



ISSN Print: 2394-7500  
ISSN Online: 2394-5869  
Impact Factor: 8.4  
IJAR 2021; 7(8): 123-127  
[www.allresearchjournal.com](http://www.allresearchjournal.com)  
Received: 28-06-2021  
Accepted: 30-07-2021

**Rutuja Kate**  
Intern, PES Modern College of  
Physiotherapy, Pune,  
Maharashtra, India

**Dr. Shrikant Mhase**  
Assistant Professor, PES  
Modern College of  
Physiotherapy, Pune,  
Maharashtra, India

**Dr. Sucheta Golhar**  
Principal, PES Modern College  
of Physiotherapy, Pune,  
Maharashtra, India

**Corresponding Author:**  
**Rutuja Kate**  
Intern, PES Modern College of  
Physiotherapy, Pune,  
Maharashtra, India

## Immediate effect of short foot exercise on dynamic balance in elderly population having excessively pronated foot: An experimental study

**Rutuja Kate, Dr. Shrikant Mhase and Dr. Sucheta Golhar**

DOI: <https://doi.org/10.22271/allresearch.2021.v7.i8b.8838>

### Abstract

**Purpose:** Balance is one of the most essential aspects required in activities of daily living in all individuals. Due to ageing various factors interplay and result in compromised balance leading to increased falls. Feet acts as a support base and any deficits in structure of foot may lead to increased incidents of falls in elderly population. This study aims to study the immediate effect of short foot exercise on dynamic balance in elderly population having excessively pronated foot.

**Subjects:** This study included 41 male & female (65 years and above) subjects with excessively pronated foot selected using inclusion and exclusion criteria.

**Method:** The written consent of all the participants was taken. The test was explained to each participant to evaluate dynamic balance before SFE. Participants were explained the SFE protocol and performed first in sitting then in standing position. After SFE, SEBT was done to note the difference in excursion values.

**Result:** After the SFE, values on SEBT increased significantly in all directions. The two tailed p-value was <0.0001 which is considered statistically extremely significant.

**Conclusion:** The study concludes that there is an immediate effect of SFE on dynamic balance in elderly population having excessively pronated foot. Subsequent studies will be conducted to see the time limit for which effect lasts after intervention.

**Keywords:** short-foot exercise, dynamic balance, excessively pronated foot, elderly population

### 1. Introduction

Ageing is a fundamental process that affects all our systems and tissues. Various physiological changes in all the systems of the body takes place with ageing.

The physiological changes in musculoskeletal, nervous, vestibular, and visual systems interferes with balance and stability & may increase the risk of fall. [1] Balance or Postural control is a generic term used to describe the dynamic process by which the body's position is maintained in equilibrium.

Balance is a complex motor task involving interaction of nervous, musculoskeletal & contextual effects. Interplay of joint ranges, joint integrity, muscle performance, sensations is required for maintaining balance [2].

The feet are placed at the farthest point and acts as the support base. Any deficits in foot posture, flexibility, strength, or sensation impair the support function of the foot and predispose to loss of balance (Dong-chul M, 2014) [1].

Pes planus/ flat foot/ excessively pronated foot is a condition with decreased medial longitudinal arch (MLA) and pronation of hindfoot [2].

Pronation is a complicated triplanar motion of the foot. It is a critical motion that contributes to shock absorption from ground reaction forces and to the attenuation of the forces transmitted to the body during normal gait.

Even minor biomechanical alterations in the support surface may influence postural-control strategies. When the arch starts collapsing, balance is broken at the feet, & therefore the balance throughout the entire body is also broken.

If the foot has a pronated structure it can affect proprioceptive inputs through the movement of joints, changes in the contact area, and muscle strategy for maintaining the stability of the support base, thus compromising the balance (Dong-chul M, 2014) <sup>[1]</sup>. 72% elderly population have excessively pronated & pronated foot. (Sayali T 2019) <sup>[8]</sup>

Thus, having an excessively pronated foot adds up in the risk of fall in elderly Population <sup>[4]</sup>.

Short foot exercises (SFE) are performed to activate & strengthen the foot intrinsic muscles and helps shortening of MLA by pulling the metatarsal heads toward the heel, while the long toe flexors are relaxed. (Do-Young, 2011) <sup>[3]</sup>

SFE is also the first step in sensory motor training (proprioceptive training) and can improve proprioception and postural stability if applied along with other exercises (Dong-chul M, 2014) <sup>[1]</sup>

The aim of this study was to study the immediate effect of short foot exercise on dynamic balance in elderly population having excessively pronated foot.

