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Foot arch index during Jana's Short-Foot maneuver in subjects with excessively pronated feet

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Abstract. The purpose of this study was to examine the foot arch index during short-foot sensory-motor maneuver intervention in subjects with excessively pronated feet. *Material and Method*. This study included thirty-five subjects with excessively pronated feet. Diagnosis of pronated foot was based on a valgus position of the heel (rear foot angle that was defined as the angle of the upper Achilles tendon and the distal extension of the rear foot) and a poor formation of the arch. At rest and during short-foot exercise feet of the children were scanned (while they were in a standing position) by using a plantar scanner. The Staheli Arch Index and Chippaux-Smirak Index were assessed before and during maneuver. Data were analyzed using a paired t-test. *Results*. Research results showed a significant decrease in the Staheli Arch Index (p=0.000) and Chippaux-Smirak Index (p=0.000) during short-foot sensory-motor maneuver intervention. *Conclusion*. Results from this study demonstrate short-foot maneuverers more effective in increasing the arch width and improves arch indexes. Therefore, the short-foot maneuverer and exercise is recommended for improving foot arch parameters in subjects with pronated feet.
***Key words**: medial longitudinal arch, short-foot exercise, pronated feet.*

Introduction

One of the most commonly discussed topics in the pediatric orthopedic realm, are the postural changes of the feet. With regard to the arch of the foot, the foot has a pronated and supinated structure, and 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 (1). Flat feet have excessive subtalar joint pronation. Kernozek et al. (1990) have reported that individuals with flat-arched foot have significantly higher pronation in stance than high-arched individuals (2). In the case of flat feet, instability and damage to the lower extremity cause hypermobility and passive instability (1), and more neurological control by the neuromuscular system is required to maintain stability and balance. Thus, while the feet are supporting the body weight, the instability resulting from a flat foot could cause patho-mechanical problems as well as a compensating action in the close kinematic chain of the lower extremity (3). Excessive pronation transmitted to internal rotation of the tibia, may cause overloading of the knee joint or may be the cause of other changes in proximal part of the lower extremity (4). There are some studies that describe the relationship between excessive foot pronation and increased risk of acute injury or repetitive strain injury (5, 6).

The deformation into flat foot is induced when the medial longitudinal arch (MLA) has descended because the arch had been excessively relaxed to the extent that the arch cannot be maintained and causes the feet to be excessively pronated compared to normal feet so that heel eversion appears and the weight load is shifted inward to compress the medial longitudinal arch (7, 8). When the medial longitudinal arch has descended or has been completely lost leading to structural or functional deformation, the ability to absorb impacts will decrease and the sense of balance will be lost so that stability decreases during walking or running leading to walking difficulties and endurance decreases (9, 10).

The plantar intrinsic foot muscles play a crucial role in supporting the medial longitudinal arch, providing the foot stability and flexibility for shock absorption. These muscles also have an influence on the range of foot pronation (11). The previous studies reported that sole stimulation could improve the motor sensation and postural movements to maintain proper postures (12). Sensory-motor training applies the proprioceptive feedback of the body to activate the abductor pollicis muscle and the flexor halluces brevis muscle, which are the intrinsic muscles of the feet important for maintenance of the medial longitudinal arch, to help the

formation of the arch and the maintenance of the balance of the body. Fiolkowski et al (2003) reported that sensory stimulation training was helpful for flatfoot patients to form and support the arch (13).
Thus far, several training techniques have been applied for improving foot posture. Among exercise methods to improve flatfoot, toe bending exercises or towel-curl exercises mainly mobilize the extrinsic muscles of the foot such as the flexor digitorum longus muscle (14). Recently, an exercise known as the short-foot exercise or foot doming which takes appropriate foot positioning into consideration, has been widely accepted by therapists. As the name implies, this exercise using the intrinsic foot muscles to create a dome by pulling the metatarsal heads (balls of the toes) toward the heel, which shortens the length of the foot. However, short-foot maneuverer is sensory-motor training that activates the intrinsic muscles of the foot and actively forms the longitudinal arch and the horizontal arch (15). Janda and Vavrova (1996) stated that short-foot exercise is the first step in sensory motor training (proprioceptive training) and can improve proprioception and postural stability if applied along with other exercises (16). Mulligan and Cook (2013) showed that short foot exercise training in healthy individuals reduces arch collapse as assessed by measures of navicular drop and arch height index (17). Moon et al. also showed short-foot exercise can improve the dynamic balance of subjects with excessively pronated feet (1).
In another study, Lynn et al (2012) reported that short-foot exercise significantly decreased the mediolateral center of pressure movement during the dynamic balance test (18). Drewes (2009), also, reported that daily short-foot exercise improved self-reported function and the outcomes in two other function tests (19). However, few studies have been conducted on the foot arch indexes in short-foot exercise, although studies on short-foot exercise have proposed that this exercise strengthens the intrinsic foot muscle and improves the functional performance of the lower extremity. Foot wedges are clinically applied for correction of diverse foot diseases and customized insoles are used for correction of pronated feet (20). Insoles widen the contact surface of the sole to improve stability during weight bearing, reduce turning actions when the foot has been pronated or supinated, and can be applied to the medial longitudinal arch of the foot to increase the sensory inputs of the sole (21).
Some study results have been reported indicating that the conservative intervention methods of foot orthotics using support for the arch of the foot improve malformations of the foot, are effective for leg alignment and pain control, and improve gaits to become normal (20).
Although studies utilizing foot orthotics such as therapeutic footwear, wedges, and insoles to improve the medial longitudinal arch of flatfoot have been mainly conducted, studies for improvement of flatfoot arch index with sensory-motor training such as short-foot sensory-motor maneuver are insufficient.
Therefore, the aim of this study was to determine the foot arch index during the short-foot maneuver intervention in subjects with excessively pronated feet.

