

## Effect of Pre-Fabricated Toe Separator in Standing and Walking Balance in Individuals with Bilateral Hallux Valgus



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**ABSTRACT:** Hallux valgus is deviation of forefoot's first ray toward midline of the body. Hallux valgus identified with proximal phalanx deviating laterally, first metatarsal head deviating medially with angle greater than 15°. The deformity is complex and affect standing balance and walking balance, causing disturbance to daily activities. Pre-fabricated toe separator is widely used in individuals with hallux valgus in order to prevent progression of deformity. It is cheap, easy to find in market, and simply fit inside shoes.

**Objective:** analyzed the effect of silicone toe separator on individual with bilateral hallux valgus in standing balance and walking balance.

**Methods:** There were 26 participants with bilateral hallux valgus joined the study, they were asked to stand and walk on a footscan. RSscan Footscan® measurement system was used to record and analyze standing and walking. Pressure and force distribution of foot without and with toe separator were analyzed. Then, participant asked to walk for 3 gait cycles without and with silicone toe separator. Center of Pressure Displacement (CoP) to base of support and forefoot balance were collected in this process.

**Results:** Using paired t-test, it was revealed that there are significant differences (P value 0.001) in center of pressure movement, forefoot balance are significant different with p-value 0.036; both without and with silicone toe separator in participants with bilateral hallux valgus conditions.

**Conclusion:** Silicone toe separator improves standing balance and walking balance in individual with bilateral hallux valgus.

**KEYWORDS:** Hallux valgus, standing and walking balance, pre-fabricated toe separator

### I. INTRODUCTION

Hallux valgus is deviation toward midline of the body of forefoot's first ray. Hallux valgus identified with proximal phalanx deviating laterally, first metatarsal head deviating medially with angle greater than 15° [1]. The deformity is complex and affect static balance, dynamic balance, painful, and causing disturbance to daily activities. Hallux valgus associated with Body Mass Index (BMI), foot pain, flat foot [2]. Footwear; pointed shoes and heel height also associated this condition [3]. The prevalence of hallux valgus is 23% in adults; 44% in women and 22% in men [4].

Hallux valgus causes metatarsal pronation and foot pronation, these position prevents the foot from moving into supination. Furthermore, it makes subtalar joint becomes too flexible and creates unbalance foot during standing. The pronated foot causes greater center of pressure (COP) shift medially than in normal foot, causing lack of stability during standing [5]. In normal gait, especially during push off, ankle joint requires dorsiflexion and supination movements to help strengthen the structure of the foot before swinging the leg. This mechanism requires rigid foot structure created by hallux extension to raise medial longitudinal arch thus provide power during push-off [6-7]. The mechanism fails in individual with hallux valgus because of great toe extension limitation during push-off, thus creates lack of stabilisation during walking [8]. Treatment of hallux valgus should be initiated as soon as possible to prevent worse progression in the future [9]. Pre-fabricated toe separator is widely used in individuals with hallux valgus in order to prevent progression of deformity. The device is made of foam, silicone, gel, rubber, designed to fit among toes. It is cheap, easy to find at market, and simply fit inside shoes. Wearing prefabricated silicone toe separator in proper shoes could prevent the progression of hallux valgus [10].