## 2. Need of Study

- Balance is a process through which the center of gravity is maintained by the body's support base, and it has been measured by measurement of lower extremity function.
- It is a vital component for normal gait. A small dynamic change in the foot, i.e., the support base, could affect the postural control of the entire body. Excessive subtalar joint pronation; in the case of flat feet, instability and damage to the lower extremity cause hypermobility and passive instability.
- Prevalence of excessively pronated & pronated feet in elderly population is 72% <sup>[8]</sup>.
- There are many studies which prove Dynamic balance is affected in pes planus. Therefore, they are more prone to falls due to compromised balance <sup>[5]</sup>.
- Thus, if short foot exercises are proved to have an immediate effect on dynamic balance can be performed prior to other forms of exercises to increase stability.
- There are many studies done on the long term effect of short foot exercises but very few on immediate effects.
- Therefore, it is important to study the immediate effect.

## 3. Aim

To study the immediate effect of short foot exercise on dynamic balance in elderly population having excessively pronated foot.

## 4. Objectives

- To assess pre and post-intervention dynamic balance using Star Excursion Balance Test (SEBT)
- To study the immediate effect of Short Foot Exercises on dynamic balance in elderly population having excessively pronated foot using the Star excursion balance test.

## 5. Review of Literature

Dong-chul Moon, PT, MS1), Kyoung Kim, PT, PhD1)\*, Su-kyoung Lee, PT, PhD2) Immediate Effect of Short-foot Exercise on Dynamic Balance of Subjects with Excessively Pronated Feet. Journal of Physical Therapy Science.2014; 26(1): 117–119.

[Conclusion] SFE immediately improved the dynamic balance of subjects with excessively pronated feet. Subsequent studies will be conducted to examine the effects of SFE performed over the long term on postural stability.

Do-Young Jung a, Moon-Hwan Kim b, Eun-Kyung Koh c, Oh-Yun Kwon d,\*, Heon-Seock Cynn e, Won-Hwee Lee A comparison in the muscle activity of the abductor hallucis and the medial longitudinal arch angle during toe curl and short foot exercises. Physical Therapy in Sport 12.(2011); 12: 30-35

Conclusions: These results suggest that SF exercise is a more useful strengthening exercise than TC exercise in activating the AbdH muscle.

Eun-Kyung Kim, PT, PhD1), Jin Seop Kim, PT, PhD2)\* The effects of short foot exercises and arch support insoles on improvement in the medial longitudinal arch and dynamic balance of flexible flatfoot patients.

[Conclusion] In the present study, it could be seen that to improve flatfoot, applying short foot exercises was more effective than applying arch support insoles in terms of medial longitudinal arch improvement and dynamic balance ability.

Banu Unver, PhD, PT1 Emin Ulas Erdem, Assist Prof, PhD, PT1 Eda Akbas, Assist Prof, PhD, PT1 Effects of short foot exercises on foot posture, pain, disability and plantar pressure in pes planus. Journal of Sport Rehabilitation.2019; Vol. 29: 436–440

Conclusions: Six-week short-foot exercises provided a reduction in navicular drop, foot pronation, foot pain and disability, and increment in plantar force of medial midfoot in pes planus.

## 6. Methodology

Sample size: 41

Study setting: Hospital OPDs, Old Age homes in and around the city.

Study design: Experimental study

Sample method: Purposive sampling

Study population: Male and females 65 years & above.

Study duration: 6 months.

## 7. Criteria

### Inclusion Criteria

- Individuals with excessively pronated foot (navicular drop  $\geq 10$  mm). Age 65 year & above old male & females.

### Exclusion Criteria

- Individuals having neurological or vestibular dysfunction/disorders.
- Any Pathological condition.
- Individuals using assistive aids for gait.
- Inflammatory joint diseases like RA (foot joints involvement).
- Great toe deformities.
- Any recent fracture, trauma of lower limb.(past 6 months)
- History of any surgery of the lower limb.
- Impaired auditory, vision &/or Cognition.
- Limb length discrepancy.

## 8. Materials and Tools

- Pen
- Paper

- Chair /low height stool

**9. Outcome Measures**

Star excursion balance test: Reliability ICC - 0.91 to 0.95  
 The SEBT was performed with the participants standing in the middle of a grid formed by eight measure tapes extending out at 45° from each other.  
 The participant were asked to reach as far as possible along each of the eight measure tapes, make a light touch on the tape, and return the reaching leg back to the center, while maintaining a single-leg stance with the other leg in the center of the grid. Test will began with the anterior direction and progressed clockwise around the grid.  
 All participants began with a right stance leg in the center of the grid. Three trials in the eight directions were allowed, before the test 5-min rest period was given [5]. The distance from the center of the grid to point of maximum excursion by the reach leg was recorded.