Material and Method

This study included 35 children with excessively pronated feet who were selected through the poor formation of the arch (by the podoscope evaluation) and Helbing sign ($\geq 10^{\circ}$) that was based on a valgus position of the heel and rear foot angle that was defined as the angle of the upper Achilles tendon and the distal extension of the rear foot. Then, the children feet were scanned while they were in a standing position by using a plantar scanner device (ISRRC, model: DSI F/S 941). The average age, weight, and height of the researched subjects were 10.68 ±1.92yrs, 42.09 ±14.73kg, and 140.88 ±13.36cm, respectively. None of the subjects had experienced any pathologic symptoms in the feet and legs or gait problems for the last 6 months before of the study, and none had any history of operation on the lower extremities. Further, they also had no history of neurological disease or vestibular dysfunction. Informed consent was obtained from each subject, and subjects were not exposed to any risk of harm or physical discomfort in this study.
For the short-foot maneuver, the subjects were instructed to pull the first metatarsal head toward the heel without toe flexion and maintain this for 5 seconds in order to increase the medial longitudinal arch. Then, the feet of the children were scanned again (Figure1).
Teaching of the short foot begins with the patient seated. The patient places the foot flat on the floor, the knee was flexed at about 80°. Clinician cups the heel in one hand and grasps a cross the dorsum of the foot so that the arch and foot can be controlled (Figure1). He slowly approximates the grasping hand toward the cupping hand that remains stationary, allowing the approximation of the metatarsal heads toward the heel. The clinician holds this position for a few seconds, making sure that the subject can perceive the change in foot form and is Aware that the metatarsal heads all stay in contact with the floor. The clinician slowly returns the foot to the original position and, then, repeats the whole process 3 to 5 times, making sure that the

tibialis anterior muscle is not over active during training and that the tendon is not prominent during the formation of the short foot. Next, the patient is asked to actively assist in the formation of the short foot for several repetitions and then finally to perform the action independently. The patient can then practice forming the short foot with the foot placed in different positions on the floor and within creasing loading through weight bearing until the patient can perform this exercise in the standing position. The goal is to train the patient's aware-ness of foot function and its role in maintaining stability while integrating this function in to the initial postural correction (22).

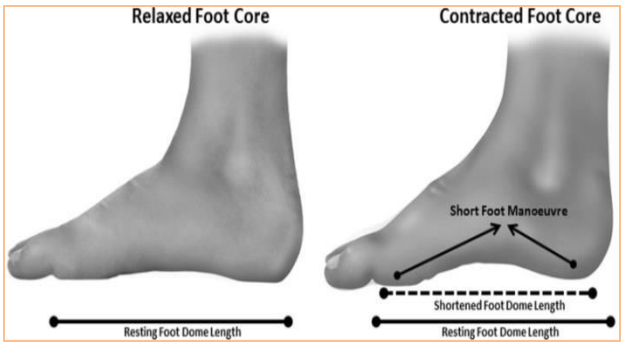

Figure 1. Janda's Short-Foot maneuver

Normal distribution of data was assessed using the Kolmogorov-Smirnov test. Data showed normal distribution. The statistical analysis of the variables and hypothesis testing were performed using parametric tests. SPSS (Ver. 20.0) was used for data collection, and a paired t-test was used to compare the results of the foot arch index before and during the Short-Foot maneuver.

Results

The mean and standard deviation of some of the characteristics of the subjects participating in the study such as age, height, and weight are presented in the Table 1.

