

Immediate Effects of Silicone Arch Support Insoles on Postural Balance in Children with Flexible Flat Feet

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Abstract

Background and purpose: Flexible flat feet in children results in disappearance of medial longitudinal arch during weight bearing that again reappears when they stand on their toes or heels. Orthotic insoles or arch supports are frequently used treatment to normalize foot mechanics and relieve pain. However, literature support for quantifying the efficacy of silicone arch support insoles on postural balance in children with flexible flat feet is scarce. Aim of this study was to check and compare the immediate effect of silicone arch support insoles on postural balance in children with flexible flat feet. **Methods:** Thirty children (17 boys & 13 girls of age 11.63 ± 2.57 years, height 145.36 ± 23.58 cm and weight 41.56 ± 12.71 kg) with bilateral flexible flat feet were instructed to use silicone arch support insoles with shoes. The balance test was performed in three sessions by HUMAC[®] Balance & Tilt System. Level III and a time period of 60 seconds were maintained for all parameters of center of pressure (CoP) and dynamic stability following standard operational protocol. Paired t-test was used to analyze the difference between pre and post orthotic conditions. **Results:** There is a significant improvement in stability ($p < 0.04$) and mobility ($p < 0.001$) scores whereas path length ($p = 0.66$) and average velocity ($p = 0.55$) showed statistical non-significant values. However, minor improvements were observed with the use of silicone arch support for all tested parameters. **Conclusion:** Silicone arch support has immediate beneficial effect in improving static and dynamic balance in children with flexible flat feet. A long term evaluation of its efficacy is warranted to validate the findings.

Keywords

Arch Support, Balance, Center of Pressure, Flat Feet, Silicone

1. Introduction

The foot serves as an engineering marvel that supports body weight, adapts to variety of terrain and improves efficiency of walking through arch and beam mechanism [1]. Usually longitudinal arch develops around 3 to 5 years of age and completes before the age of 10 while critical age being 6 years [2]. Children with flatfeet present with a

depressed medial longitudinal arch and pronated subtalar joint during weight bearing. Flexible flatfoot is unlikely to develop after 7 to 9 years of age. This information guides clinicians to make decisions for orthotic therapy to improve foot mechanics and relieve pain [3]. Many studies have been performed on the use of foot orthoses [4-7], insoles [8-11], UCBL shoe inserts [12, 13] and supra-mallolar orthoses [14] for flat feet. The efficacy of these orthoses was evaluated primarily in terms of pain reduction, gait and foot (talo-calcaneal and tarso-metatarsal) angle measurements. With the advancement in polymer technology, silicone and its variant has been evolved and used in medical sciences for its enhanced material properties. Few studies [15, 16] have focused on the effect of the silicon insole on gait and other parameters. To authors' knowledge, no studies on the efficacy of silicone arch supports insoles on posture and balance in children with flexible flat feet were found in the literature. The aim was to evaluate an immediate effect of silicone arch support insole on postural balance in children with flexible flat foot and to check whether improvement of balance parameters follows similar trend with posture. We hypothesized that use of silicon insole would improve postural balance compared to bare foot in children with flexible flat foot.

2. Materials and Methods

2.1. Subjects

Thirty children (17 boys, 13 girls) with bilateral flexible flatfoot were included in the study. The mean age of 11.63 ± 2.57 years, height 145.36 ± 23.58 cm and weight 41.56 ± 12.71 kg was recorded. Severity of flatfoot was diagnosed by navicular drop test. The children with radiographic measurements of lateral talus-first metatarsal angle less than 30 degrees [17] and talonavicular uncoverage of less than 30 percent [18] were included to exclude severe flatfeet. None were overweight and had a history of foot and ankle surgery, use of foot orthoses, trauma, or inflammatory joint disease.