**Short Foot Exercise (SFE)**

- To perform SFE, participants were requested to elevate the medial longitudinal arch, shorten the foot in the anterior-posterior line, and to approximate the first metatarsal head toward the heel without toe flexion.
- Elevated MLA position was maintained for 5 seconds in each repetition. First Participants performed the exercise sitting and then standing (stance) 3 sets of 15

repetitions in sitting and standing were performed for both legs [6].

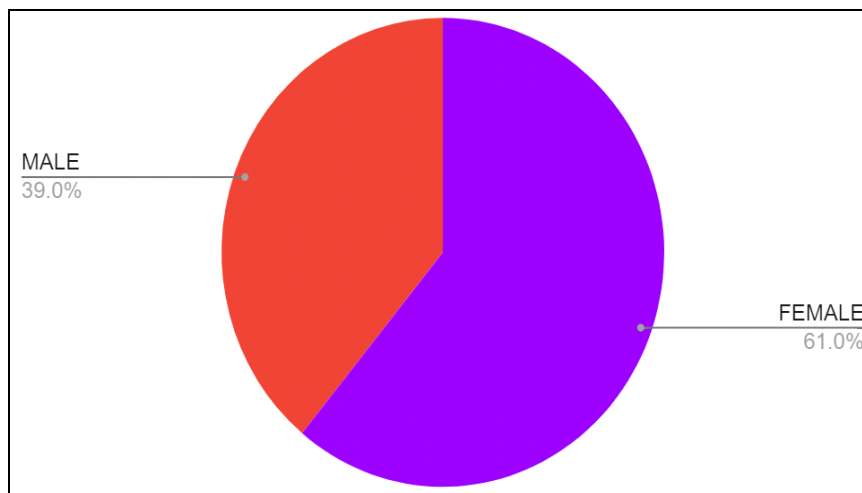
- Two minutes of rest was allowed after every set.

**10. Procedure**

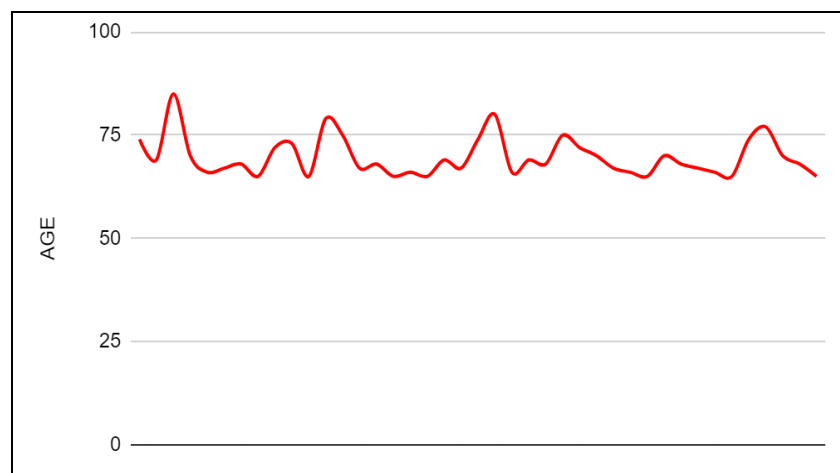
- The study was started with a synopsis presentation to an ethical committee of P.E.S Modern College of Physiotherapy.
- Ethical clearance was obtained from the ethical committee
- Participants were selected according to inclusion and exclusion criteria
- Participants were explained about study and consent form was taken
- Pre intervention SEBT was done and they received SFE for both feets and post intervention SEBT was noted.
- Data was collected and analysed.

**11. Data Analysis**

- Dynamic balance of both limbs was assessed Pre and Post Intervention using Star Excursion Balance Test Average distance of limbs in each direction was measured.
- Data was entered in Microsoft Excel spreadsheet, tabulated.
- The data was then subjected to statistical analysis using Paired t-test on Graphpad prism software.



Gender Distribution



Age Distribution

## 12. Statistical Analysis

- The data was collected pre and post intervention on SEBT.
- The mean of average distances in 8 directions of both legs was compared.
- The statistical test used was paired t- test in pre and post values.