During the Short-Foot maneuver, Staheli Arch Index increased significantly compared with the corresponding values before the Short-Foot maneuver (p=0.000). Further, the value of the Chippaux-Smirak Index increased significantly after the Short-Foot maneuver (p= 0.000).

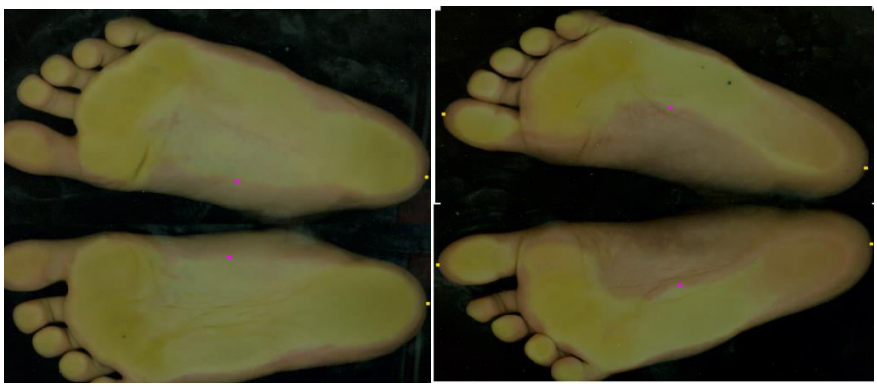

Figure 2. Foot-print with and without Short-Foot maneuver

Table 1. Mean and standard deviation (SE) characteristics of the subjects

	N	Minimum	Maximum	Mean	Std. Deviation
height	35	116.00	168.00	140.88	13.36
weight	35	22.00	78.00	42.09	14.73
age	35	7.00	15.00	10.68	1.92

Table 2. Comparison of foot arch index with and without S-F maneuver, assessed using paired t-test

	Paired Differences			t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean			
Staheli Arch Index left	25.98	9.68	1.63	15.87	34	.000*
Chippaux index left	50.68	12.0	2.02	24.97	34	.000*
Staheli Arch Index right	35.23	9.79	1.65	21.27	34	.000*
Chippaux index right	46.19	13.19	2.23	20.71	34	.000*

**Significance (P<0.05)*

Discussion

The Short-Foot maneuver using the intrinsic foot muscles to create a dome by pulling the metatarsal heads (balls of the toes) toward the heel, which shortens the length of the foot. Also, short-foot maneuverer is sensory-motor training that activates the intrinsic muscles of the foot and actively forms the longitudinal arch and the horizontal arch (1).

Janda and Vavrova (1996) found that short-foot maneuverer contracted the intrinsic muscles of the foot to increase the inner arch of the foot, thereby shortening the longitudinal arch of the foot (16). They stated that short-foot exercise improved the position of body segments and the stability of the body in the standing position by increasing afferent inputs from the bottom of the foot.

Decrease of both foot arch index during short-foot maneuverer is considered attributable to the fact that short foot exercises improved the functions and activity of the abductor pollicis muscle that plays the role of bearing the weight and the flexor hallucis brevis muscle that maintains the medial longitudinal arch.

Kyung-Kim and Seop-Kim (2016) in a study reported that to improve flatfoot, applying short foot exercises was more effective than applying arch support insoles in terms of medial longitudinal arch improvement (12). Sulowska et al (2016) reported a significant improvement was observed in foot posture index (3). Also, Lynn et al (2012) in a study reported that the short-foot exercise appeared to train the intrinsic foot musculature more effectively than the towel-curl exercise (18).

Several studies have examined the effect of short-foot as an exercise on postural control (23), dynamic balance of flexible flatfoot patients (12), dynamic balance of the subjects with excessively pronated feet (1), on functional movement patterns and foot posture (3).

The short foot exercise can be viewed as a foundational exercise for foot and ankle rehabilitation similar to how the abdominal drawing in maneuver is foundational to lumbopelvic core stability exercise programs. With the short foot exercise, emphasis should be placed on the patient learning to sense subtalar neutral with the calcaneus and the metatarsal heads on the ground and the toes neither flexed nor extended and then being able to shorten the foot by using the plantar intrinsic muscles.