2.2. Silicone Arch Support and Instrumentation

Silicon arch support (Figure 1) of appropriate size was chosen and placed over the insole within the shoe to improve the weight bearing pattern of children. It was placed 1/2 against the insole and 1/2 against the side wall of the shoe, pointing the wider and narrow part of arch towards the toe and heel areas respectively. Balance test was performed in three sessions by HUMAC® Balance & Tilt System (CSMi, Stoughton, MA).

2.3. Data Analysis

Raw data were exported from HUMAC® Balance & Tilt System into Microsoft Excel, and data analysis was performed in SPSS version 23.0 (SPSS Inc, Chicago, Illinois). Paired t test was used to analyze the difference between orthotic and non-orthotic conditions (shoes only) and p-value < 0.05 was considered for statistical significance.



Figure 1. Silicone arch support used for the study.

2.4. Procedure and Protocol

This research followed guidelines of the Declaration of Helsinki and was approved by the Institutional Review Board of SVNIRTAR, India. The informed consent was obtained from the individuals or their parents prior to their participation in this study.

After initial assessment and evaluation, the demographic data like age, gender, height and weight were recorded. The tip toe test was performed to check the flexibility of the flat feet condition. The children were instructed to use silicone arch support insoles with shoes and the balance test was performed in three sessions by HUMAC® Balance & Tilt System (Figure 2). The average of three sessions was considered for analysis. Level III and a time period 60 seconds were maintained for all parameters following standard protocol of the instrument. Tests were performed in eyes open conditions and data was recorded for bipedal static posture with shoes. The static and dynamic stability were recorded for parameters like: CoP (stability, path length, average velocity) and dynamic stability. Comparison of balance parameters were made between orthotic and non-orthotic conditions (shoes only) on immediate basis.

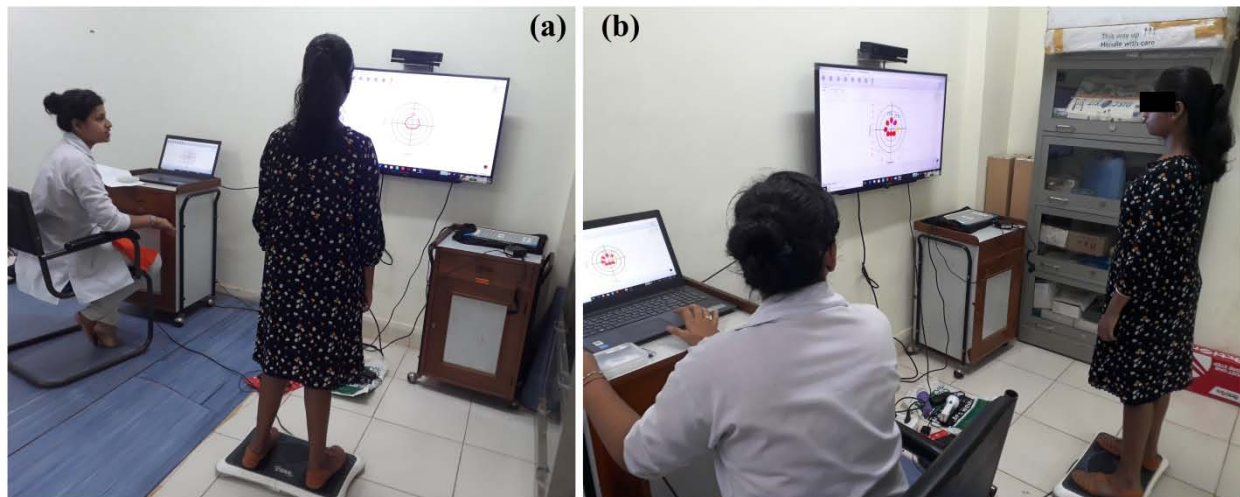


Figure 2. Balance Evaluation by HUMAC® Balance & Tilt System (a) Static (b) Dynamic conditions.

3. Results

The results of balance parameters are presented in Table 1.