**Table 1:** SEBT for right limb mean of each direction pre and post SFE.

		Right mean			
		PRE ± SD	POST ± SD	T value	P value
1	Anterior	54.87 ± 5.31	55.79 ± 5.44	t=9.936	0.0001
2	Anterolateral	53.64 ± 4.92	54.48 ± 5.20	t=9.936	0.0001
3	Lateral	49.07 ± 6.22	50 ± 6.37	t=4.432	0.0001
4	Posterolateral	39.64 ± 7.52	44.71 ± 7.65	t=28.49	0.0001
5	Posterior	32.71 ± 6.63	37.35 ± 5.55	t=10.40	0.0001
6	Posteromedial	35.8 ± 6.44	40.6 ± 6.41	t=21.92	0.0001
7	Medial	46.46 ± 6.04	47.47 ± 5.99	t=8.186	0.0001
8	Anteromedial	53 ± 5.73	53.94 ± 5.76	t=8.108	0.0001

**Table 2:** SEBT for left limb mean of each direction pre and post SFE.

		LEFT			
		PRE ± SD	POST ± SD	T value	P value
1	Ant	54.6 ± 5.40	55.41 ± 5.63	t=8.654	0.0001
2	Al	52.83 ± 5.18	53.96 ± 5.26	t=9.941	0.0001
3	Lateral	48.39 ± 6.03	49.56 ± 6.03	t=6.085	0.0001
4	Pl	39.6 ± 7.19	44.73 ± 7.46	t=22.75	0.0001
5	Posterior	32.23 ± 6.75	37.32 ± 6.68	t=31.43	0.0001
6	Pm	36.98 ± 6.68	41.24 ± 6.19	t=13.56	0.0001
7	Medial	45.59 ± 6.32	47.54 ± 6.20	t=4.553	0.0001
8	AM	53.06 ± 5.66	54.06 ± 5.54	t=6.503	0.0001

## 13. Results

The following study was to study the Immediate Effect of Short Foot Exercise on Dynamic Balance In Elderly Population Having excessively Pronated foot.

According to Table 1& 2 SEBT values in each direction of both the limbs show significantly increased excursion values post SFE (two tailed p value <0.0001).

Hence, proving that there is an immediate effect of short foot exercise on dynamic balance in elderly population having excessively pronated foot.

## 14. Discussion

The aim of our study was to study the immediate effect of SFE on dynamic balance in elderly population having excessively pronated foot. In this study total 41 participants (n=41) were included both male & female of 65 years and above. Our results showed increased SEBT values in all the directions post SFE in both the limbs.

In a similar previous study on normal healthy adults, Lynn *et al.* (2012). reported that compared with a towel curl exercise group and control group, their SFE group showed a substantially greater reduction in the mediolateral COP (centre of pressure) movement of the non dominant legs after 4 weeks of exercise while undergoing the dynamic balance test on a force plate. They speculated that the explanation for this was an improvement in the integrity of the medial longitudinal arch induced by the intrinsic foot muscle strengthening resulting from the SFE.

Rothermel *et al.* (2004). reported that in a static stability test conducted on normal healthy adults, the COP excursion velocity decreased substantially more in a traditional balance training group than an SFE balance training group and control group after 4 weeks. They stated that the traditional balance training group concentrated on maintaining balance only, whereas the SFE balance training group concentrated too much on maintaining the SFE

positions, which interfered with their involuntary neurological activity.

Do-Young Jung *et al.* (2014). In his study of the immediate effect of SFE on excessively pronated foot stated that The reason for increased dynamic stability was because the SFE stimulated the proprioceptors at the bottom of the foot resulting in immediate effect on dynamic balance.

The present study shows that there was an immediate effect of SFE on dynamic balance due to intensified afferent stimulation of cutaneous receptors and therefore, increased voluntary muscle activities as a result improving the dynamic stability. When the MLA was shortened the pressure was created by the contact area on the surface this intensified the cutaneous stimulation thus, increasing the voluntary muscle action. So by the above mechanism we can conclude that our participants immediately after SFE showed increased dynamic balance on SEBT.

## 15. Conclusion

This study concludes there is an immediate effect of SFE on dynamic balance in elderly population having excessively pronated foot.

## 16. Limitations

- It included a relatively small sample.
- Subjects with excessively pronated feet but no symptoms were selected.

## 17. Future Scope of Study

- Study to see the time limit for which effect lasts after intervention.
- Consideration of dominant and non dominant legs.
- To see effects on participants having dysfunction due to excessively pronated feet.
- Study can be done on a large sample size.

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