According to the results of measurement, both foot arch index decreased during short-foot maneuverer. Results from this study demonstrate short-foot maneuverer is more effective in increasing the arch width and improves arch indexes. Therefore, the short-foot maneuverer and exercise is recommended for improving foot arch parameters in subjects with pronated feet**.**

References

1. Moon DC, Kim K, Lee SK. (2014). Immediate Effect of Short-foot Exercise on Dynamic Balance of Subjects with Excessively Pronated Feet. *J Phys Ther Sci*. 26(1):117–9. doi: 10.1589/jpts.26.117
2. Kernozek TW, Ricard MD. (1990). Foot placement angle and arch type: effect on rearfoot motion. *Arch Phys Med Rehabil.*; 71(12): 988–991
3. Sulowska I, Oleksy Ł, Mika A, Bylina D, Sołtan J. (2016). The Influence of Plantar Short Foot Muscle Exercises on Foot Posture and Fundamental Movement Patterns in Long-Distance Runners, a Non-Randomized, Non-Blinded Clinical Trial. *PLoS.* ONE; 11(6).
4. Hintermann B, Nigg BM. 2007. Pronation in runners. Implications for injuries. *Sports Med.* 1998; 26(3): 169– 176
5. Boozer MH, Finch A, Waite LR. (2002). Investigation of the relationship between arch height and maximum pronation angle during running. *Biomed Sci Instrum*. 38: 203–207.
6. Irving DB, Cook JL, Young MA, Menz *HB*(2007). Obesity and pronated foot type may increase the risk of chronic plantar heel pain: a matched case-control study. *BMC Musculoskelet Disord*. 17(8):41.
7. Flemister AS, Neville CG, Houck J. (2007). The relationship between ankle, hind foot, and forefoot position and posterior tibial muscle excursion. *Foot Ankle Int*; 28: 448–455

8. Korpelainen R, Orava S, Karpakka J. (2001). Risk factors for recurrent stress fractures in athletes. *Am J Sports Med*; 29: 304–310
9. Abouaesha F, van Schie CH, Griffths GD (2001). Plantar tissue thickness is related to peak plantar pressure in the high-risk diabetic foot. *Diabetes Care*; 24: 1270–1274
10. Citaker S, Gunduz AG, Guclu MB, (2011). Relationship between foot sensation and standing balance in patients with multiple sclerosis. *Gait Posture*; 34: 275–278
11. Ferber R, Hreljac A, Kendall KD (2009). Suspected mechanisms in the cause of overuse running injuries: A Clinical Review. *Sports Health*; 1(3): 242–246.
12. Eun-Kyung Kim, Jin Seop Kim (2016). The effects of short foot exercises and arch support insoles on improvement in the medial longitudinal arch and dynamic balance of flexible flatfoot patients. *J Phys Ther Sci*.; 28(11): 3136–3139
13. Fiolkowski P, Brunt D, Bishop M, (2003). Intrinsic pedal musculature support of the medial longitudinal arch: an electromyography study. *J Foot Ankle Surg*; 42: 327–333.
14. Saeki J, Tojima M, Torii S. (2015). Clarification of functional differences between the hallux and lesser toes during the single leg stance: immediate effects of conditioning contraction of the toe plantar flexion muscles. J Phys Ther Sci; 27: 2701–2704.
15. Jung DY, Kim MH, Koh EK (2011). A comparison in the muscle activity of the abductor hallucis and the medial longitudinal arch angle during toe curl and short foot exercises. *Phys Ther Sport*; 12: 30–35.
16. Janda V, Vavrova M. (1996). Sensory motor stimulation. In: *Rehabilitation of the Spine*. Liebenson C (ed.), Baltimore: Williams & Wilkins, pp 319–328
17. Mulligan EP, Cook PG (2013). Effect of plantar intrinsic muscle training on medial longitudinal arch morphology and dynamic function. *Man Ther*.; 18(5):425-30.17.
18. Lynn SK, Padilla RA, Tsang KW (2012). Difference in static- and dynamic-balance task performance after 4 weeks of intrinsic-foot-muscle training: the short-foot exercise versus the towel-curl exercise. *J Sport Rehabil*, 21: 327–333.
19. Drewes LK, Hertel J (2009). Intrinsic foot muscle test deficits in a population with chronic ankle instability. *J Athl Train*; 44: S28.
20. Telfer S, Abbott M, Steultjens M (2013). Dose-response effects of customised foot orthoses on lower limb muscle activity and plantar pressures in pronated foot type. *Gait Posture*; 38: 443–449.
21. Coughlin MJ, Roger A, Mann Award (1995). Juvenile hallux valgus: etiology and treatment. *Foot Ankle Int*, 16: 682–697.
22. Page Phil, Frank Clare C, Lardner Robert (2010). Assessment and Treatment of Muscle Imbalance. The Janda Approach. *Human Kinetics*, Champaign, IL, pp.163.
23. Mignogna Christopher A, Welsch Lauren A, and Hoch Matthew C (2016). The Effects of Short-Foot Exercises on Postural Control: A Critically Appraised Topic. *Human Kinetics – IJATT*; 21(6), pp. 8-12.

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