Table 1. Comparison of Postural Balance parameters

Parameters	Silicone Arch Support and Shoes	Shoes Only	p value
Stability Score (%)	89.13±3.56	87±9.32	0.04 ^(S)
Path Length (cm)	76.09±22.56	78.64±37.15	0.66
Average Velocity (cm/s)	1.31±0.30	1.36±0.58	0.55
Mobility Score (%)	84.2±11.23	76.36±6.43	0.001 ^(S)

^(S) indicates statistical significant

3.1. Stability Score

The mean of stability score (%) with shoe only (87±9.32) was found to be lower than that with silicone arch support and shoe insole (89.13±3.56). This parameter shows statistically significant difference between these two conditions in favor of silicone arch support ($p < 0.05$).

3.2. Path Length

The mean of CoG path length (cm) without silicone arch support and shoe insert (78.64±37.15) was found to be higher than with it (76.09±22.56). However, this parameter did not show statistically significant difference between

with and without silicone arch support insoles ($p > 0.05$).

3.3. Average Velocity

The mean of average velocity of CoG (cm/s) with shoe only (1.36 ± 0.58) was found to be slightly higher than that with silicone arch support and shoe insole (1.31 ± 0.30). However, this parameter did not show statistically significant difference between with and without silicone arch support ($p > 0.05$).

3.4. Mobility Score (Dynamic Stability)

The mean of mobility score (%) without silicone arch support and shoe insert (76.36 ± 6.43) was found to be slightly lower than with it (84.2 ± 11.23). This parameter showed statistically significant difference between these two conditions in favor of silicone arch support insoles ($p < 0.05$).

4. Discussion

Balance is an ability to maintain the line of gravity of a body within the base of support with minimal postural sway. Earlier studies have reported that flatfeet might induce a loss of balance [19]. CoP is one of the kinetic-related variables which can present the whole body balance dynamics. CoP has been used to characterize static stability. Specifically, its speed has been used to indicate the extent of sway moment during a task and has been suggested as the most sensitive CoP variable for detecting the extent of sway [20]. This study was aimed at checking the immediate effect of silicon arch support insoles on postural balance in children with flexible flat foot. The results show significant improvement in stability and mobility scores (%) whereas the values for path length and average velocity of CoG were statistically non-significant, although minor improvements were observed in the mean values while wearing silicon arch support insoles.

In this study, the stability score showed statistical significant improvement while using silicone arch support ($p < 0.05$). Similar results were also obtained by Jafarnezhadgero et al. who found that arch support insoles improve the stability during walking in individuals with flatfoot [21]. But in contrast to this study, Nezhad et al. using force plate for selected kinetic variables found average time of achieving stability has no significant difference between normal and flat feet sole, either with use of insole also [16]. In spite of statistical non-significant difference in CoP average velocity, the use of silicone arch support insoles resulted in mean reduction values. However, studies conducted by Lee et al. [22] and Tahmasebi et al. [23] found statistically significant reduction in the CoP sway velocity in a unilateral stance and standing with and without insole ($p < 0.05$). This contradicting result might be due to the fact that the children recruited in our study were not given sufficient acclimatization period to get familiar with the insole use and we evaluated its immediate effects. Similar trend was observed for CoP path length too in our study. Though it was slightly higher without silicone arch support insole, the differences were not statistically significant. Tahmasebi et al. [23] found analogous results and their mean values of CoP excursion did not differ significantly between standing with and without insole ($p = 0.34$). The mobility score showed statistical significant difference ($p = 0.001$). Rome and Brown [25] in a randomized controlled trial compared foot orthoses to shoes alone and found significant reduction in medial-lateral sway (32% improvement) after 4 weeks; however, Olmsted & Hertel [24] in contrast observed no improvement in the dynamic balance with custom fit foot orthoses for flatfoot ($p > 0.05$). In a recent study, Fattahi et al. [26] found conflicting results. They observed an improvement in dynamic balance in adolescents with flat foot using medical insoles, but it has no effect on static balance ($p = 0.10$). The differences between the results of various studies are a result of the variation in methods (static or dynamic balance analysis) and material of the insole being used. It is also apparent that the rigidity of orthoses might affect postural stability in those with flatfoot.