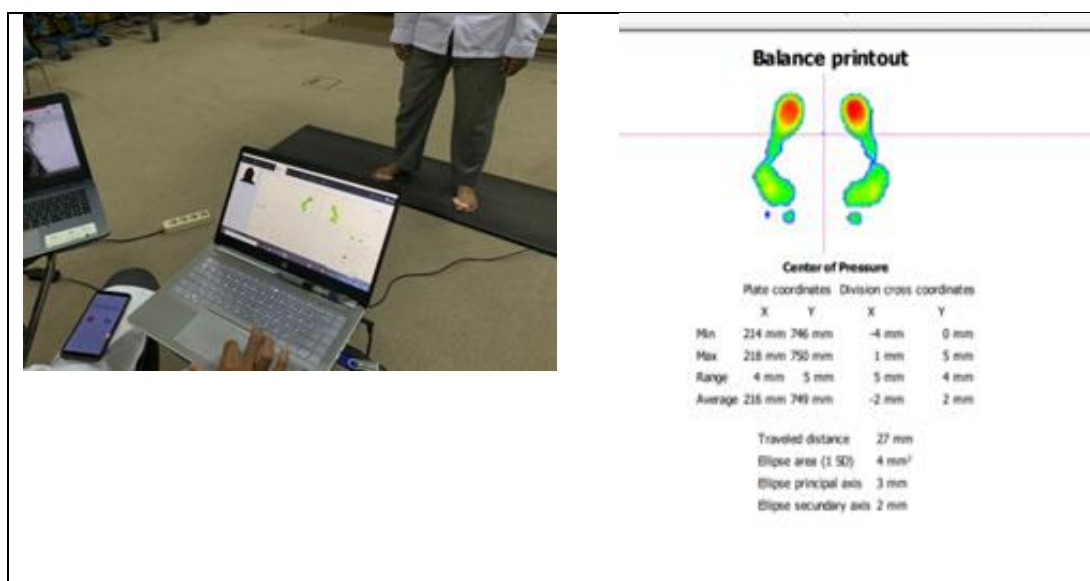
**II. METHOD AND MATERIAL**

Participants recruited in this study consisted of 26 subjects ranging in age between 19 and 25 years old. (Table I summarizes participant’ characteristics). Inclusion criterias, participants were having bilateral hallux valgus with >15 degrees angle, correctable hallux valgus (mild to moderate). Exclusion criterias, participants were age younger than 19 or older than 45 years, has unilateral hallux valgus, pregnant woman, and has underlying disease. Human research ethics committee of Health Polytechnic Jakarta I approved the study protocol, all participants taking part in the study given informed consent.

Exclusion criterias, participants were age younger than 19 or older than 45 years, has unilateral hallux valgus, pregnant woman, and has underlying disease. Human research ethics committee of Health Polytechnic Jakarta I approved the study protocol, all participants taking part in the study given informed consent. The researchers conducted assessment using Manchester scale to determine degree of hallux valgus. After all inclusions have been met, data collection processes began. RSscan Footscan® measurement system was used to record and analyze standing and walking plantar pressure data of participants. It recorded up to 500 frames of data a second uses sensors, allowing depth analysis of pressure and force distribution of the foot. The participants stood on force plate for 15 seconds and walked for 3 gait cycles without and with silicone toe separator. Center of Pressure displacement and forefoot balance were collected in this process.

**Table 1. Characteristics of participants**

VARIABLE	FREQUENCY	PERCENTAGE
Gender		
Male	6	23.1
Female	20	76.9
Total	26	100
Age		
18-19	11	42.3
20-21	13	50
>22	2	7.7
BMI		
>18.5	5	19.2
18.5-23	11	42.3
23-25	3	11.5
25-30	5	19.2
>30	2	7.7



**Figure 1. Data collection with footscan**

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## III. RESULT

**Table 2. Frequency Distribution of Centre of Pressure Displacement With and Without Toe Separator**

Centre of Pressure displacement	Without		With	
	Frequency	%	Frequency	%
0-50 mm	20	76.9	33	88.5
50-355 mm	6	23.21	3	11.5
>355 mm	0	0	0	0
Total	26	100	26	100

Table 2 shows Frequency distribution of participants based on COP displacement

**Table 3. Frequency Distribution of Participants Based on Differences in Forefoot Balance**

Forefoot balance	Without		With	
	Frequency	%	Frequency	%
-40 - -20 Very stable	1	3.8	5	19.2
-20 - -0 stable	12	46.2	12	46.2
0 - 20 unstable	11	42.3	7	26.9
20-40 Very unstable	1	3.8	2	7.7
>40 Severe	1	3.8	0	0
Total	26	100	26	100

Table 3 shows frequency distribution of participants based on differences in forefoot balance.

The normal distribution of data was tested with Saphiro-Wilk test. Data obtained for all variables are normally distributed with p value > 0.05. Using paired t-test, it was revealed that there are significant differences (P value < 0.05) in center of pressure movement with p-value 0.001, forefoot balance p-value 0.036 both without and with silicone toe separator in participants with bilateral hallux valgus conditions. (Table 4).

