignment was slightly but significantly corrected by SF exercise. It also helpful in Preventing foot injuries related to FF and improving windlass mechanism of the foot (25). They conduct this SF exercise RCT study for 8-weeks (25). Studies demonstrated that intrinsic muscle strengthening exercises supports MLA maintenance, decrease in pain, disability and maintain PP (4).

Strengthening exercises has been proven statistically significant in after 6-weeks of SFE, they observed that the midfoot's maximum plantar force increased significantly, while the forefoot and rearfoot's maximum plantar force remained the same(4). In studies it suggests that 3-8 weeks of SFE effective in decreasing pain, posture, PP and alignment of foot in case of FF (4,14,20–25). Though strengthening exercises are effective in FF condition. It will, in turn, decreases the prevalence of FF in young adults respectively. Also, it presents no adverse effects in contrast to alternative interventions such as surgery or orthoses, thereby enhancing individuals' quality of life. From an economic standpoint, strengthening exercises prove advantageous, as they are up-front, easily understandable, and demand only initial guidance from a physiotherapist, after which they can be self-administered at home without the need for costly equipment, unlike lifelong interventions.

6.1 Limitations

While this study provides evidence-based intervention for FF treatment, it does have limitations.

Firstly, the sample size could be seen as a constraint, although it was determined using statistical methods, suggesting potential for future exploration in larger samples.

Secondly, the study's duration, limited to three days, may also be viewed as a limitation, indicating the need for longer-term investigations.

7.1 Clinical Implication

For the young adults who don't want to take the medication, go for surgery and orthoses this study will give an alternate treatment with good result to them. Moreover, it does not require costly or specialized equipment for implementation in clinical settings and can be easily replicated in various environments, including clinics or homes.

When appropriately customized, this intervention can be extended to individuals of all age groups capable of actively engaging in muscle-strengthening exercises, thus helping in the prevention of foot injuries, pain, disabilities and maintain PP.

8.1 Recommendations

There is a lack of literature regarding the immediate effects of strengthening exercises on PP in FF conditions, highlighting the need for further research to explore the impact of various interventions on plantar pressure in FF cases.

Although a long-term interventional study was not feasible in our investigation, future studies could explore prolonged treatment sessions to observe immediate changes in plantar pressure.

Also, comparative studies between physiotherapy and surgical interventions could be pursued, and with advancements in physiotherapy techniques, research could investigate the effects of different exercise regimens.

9.1 Conclusion

Flat feet are a prevalent foot condition that significantly impacts an individual's quality of life, emphasizing the importance of prevention over cure. This research proves that administering strengthening exercises to young adults with FF yields positive effects on certain PP variables. Consequently, this study offers valuable insights to clinicians regarding the efficacy of strengthening exercises in alleviating FF symptoms. Strengthening exercises also play a vital role in preserving PP, enhancing foot posture, and preventing flat foot-related injuries. As a result, it can be inferred that integrating SE into regular routines is crucial for optimizing PP maintenance, reducing discomfort, minimizing injuries, aligning the feet, and ultimately enhancing the quality of life for young adults with flat feet.

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