There was minimal excursion of CoP path indicating higher balance and maintenance of posture while standing with silicone arch support insole compared to shoes alone (Figure 3). Instead of being independent in direction, the subject demonstrated larger medio-lateral sway compared to antero-posterior direction (Figure 3a, 3b).

Earlier studies have shown efficacy of orthotic intervention using other parameters. Chang et al. [27] found that a full-length insole resulted in a 47% reduction in forefoot plantar peak pressure after 4 weeks. Similarly Bonanno et al. [28] noticed that a silicon heel cup may reduce the heel pressure by 29%. Miller et al. [29] found reduction in vertical and antero-posterior ground reaction forces in the early stance phase of gait cycle using a rear foot orthotic device. Kuhn et al. [30] investigated the effect of a custom-made flexible orthosis on the bone alignments in patients with flexible flatfoot by radiographic measurement of antero-posterior and lateral talo-calcaneal angles. Jafarnezhadgero et al. [31] evaluated the long term application of foot orthoses in a randomized controlled trial. They

found significant improvements in weight bearing foot alignment, kinematics and kinetics of gait including maximum posterior and vertical GRF in boys aged 8-12 years with flexible flatfeet compared to a sham condition.

Previous study reports are controversial and results are inconsistent. However, use of foot orthoses, in general has positive effects on gait, balance, posture, plantar pressure distribution and radiographic findings in children with flexible flat feet. Limited sample size, study area and acclimatization time period given for data collection may limit the generalizability on efficacy of silicone arch support insoles in children with flexible flat feet. In addition, how does the silicone arch support insoles change course of flatfoot need to be evaluated through a longitudinal study.

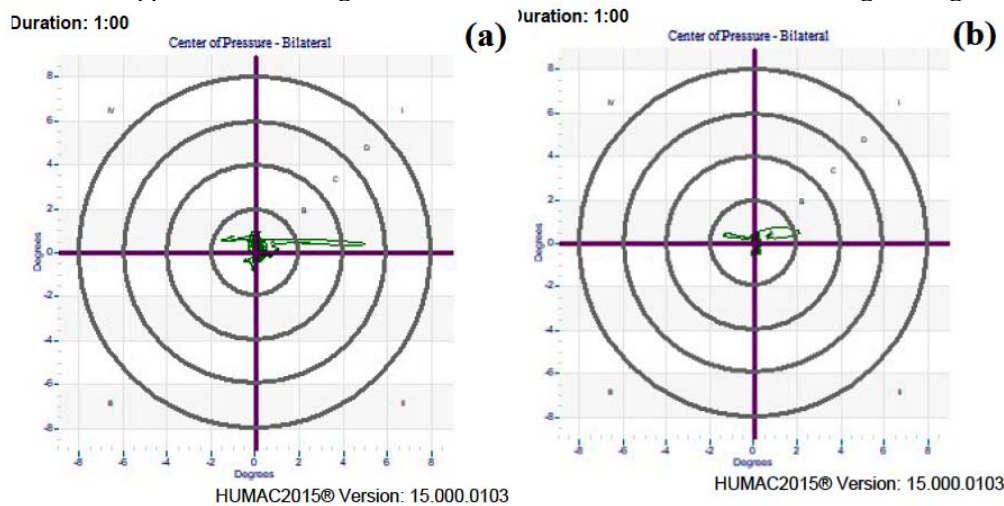


Figure 3. CoP trajectory static balance (a) bilateral standing shoes only (b) bilateral standing with silicone arch support insole.

5. Conclusion

Silicon arch support insoles improved the postural balance in children with flexible flat feet in general. It has immediate beneficial effect in stability and mobility scores, however, average velocity and path length of CoP showed statistical non-significant findings. The application of silicone arch support insoles may be used as an established and recommended therapeutic management for children with flexible flat feet.

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