**Table 4. Data Comparisons of Study Variables without and With Silicone Toe Separator**

	without	with	mean	p-value (p<0.05)	Description
CoP displacement	4.05	2.70	1.350	0.001	significance
Forefoot balance	2.09	-4.27	6.365	0.036	significance

Based on result, mediolateral center of pressure displacement in the dependent paired t-test stated that there was significant difference in the change of center of pressure position to base of support with P-value 0.001. There were significant difference in forefoot balance as well with P-value 0.036.

## V. DISCUSSION

Usage of toe-separator caused reduction of centre of pressure displacement in participants. The displacement reduced because toe separator provides better standing alignment of toes, those increase balance. The toe separator decreases pronation of foot, creates better structure of foot. This investigation is accordance with research conducted by [11], stated that the condition of the foot with pronation has greater center of pressure shift than the normal foot. More pronation of foot creates unstable foot. In this study, significant results were obtained. Silicone toe separator reduced medially displaced Centre of Pressure, thus reduced pronated foot, and creates better standing balance.

Data obtained shows significance value of forefoot balance with usage of silicone toe separator. The results of this study are in line with [11], which stated silicone toe separator can improve dynamic balance in participants with hallux valgus. This study

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obtained significant results, toe separator improved forefoot balance, spreading pressure more to great toe, provides better foot structure, reduce pronation of the foot thus make the foot more stable. Hallux is easier to extend, creates more rigid and stable foot for push off.

### VI. CONCLUSIONS

Silicone toe separator proven to be effective in standing and walking balance in patient with bilateral hallux valgus. It is reduced pronation, provides evenly distributed pressure, and creates rigid foot during walking. Stability and walking power, especially during push off were better. However, there are some variables excluded in this research because of investigators's limitations. In future research, it is recommended to add variables such as speed, cadence, and energy expenditure.

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### REFERENCES

- 1) Saltzman CL, et al. Reliability of standard foot radiographic measurements. *Foot Ankle International* 1994;661-665.
- 2) Nguyen, Uyen-Sa D.T. et al. Factors Associated with Hallux Valgus in a Population-Based Study of Older Women and Men: the MOBILIZE Boston Study'. *Osteoarthritis and Cartilage* 2010; 41-46. doi: 10.1016/j.joca.2009.07.008.
- 3) Puszczalowska-Lizis, E. et al. Foot deformities in women are associated with wearing high-heeled shoes. *Medical Science Monitor* 2019;25,:7746–7754. doi: 10.12659/MSM.917983.
- 4) Dufour, A. B. et al. Characteristics associated with hallux valgus in a population-based foot study of older adults. *Arthritis Care and Research* 2014; 66(12):1880–1886. doi: 10.1002/acr.22391.
- 5) Wagner, E. and Wagner, P. Metatarsal Pronation in Hallux Valgus Deformity: A Review. *Journal of the American Academy of Orthopaedic Surgeons Global Research and Reviews* 2020;4(6). doi: 10.5435/JAAOSGlobal-D-20-00091.
- 6) Kharb, A. et al. A review of gait cycle and its parameters. *IJCEM Int J Comput Eng Manag* 2011;13:78–83.
- 7) Farris, D. J., Birch, J. and Kelly, L. Foot stiffening during the push-off phase of human walking is linked to active muscle contraction, and not the windlass mechanism. *Journal of the Royal Society Interface* 2020;17(168). doi: 10.1098/rsif.2020.0208.
- 8) Perera, A. M., Mason, L. and Stephens, M. M. The pathogenesis of hallux valgus', *Journal of Bone and Joint Surgery - Series A* 2019; 93(17):1650–1661. doi: 10.2106/JBJS.H.01630.
- 9) Kuhn J, Alvi F. Hallux Valgus. [Updated 2022 Jun 11]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK553092/>
- 10) Kelly, A. R. ISU ReD : Research and eData The Effects of a Foot-Toe Orthosis on Dynamic Balance and Hallux Valgus Angle 2014
- 11) Kim, J. ah, Lim, O. bin and Yi, C. hwi. Difference in static and dynamic stability between flexible flatfeet and neutral feet. *Gait and Posture* 2015;41(2):546–550. doi: 10.1016/j.gaitpost.2014.12.012.



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